AVIATION IN THE XXI-ST CENTURY

NATIONAL ACADEMY OF SCIENCES OF UKRAINE
MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY

PROCEEDINGS

THE SEVENTH WORLD CONGRESS "AVIATION IN THE XXI-st CENTURY"

"Safety in Aviation and Space Technologies"

September 19-21, 2016
Kyiv, Ukraine

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- ✈ National Aviation Academy "Azerbaijan Hava Yollari" Closed Joint-Stock Company, Azerbaijan
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SYMPOSIA

SYMPOSIUM 1. MODERN SPACE AND AVIATION TECHNOLOGIES

1.1. Automation and energy saving on aviation transport
1.2. Modern technologies of aircrafts airworthiness support
1.3. Fatigue and fracture of aircraft structures
1.4. Modern tribotechnologies in aircraft and general-purpose mechanical engineering
1.5. Engines and Power Installations
1.6. Methods and facilities of technical and medical diagnostics
1.7. Automated process control systems
1.8. Information technology and systems in the aviation industry
1.9. The intellectual robot-technical measuring complexes and systems
1.10. Cybersecurity in civil aviation
1.11. Mathematical modeling and numerical methods
1.12. Computer systems
1.13. Advanced information technologies in aviation

SYMPOSIUM 2. UNMANNED AIRCRAFT SYSTEMS (UAS)

SYMPOSIUM 3. AIR NAVIGATION AND ATM SYSTEMS

3.1. Prospects aviation telecommunication systems
3.2. Aviation English for flight safety
3.3. Complex systems control
3.4. Avionics
3.5. Human Factors: engineering and technical, psychological and medical-biological aspects
3.6. Communication, navigation, surveillance

SYMPOSIUM 4. IEEE RADAR METHODS AND SYSTEMS WORKSHOP (RMSW-2016)

/September, 27-28, 2016/
http://ieee.nau.edu.ua/rmsw-2016/index.html

SYMPOSIUM 5. ENVIRONMENT PROTECTION

5.1. Biotechnology in aviation
5.2. Land management, cadastre and land monitoring
5.3. Chemical technology and engineering
5.4. Environmental protection

SYMPOSIUM 6. AVIATION CHEMMOTOLOGY

SYMPOSIUM 7. COMMUNICATION FACTOR IN MODERN INTERNATIONAL RELATIONS

7.1. Information and legal principles of international relations

7.2. The transformation of journalism in the context of technologizing the world and the processes of globalization

7.3. The international scientific and technical cooperation of Ukraine in aerospace industry

SYMPOSIUM 8. ECONOMY AND MANAGEMENT IN AVIATION

SYMPOSIUM 9. HUMAN FACTOR IN AVIATION

SESSION A. Language Modelling of Aviation Information Systems

SESSION B. Human Factor Management: Current Situation and Prospects

SESSION C. Psychology of Aircraft Operation Safety

SYMPOSIUM 10. PROBLEMS OF DEVELOPMENT OF THE MODERN AIRPORT

10.1. Urban, industrial, civil and transport construction

10.2. Design of architectural environment

10.3. Technical aesthetics and design

SYMPOSIUM 11. AIR AND SPACE LAW: INTERNATIONAL AND NATIONAL ISSUES OF SECURITY

SYMPOSIUM 12. INNOVATIVE TECHNOLOGY OF PROFESSIONAL TRAINING ON THE BASIS OF HIGHER EDUCATION

SYMPOSIUM 13. ICAO SAFETY STRATEGIES

CONTENTS

SYMPOSIUM 1. MODERN SPACE AND AVIATION TECHNOLOGIES

1.4. Modern tribotechnologies in aircraft and general-purpose mechanical engineering

1.5. Engines and Power Installations

1.6. Methods and facilities of technical and medical diagnostics

1.7. Automated process control systems

1.8. Information technology and systems in the aviation industry

1.11. Mathematical modeling and numerical methods

1.12. Computer systems

1.13. Advanced information technologies in aviation

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3.5. Human Factors: engineering and technical, psychological and medical-biological aspects

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The structure of the electricity system with digital control for future aircraft

Considered one of the possible approaches to the construction of digital control systems autonomous power supply systems, taking into account the «technological» unity of the processes of production, distribution and consumption of electrical energy and providing an effective solution of the set of tasks assigned to a digital control system.

One of the main problems that occur in digital control systems (DCS) for autonomous power supply systems (PSS) is the problem of rational choice of its structure, which largely depends on the structure and parameters of the control object and the composition of functional tasks solved.

Airplane PSS have a number of specific features [1,2], allowing to directly apply methods for constructing DCS developed for other systems of aircraft equipment. The principle of construction of DCS distributed architecture based on functional and topological decentralization [1,2,3]. Functional decentralization involves partitioning is quite complex overall process management to a number of loosely connected sub-processes with clearly defined ways of interaction. Under topological decentralization refers to the spatial distribution of sensors, devices, information processing and actuators. It should be noted that for digital control system PSS functionally optimal decentralization of the system practically coincides with the topological optimum.

Analysis of the structure and characteristics of offline PSS [1,3,4], the amount of information and the composition of functional tasks solved suggests that for multi-channel PSS is optimal hierarchical structure of the DCS, consisting of two levels. such a structure implies the existence of a central specialised on-board digital computing machine (ODCM) on the upper level and the peripheral digital control devices (DCD) in the subsystems of the lower level.

On the lower level of the hierarchy to solve problems of operational management of the channels of generation (CG): ensuring required quality of electrical energy in normal operation; analysis of the technical condition, diagnostics and protection of the generation system.

To the tasks solved at the top level of the DCS, including the tasks of control of PSS as a whole: management of PSS and receivers of electrical energy during all modes of operation and flight situations; diagnosing the technical condition and protection system of distribution of electric energy; control the efficiency of the PSS and DCS, as well as display of information; forecasting of the technical condition of the generating plants.

Usually in systems with distributed control, DCD, problem solving the lower level coordination direct assistance of the central ODCM. Since in this structure coordinating ODCM freed from the functions of the control channels to generate, its operating system is greatly simplified. Thus, the parallelization of information processing not only improves the performance of the DCD, but also reduce the cost of preparation of mathematical software. The latter factor is currently of considerable significance, since the cost of developing mathematical software can reach 70-80% of the cost of creating the entire digital control system.

If the specified functional and topological decentralization of the digital control system ODCM responsible mainly for logical tasks and operates with discrete information, which determines the relatively low requirements to the frequency of information exchange f_n = 5-10Hz. As the frequency and duration decisions of top-level tasks are small enough, then ODCM can be comprehensively used to control other systems of aircraft equipment that do not require high performance of the DCD. When you apply for connection with the facility SCADA control system on ODCM it is advisable to entrust the functions of coding, decoding and distribution of information.

Considerably more stringent requirements apply to DCD used for the operational management of CG of electric energy. The need to ensure maximum performance, DCD has a significant impact on their structure.

The efficiency of digital control channels generate is largely determined by the rationality of constructing communication devices with the object, the characteristics of which are selected based on a thorough analysis of the management processes. Given the existing requirements to quality of electric energy [1,5] we can assume that the allowable error voltage and frequency shall not exceed 0.5%, and the duration of the measurement cycle is the output coordinate for direct digital regulation must not exceed 5 g it should be noted that a number of required characteristics can be achieved both through the use of better equipment [1,3,4], and by a rational structure of the measuring part of the device. The high complexity and cost of the transducers involves the use of a minimum number of ADC, which forms a centralized measurement system for multiple micro-processes (MP1 and MP2), is designed to address a specific functional task.

The microprocessor MP1 it is advisable to hold functions control the operation of the communication devices with the object, advanced information processing and implementation of algorithms of protection CG from inadmissible deviations of voltage frequency. Then the microprocessor MP2 will be able to provide effective solutions in direct digital regulation of the output coordinate system.

In the development of DCD used for the operational management of CG of electric energy, requires significant attention to the organization of the process of entering the measured information. Analyze large volume of information and high speed of flow of electromagnetic transients makes it impractical the application of the system of information input with the interruption of the computation, leading to inefficient use of the computing potential of the processor. For example, when the duration of the measurement cycle T_n = 5 ms in ODCM with a speed of about 100000 on/c about 20% of machine time is spent only on processing interrupt signals and the subsequent recovery calculations. Therefore, in DCD CG of electrical energy, characterized by high frequency of information exchange, it is desirable to provide the possibility of direct entry in random access memory (RAM).

Central ODCM manages the PSS in two modes: automatic (depending on the flight conditions and the technical state of individual elements, PSS); commands entered by the crew from the control panel.

To ensure high-speed protection system of distribution of electric energy in OCDM you enter information from the set of sensors and the distribution system are transmitted control signals of the switching devices. In addition, OCDM received information about the technical condition of the rectifier device and battery, which is used to control the operation of these devices.

In conclusion: the use of PSS digital control system will allow you to have automatically managed a highly efficient power supply system, the operation of which is ensured by its actual technical condition with the diagnosis of fault locations in the system; achieving a positive effect when used in PSS with a digital control system requires the development of new methods of analysis and assessment of the state of the system, optimal algorithms and matching actuators to the digital control; the use of DCD in offline PSS, do the latter highly operational, independent of the aircraft controls.

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Neural network model for predicting the level of residual knowledge of the subjects of study

The task is to build a neural network model depending on residual knowledge the trainees with whom they come into the labor market. Neural network model makes it possible with enough precision to predict the level of professional training according to their individual abilities.

At the present time the quality issue of training expert crews are very relevant, due to the mismatch of quality of training education requirements of their customers, and the lack of necessary competences needed by modern technology.

The main tools in this case are the intelligent methods of modeling and optimization, which allow to predict the course of events, the consequences of different management decisions, and most importantly, allow you to find the best optimum decision on training of aviation personnel. After the synthesis of architectures of neural networks (NN) for determining the residual knowledge of subjects of study, was based on a multi-layered network of direct distribution. Education of NN was conducted by “learning with teacher” method by feedback distribution errors algorithm. NN estimation of residual knowledge of subjects from their individual abilities offers synthesize using the following steps:

1) forming a set of statistical data;

2) structural NN synthesis according to residual knowledge of subjects of learning from their individual abilities;

3) parametric synthesis model of professional training with NN training on formed signs with training algorithm;

4) verification of the quality of training of NN according to residual knowledge of subjects from their individual abilities.

To construct NN training specialists should consider factors that affect the subjects and to identify their degree of influence. As each subject is a person, first we should do is to analyze his personality characteristics. Factors affecting subjects in their preparation [1] were analyzed. As a result of personality analysis were formed the following factors: motivation for education, intellectual abilities of subjects, psychological characteristics, physical factors that affect learning. Each of these types is divided into several indicators, which can be determined by the results of test surveys [2, 3].

The process of expert preparation is a transfer of teacher's knowledge and skills. The quality of teaching is recorded in the examination information. NN learning process should form the output of residual subject’s knowledge in a particular discipline with which subject enters the labor market. During this process the employers decide on candidates for job vacancies.

For NN learning there are following objectives:

– psychological portrait of individual abilities that characterizes the mentality of the subjects;

– curriculum disciplines;

– evaluation criteria of knowledge;

– the examination sheet that reflects the success of the subjects.

Prediction of residual knowledge of one specifical discipline for one subject, is carried out in two stages.

The first stage is projected on the basis of test scores of individual abilities.

In the second stage, based on the estimated scores an average set of knowledge and skills which corresponds to this assessment is formed .

The first NN will be trained based on the individual abilities of a group of subjects and examination information.

Input parameters of the second NN are test rating obtained from the output of the first NN.

Outgoing signals of second NN forms a vector, components of which record the presence or absence of corresponding residual knowledge or skill. Teacher forms the training set for the second NN for his discipline, using the approved evaluation criteria and curriculum subjects, which contains the list of knowledge and skills.

NN education was carried out by the “learning with teacher” method by back propagation of errors algorithm.

For the modeling environment for NN was used the Neural Network Toolbox package, which is included in the standard supply of MATLAB [4, 5].

In the construction of training set for the first NN 10 subjects were chosen, who attended a training course "Automation and automation in transport" and already got the exam scores.

For the training set data first 9 subjects were taken. The results of subjective at number 10 were used to verify trainees NN.

As can be seen from fig. 1, for the training of two-layered NN 5 eras at zero accuracy was enough.

Fig. 2 represent a errors histogram of 10th subject, which values were used for verification the NN.

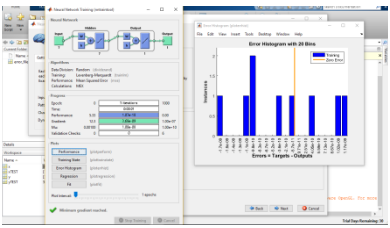

Fig.1. Histogram errors of trainees set

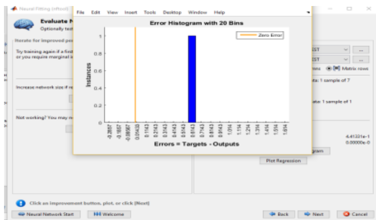

Fig.2. Histogram errors of testing set

Analysis of the first stage showed that the value of a component of the original signal close to code (11101111111).

This encoding matches the examination mark "excellent", which this subject really got at examination.

Estimated valuation of the output of the first NN came to the entrance of the second NN, which forms the effective vector *Y* of knowledge and skills of this subject.

Where the value of a vector *Y* can be interpreted as a degree of confidence that this entity is stored in his memory of the appropriate knowledge and skills [6].

Comparing the received result (11101111111) to the criteria of assessment in the discipline, the represented set of predictive knowledge and skills matches the assessment of "excellent".

That confirms the correctness of the proposed ideas to tackle the problem. The proposed NN allows to predict the level of professional training with high enough precision.

Conclusions

The proposed approach to the neuron modeling of weakly-formalized process of training of aviation specialists, based on the definition of professional skills and knowledge of the subjects of the education, which they enter the labor market with.

Special software for automated systems of learning and knowledge control in the preparation of aviation personnel can be developed based on this NN.

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Automation and remote control of lighting airfields systems modern civil aviation

One way to increase the level of safety of civil aviation aircraft is automation lighting airfields systems. Automation is provided by remote control lighting equipment to obtain the required warning about the system and its individual elements according to international specifications and technical documentation to the type of equipment.

Introduction. One of the links in the chain safety and regularity of flights is lighting airfields systems (LAS). It LAS is the only source of visual information to the crew at the most critical phase of flight. According to statistics most important stage is the stage of visual piloting. The most crucial stage of the flight crew is interaction with LAS and depends on the visibility range, depending on the weather near the airport. For this, the requirements for reliability LAS should reflect the ability to perform necessary functions within a specified period of time specified in terms of operation, maintenance, storage and transportation equipment items LAS. Reliability LAS regulated by GOST 2860-94 Ukraine «Reliability engineering and includes reliability, durability, maintainability and safety of or some combination of these properties». Quality lighting performance standards LSA regulated by a number of ICAO [1,2,3], which aim to ensure the necessary elektrosvetotehnicheskih characteristics (power consumption, brightness, color, strength and intensity of the light, and others. ICAO required level of safety and regularity of aircraft operations (PS) is one of the main challenges facing civil aviation.

Problem research. Remote control system SSA lights for large aerodromes are complex and proper management is determined by atmospheric conditions, time of day, and sometimes recommendations pilots maneuvering and a few aircraft and other types of held on the airfield operations. The biggest information regarding these conditions placed dispatchers air traffic control (ATC), and so most of the management of airport lights located on the remote control lights in the aerodrome control point and used by ATC controllers.

The main control panel is usually placed in the aerodrome control point on the dashboard or control panel lights. This remote is designed so that it operator were control switches governance indicator lights of the chain and controls the power light lights, and the relevant point elements are easily recognized for all the lighting conditions in paragraph control. For this purpose, it may be necessary to establish control switches with symbols and switch luminance control panel indicator lights. A standardized form layout of controls and indicators provides a number of advantages, and is currently a trend towards standard modular circuit control panels. It is necessary that switches and controls gave a clear indication of working position and were grouped according to the respective functions and circuits. Data type of controls should be selected so that the possibility of accidentally switching the light was reduced to a minimum [1-3].

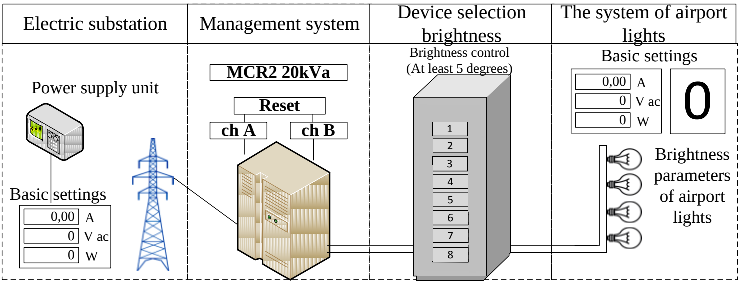

Fig. 1. Scheme of remote control of lighting airfields systems

The required amount of equipment remote control lighting equipment is determined for each airfield, leaving from the controlled process equipment. According normative and technical documentation control equipment lighting equipment must be:

– equipment items for lighting control means control dispatchers landing and taxiing;

– equipment items for lighting control means control dispatcher start;

– equipment controlled areas;

– mimic in sight controllers landing, taxiing that should not close other equipment;

– panel operational management consoles as controllers landing, taxiing, starting.

For power and adjust the brightness of lights depending on weather conditions using the brightness controls with microprocessor control. Active remote management of the entire light signal system, automatic control of all its elements with the software. The operator can control the switching, switching off lights and adjustable brightness depending on the brightness of the landing system.

For the implementation of the airfield lighting system control, monitoring and signaling functions required to implement such devices in the system:

– the level of equipment, devices and lighting equipment and safety devices zlitnoposadkovyh rulizhnyh bands (AGL); Brightness controls TCR; installation and radio navigation systems (ILS, DME, NDB); power systems; meteorological system; Safety Zone; backup power supply; distant objects; Interaction Communications (AFTN); Exact time; emergency power during emergency and emergency situations;

– at the level of working conditions for all categories of visibility ICAO: fire and alarm; image data with surrounding systems; data transfer into the surrounding system; data analysis for the purpose of CAT II and CAT III; archiving and emergency operating conditions [4,6].

Remote control airfield ground lighting equipment should ensure delivery of information on screen commands and visualization (indoors aerodrome control item in the room for maintenance and two indoor substations).

Specialized fiber optic network used to connect computers in a room aerodrome control point with computers in the building of the substation and interface racks containing programmable logic controllers that are installed at the substation. Consider using a remote radio control. Equipment can provide radio management intensity lights and lights switching networks. This method of control allows the pilot to select the intensity of the lights, and results in energy savings of energy, because the absence of necessary system lights are off. There are facilities for radio systems operating in the "air-land", "land-land" and the combination of "air-land" and "land-land." Most types of radio control network automatically switches the lights after 15-60 minutes after the last setting radio. Of radio control used to control the lights, simple approach lights systems, systems of visual glideslope indication as separate systems, and some combination of advance [5].

To work in the "air-land" at the airport set only receiver and decoder. Signal inclusion may consist of some short series of signals that are fed through a microphone transmitter aircraft.

Reliability of subsystems lights and remote subsystems characterized by the following factors: availability factor subsystems airfield lights of lighting airfields systems ; availability factor of power supply subsystem airfield lights; unavailability factor of power supply subsystem airfield lights.

Conclusions

Automated remote control of lighting airfields systems is one of the main condition for a safe and regular flights during visual piloting in simple and adverse weather conditions on the ground of civil aviation. The level of equipment reliability, which is part of automated control systems Lighting systems airfields, implemented at the design and production of the main manufacturers of such equipment and compliance with regulatory and technical documentation ICAO. The analysis of modern automated lighting systems airfields using programmable logic controllers and control by means of radio control systems made it possible to identify key areas of operation of lighting systems airfields and flight safety in civil aviation airfields.

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Designing an automated decision support system for energy management system of educational institutions

Determining the causes and sources of losses in the accounting and energy consumption is the basis for making management decisions and construction of power management and energy efficiency measures.

Introduction. To generate data management system is necessary to minimize the impact of human factors on the objectivity of the information received and evaluating actual results. This is achieved by using additional technical means reliable measurement parameters and primary energy flows (in terms of top-level management) data within the automated system integrating energy (ASKOER).

Problem of the research. The purpose of automating energy management system is to improve power management. The main objectives for the development and implementation of energy efficiency and its automation is: the current state of research in the field of consumption; develop the concept of power management; design and creation of the automated system power management; testing systems in all regions of Ukraine; formation of organizational and methodological conditions for implementing the system power management.

To develop mechanisms for automated building energy management system (ASEM) was chosen object-oriented approach, as it allows for a powerful means of expression object and object-oriented programming using blocks as classes and objects as in the object model is reflected and many other factors. Objective approach is unified whole idea of computer science, applied not only in programming but also in designing user interfaces, databases and even architecture computers. Therefore, the use of object-oriented approach to system design simplifies its software implementation. Targeting objects allows systems to cope with the complexity of diverse nature. In object-oriented analysis classification or definition of common object properties, helps find common key abstractions and mechanisms which, in turn, results in a simpler system architecture. When designing an automated decision support system for energy management system used common notation (UML standard).

In the first stage carry out development diagram precedents. The diagram shows three actors (Actor): system administrator, accountant and energy manager and a list of executable This diagram allows you to create a list of operations that performs system. So with (Figure 1) shows that the system administrator performs basic tasks, also shows that the operation as a "system administration" is mainly because it is related to many problems even are attached to other actors.

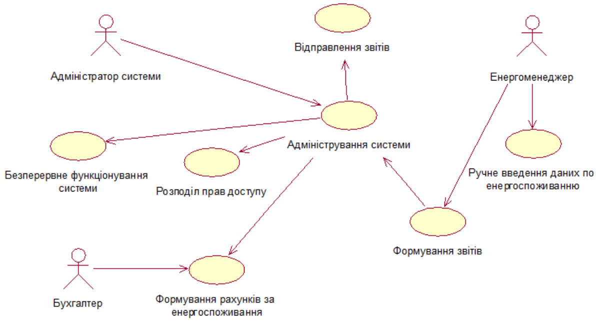

Fig.1. The diagram of precedents

The next step in designing an automated decision support system is to develop a class diagram that will serve in the future for database design and functions linking classes (Fig. 2) and objects automated system. Class diagram is a set of static declarative model elements. These charts can be used both in direct and design at the back. This diagram this is the end result of the design and development process starting point.

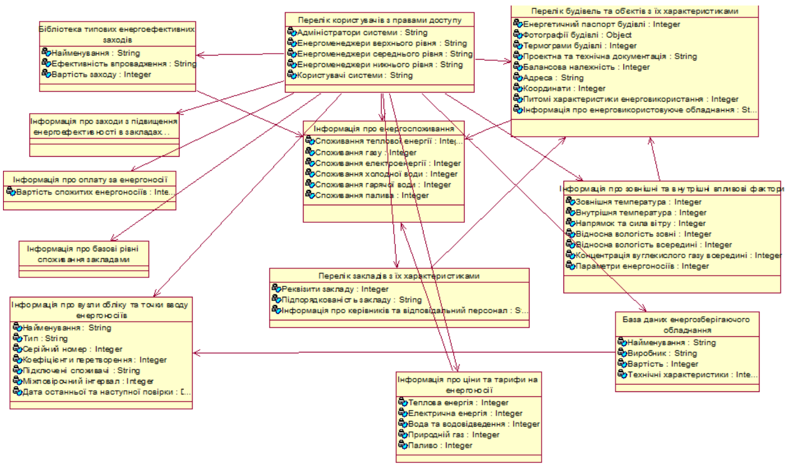

Fig. 2. The diagram of classes

The next step will create cooperatives diagram (Fig. 3). Cooperative charts allow you to spatially locate objects. Unlike sequence diagrams, charts on cooperative instances of objects are displayed as icons. The chart only shows objects that are directly or indirectly involved in the implementation of this use case. As well as the diagram sequence, a line with an arrow on the end means the messages exchanged performed within this use case. Their temporal sequence, however, indicated by numbering messages. Line arrow is made about a line connecting objects and points in the direction of the object to which the message is sent.

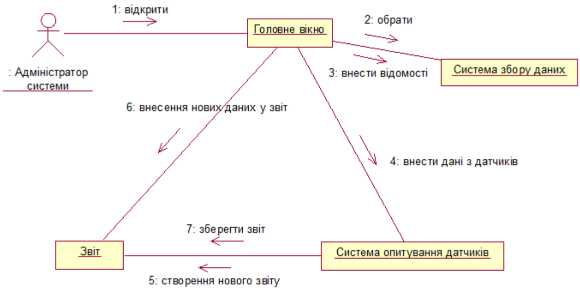

Fig. 3. The diagram of cooperations

Next step is create a diagram of states. In this diagram objects characterized by behavior and state where located. State of the object is determined by the values of some of its attributes and relationships with other objects. Diagram shows how the object moves from one state to another and serves to model the dynamic aspects of the system. Example state diagram shown in Fig. 4.

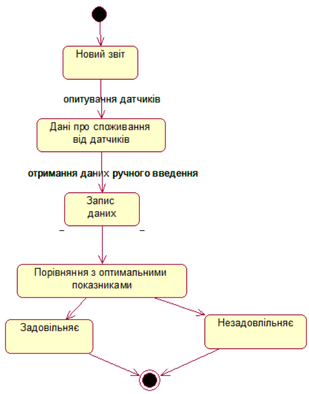

Fig. 4. The diagram of state

Create a chart activity. In this chart shows the decomposition of some of its components. Here, the activity is meant specificity behavior performed in a consistent and coordinated implementation of parallel subordinate elements interconnected streams, which are outputs from one node to the other inputs.

In (Fig. 5) shows a diagram of energy activity.

Energy can be broadly divided into three stages:

1. Preparatory, you provide information about the facility inspected by completing a questionnaire or contacting experts love energy. After agreeing on the cost, timing and scope of work agreement is signed;

2. Direct Energy, begins immediately after signing the contract and characterized by obtaining data on the grids by collecting available information and carrying out instrumental examinations. Further to the analysis of the data developed specific energy efficiency measures;

3. Final: combines the results of the entire survey: Energy passport; energy saving program which includes specific measures for evaluation of their economic efficiency by which you can reduce the cost of fuel and energy resources and, therefore, reduce production costs and increase its competitiveness in the market report of examination and presentation of all its customers.

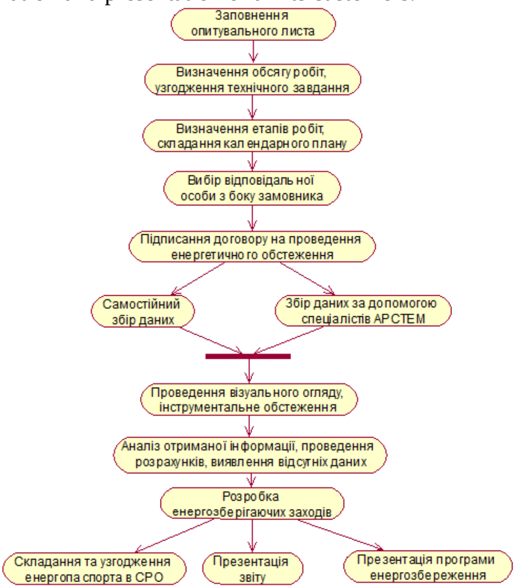

Fig. 5. The diagram of activity

To address energy conservation management should review their cash flow and begin to invest funds in the development and upgrading of production.

Scientific and technological progress reduces the problems that exist in the industry. Modern microprocessor technology allows to analyze the operation of power equipment and networks in real time, analyze and predict energy consumption accordingly. This to them is not clearly regulated by algorithm analysis and decision making for the implementation of the goals and objectives of energy saving in the industry.

The chart shows the activity (Fig. 6) of a systematic approach to process management based on energy conservation monitoring and planning.

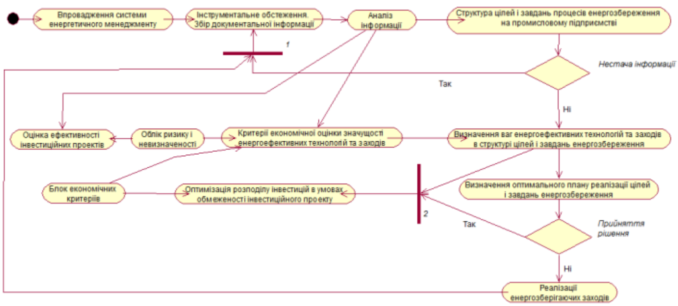

Fig. 6.The detailed diagram of activities (systematic approach to process management based on energy conservation monitoring and planning)

Developed chart covers the basic problem of lack of energy saving and – incorrect analysis of information on energy savings in the industry. And if business is not enough funds to organize energy management system, the solution of these issues must be put on energy enterprises, as now, most companies have only service chief power, which deals mainly with routine operation of a reliable energy economies.

Conclusion. Thus demonstrated a possible approach to modeling energy management information system of the institution, based on the use of Unified Modeling Language (Unified Modeling Language) (UML), and harmoniously combines the benefits of structural and object design methods in CASE Rational Rose. A 7 diagrams (precedents, class, order, cooperatives, state, activity, scan) specifically for a given task - namely, automated information system integrating energy.

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Integrated automated test control systems of aviation equipment

An approach of solving the integrated automated test control systems (IATCS) tasks has been considered. The structure of IATCS, conditions of functioning, composition by the unity matrix, classification according to different criteria have been presented for understanding the system operation. It makes better to increase the level of automation as part of a complex system throughout the life cycle of aviation equipment.

Introduction. Integrated automated test control systems in the aviation industry is a complicated and varied in solving tasks, ergatic scientific and technical complex, designed to provide the maximum possible, in each case, the level of test work automation. The IATCS combines information-measuring and control functions as for test object: aviation equipment (AE) (and for the process – failure safety), and as for its conditions of functioning.

Problem of the research. The purpose of the functioning is a qualitative estimation and a corresponding measurement of its technical condition. It is achieved by using the high-performance computing environment, simulation methods (mathematical, seminatural, physical), methods and facilities of acceptance and performance the automated solutions. The solving of the IATCS tasks provides the staff and the complex tools test automation with the following support: technical, mathematical, program, information, linguistic, organizational and methodical. The IATCS should implement the decision of typical test cycle algorithm. The logic of interaction between the staff and the complex should ensure the performance of the main the test cycle functions.

The IATCS structure has fourteen functional subsystems:

$S_{\bullet 1}$ – the test plan; $S_{\bullet 2}$ – the test preparation; $S_{\bullet 3}$ – simulation of operating conditions; $S_{\bullet 4}$ – measurements parameters of the environment and the object; $S_{\bullet 5}$ – estimation parameters of the environment and the object; $S_{\bullet 6}$ – analysis and comparison estimates with expectations and conditions; $S_{\bullet 7}$ – completion of the test with satisfactory results; $S_{\bullet 8}$ – diagnosis of the object and the equipment; $S_{\bullet 9}$ – formation of corrective solutions; $S_{\bullet 10}$ – performance of corrections; $S_{\bullet 11}$ – registration of required results; $S_{\bullet 12}$ – display of the information; $S_{\bullet 13}$ – documentation of test results; $S_{\bullet 14}$ – control of the test process.

Each functional system $S_{\bullet j}\left(j=\overline{1,14}\right)$ represents the unity of the six types of support: S_{1j} – technical; S_{2j} – mathematical; S_{3j} – program; S_{4j} – information; S_{4j} – linguistic; S_{4j} – organizational and methodical.

Hence, the composition of the IATCS is represented by the unity matrix of interrelations the functional systems (FS) or by the integrity matrix of the complex:

$$S = \begin{Vmatrix} S_{1.1} & S_{1.2} & \dots & S_{1.14} \\ S_{2.1} & S_{2.2} & \dots & S_{2.14} \\ \dots & \dots & \dots & \dots \\ S_{6.1} & S_{6.2} & \dots & S_{6.14} \end{Vmatrix},$$

where at each column corresponds the functional system $S_{\bullet j}$ and at each row – the accounting connection between elements:

$S_j = \| S_{i\bullet 1}, S_{i\bullet 2}, ..., S_{i\bullet 14} \| \quad (i = 1,6)$,that determines the type of support, i. e the support system of the IATCS. The variety of IATCS may be classified according to different criteria. It is used for estimation the quality, scientific and technical level of test automation tools.

IATCS classification. According to solvable tasks – local and group systems (interrelations systems). According to relations with other systems – stand-alone and integrated systems. Stand-alone systems are independent to the higher ranks: computer-aided design (CAD), automated control system (ACS), ACS of the enterprise, ACS of the operation. Integrated systems are the part of subsystems.

Depending on the degree of unification decisions: flexible automated test systems (ATS) with the tools of the task and the object settings on the various techniques and test objects; ATS of certain classes; an unique ATS.

Depending on the level of test automation that estimated the proportion N_{ATP} of tests and the degree of coverage the life cycle stages: low automated $N_{ATP} < 25\%$; middle automated $25\% < N_{ATP} < 50\%$; high automated $N_{ATP} > 50\%$. Highly level of automation is achieved as part of a complex system throughout the life cycle: according to method of visualization the text display; according to performance of the IATCS as the most important criteria of the efficiency the IACS: according to low, middle and high performance; according to on the computer power.

Conclusion. Basic principles of the IATCS is the unity of the system which provided through integrity when creating a synergistic effect (during the operation of the system, it would have properties that cannot be reduced to the sum of the component properties); development; compatibility; standardization and invariance; accumulation of test experience. Global test automation criteria is the principle of a complex test automation at all stages of the life cycle.

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CUDA-based massively parallel computing application for improving the efficiency of turbulent flows modeling and methods of their control

A perspective approach of increasing the computing performance properties of turbulent flows, based on productivity of Graphics Processing Units utilization has presented. It can be effectively applied for development of new principles of adaptive turbulent flow control strategies.

Introduction. Turbulent flow control is the direction of increasing the efficiency and competitiveness of high-speed transport vehicles due to drag reduction and, as a result, fuel consumption decreasing and environment saving. In order to make flow control of the streamlined surface better, the technique of turbulence modeling and improving the computing data performance has been widely used for many years as a tool for the drag reduction of aircraft and has shown its advantages in many aspects [1].

Modern perspective methods of flows modelling with abilities to predict high-resolution features of structure and dynamics of turbulent vortex formation such as Direct Numerical Simulation (DNS) and Large Eddy Simulation (LES) provide integration of equations on a spatial grid with high scaling and with very fine pitch by the time variable. This requires high costs of computational resources and a considerable time, which is necessary in the research and engineering activity. So, in researches [2] with serial and multithreaded LES calculations on the base of Symmetric Multiprocessing (SMP) computer with two quad-core processors the parallel solution of Poisson equation had to use about 45% of the total calculation time. Therefore, it is necessary to find more effective methods of parallelization than SMP technology based on computational scaling of solving problem by existing number of Central Processing Units (CPU) or their cores. One of the perspective ways is a translating the most resource demanding elements of solving computational problem to the Compute Unified Device Architecture (CUDA) technology algorithms with further scaling of achieved growth by use in the computations much more powerful Graphics Processing Units (GPU) in comparison with CPU productivity.

The goal of this research is to analyse the perspective ways of improving the efficiency of scaling the process of parallel calculations in turbulent flows modeling on CUDA based graphics accelerators.

Turbulence modeling in general is the meaning to calculate the so-called eddy viscosity; and is taken into account in the viscous flow in the system of the Navier-Stokes equations:

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x_i}(\rho u_i)=0$$

$$\frac{\partial}{\partial t}(\rho u_i)+\frac{\partial}{\partial x_j}(\rho u_i u_j)=-\frac{\partial p}{\partial x_i}+\frac{\partial}{\partial x_j}\left[\mu\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)-\bar{p}\delta_{ij}\right]+\frac{\partial}{\partial x_j}\left(-\rho\overline{u_i' u_j'}\right)$$

(1.1)

The left side of second equation (transient member) describes the change of the of chosen liquid volume momentum due to the change in time as averaging velocity component. This change is compensated in the right part by averaging external forces $\frac{\partial p}{\partial x_i}$, by averaging pressure forces $\bar{p}\delta_{ij}$, viscous forces $\mu\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)$ and turbulent stresses $\left(-\rho\overline{u_i' u_j'}\right)$ taking into account the additional losses and redistribution of energy in turbulent flow.

The method of turbulence modeling with LES for Navier-Stokes equations has following steps:

Filtering procedure: the separation of the vortices in the "large" (more than certain size) and "small":

$$\overline{w}(x)=\int_D w(x')\varphi(x,x')dx' \tag{1.2}$$

where D is the fluid domain, and φ is the filter function that determines the scale of the resolved eddies;

Filtered equations: the construction of such a system of equations, whereby large vortices are resolved accurately (the dependent variable are now filtered quantities rather than mean quantities, and the expressions for the turbulent stresses differ);

Subgrid-scale model: description of "small" vortices and their interaction with large ones that are modelled directly.

Boundary conditions: on the sides of computational area, perpendicular to the longitudinal X-axis, the periodic boundary conditions are traditionally used. It allows to research the three-dimensional effects, which is caused by the internal flow instability.

The construction of the parallel algorithm, as the basic computer operation, is a calculation of the velocity gradients in cells on three spatial directions. It is necessary for both algebraic and differential models of turbulence. In the case of a vertex-centered scheme usage for this calculation node surgery gradients computed at each node by summing the gradients on all grid elements containing the node ([1,3], where the same operation is used for reconstruction of a high-order). The element-centered case for the calculation of gradient applies the method of least squares on the adjacent cells (coefficients computed during the initialization phase when you start).

Computing power performance. Testing the computing performance of turbulence modeling has been made with paralleling technologies: OpenMP and CUDA [2,4]. The first one (OpenMP) focused at multi-threaded programming and is effective in multiprocessor or multicore systems. The second approach – CUDA is effective for computing performance increasing due to the use of GPU.

For making the analysis of the features of CUDA paralleling technologies four video cards GeForce GTX 680 with 2 GB video memory of GDDR5 have been used, which installed in a system based on six-core CPU Intel I7-3960x with 16 GB RAM DDR3-1600. Each of GPU software (based on OpenMP technology) treated by the corresponding CPU thread, allowing to process independently each of all grid subdomains by separate GPU on every iteration [4].

The results of acceleration scaling calculations [4,5] demonstrate improved efficiency computing on a system with multiple GPU with increasing dimension of the solved problem (fig. 1.1.). Even in case when number of grid nodes in one direction M is great ($M \geq 400$) and the number of GPU doesn't exceed 3, dependence is so close to linear form, but if we realize computations on the base of the 4-GPU computing system the growth of acceleration is slowing down due to increasing the transmitted information between GPU.

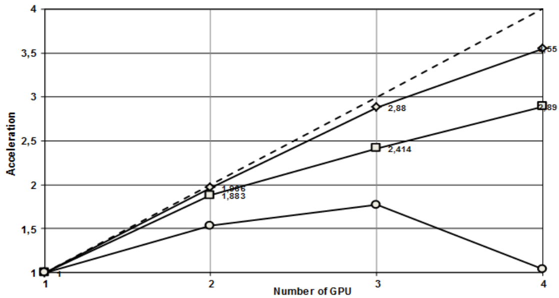

Fig. 1.1. Dependence the acceleration computing of number of GPU
○ – $M = 100$; □ – $M = 200$; ◊ – $M = 400$; Δ – $M = 500$.

The effect of scaling computation acceleration on the CPU depending on the number of involved cores (fig. 1.2) has principally different dynamics. Thus, the results show weak dependence on the arrays dimension M^3, all dependencies merged. In addition, these dependencies demonstrate closeness to linearity versus number of all used processor cores.

It can be conclude that a well optimized for long periods of multithreaded computing CPU-based technology in all the considered range of values has demonstrated better scaling acceleration computation compared to a system with multiple GPU. However, if you recalculate the results in absolute figures runtime tasks, priority GPU at $M = 400$ becomes 4.76 times.

Conclusion. The efficiency of scaling the parallel process of the most demanding structural elements of LES calculations in turbulent flows modeling on graphics accelerators by using CUDA computational technology has been investigated and analyzed.

The method of turbulence modeling with LES for Navier-Stokes equations has been considered. It helps to better understand the creation of parallel algorithm to solve governing equations of turbulence by using modern techniques of turbulent flow non-stationary processes analysis.

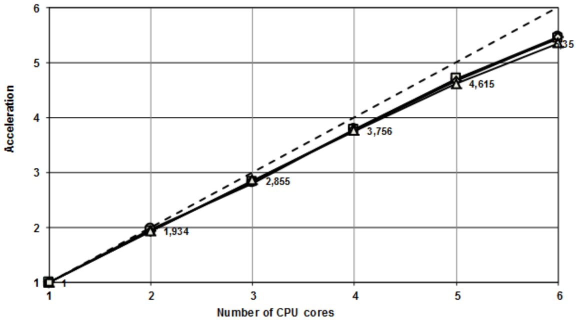

Fig. 1.2. Dependence the acceleration computing of number of CPU cores
○ – $M = 100$; □ – $M = 200$; ◊ – $M = 400$; Δ – $M = 500$.

The results of acceleration of scaling computations had been obtained, that show the priority of GPU versus CPU for computing performance of turbulent modeling. Development of technology for turbulent flow computing predictions on with graphics accelerators – a powerful perspective to ensure effective simulation of turbulent flows and perspective methods of their control. In particular, the technology NVIDIA CUDA in the Jetson implementation, based on NVIDIA Tegra, can be effectively used as a part of control systems with distributed in a certain section of the streamlined surface sensitive and actuators.

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Multi-alternativeness of aircraft airworthiness support modern technologies

In this report we discuss some usage of subjective entropy paradigm as a tool to elaborate proper, in a certain respect, criteria for aircraft flight safety management. The human factor influence is modeled for the system of aircraft operation on the basis of multi-alternativeness of airworthiness support technologies related to aircraft maintenance. Numerical simulation is illustrated with plotted diagrams.

There is a multi-alternativeness of a choice between modern technologies of aircraft airworthiness support and between modern and “old”/”obsolete” kinds of those technologies. Thus, there is a competition between them. Therefore there arises a problem of a decision making when choosing an appropriate technology or technologies of aircraft airworthiness support either amongst modern or “old” ones at their own levels separately or in a mixed combination of those. As a consequence, the problem becomes a problem of optimization on the multi-alternative basis.

There must be some more or less perfect criterion for such important choice as technologies of aircraft airworthiness support because flight safety greatly depends upon that element of the notorious human factor.

Available sources of corresponding information, mass media propagated data, like [1, 2] prove this important dependence by the kind of the fabulous publications about aviation incidents and accidences that happen in airline industry from time to time. That is why with the purpose of prevention and avoiding them the International Civil Aviation Organization (ICAO) has successfully developed and approved the related international Standards and Recommended Practices (SARPs) which are the Annexes to the fundamental in civil aviation the so-called Chicago Convention.

Nevertheless even having done with the latest Annex 19: “Safety Management” (Since 14 November 2013), still, this newest SARP amended to the Chicago Convention by ICAO, up until now, needs corresponding suitable criteria and models for the interrelationships between flight safety and aircraft airworthiness support technologies parameters.

The theory of subjective analysis having been consequentially developed in the series of monographs [3-8] and being used in many practical applications like [9-12] at present is a good tool for some qualitative and quantitative level models of evaluation, forecast, and description of human activity in active systems. Such type of problem-resource approach considers a person responsible for making a decision in a complex technical-social system (aircraft airworthiness support modern versus “old”/”obsolete” technologies plus flight safety problems) to be an active element of therefore active system.

Applicably to aircraft airworthiness support technologies with respect to flight safety a generalized problem setting might be represented in the view of a two parameter model. Namely, expectation of airline losses $E[R]$ for some time of an aircraft operation t_k depending upon the aircraft maintenance quality, related to the aircraft airworthiness support technology, measured with its cost rate V_s and the aircraft airworthiness support technology parameter measured with the quality coefficient of the maintenance expenses use effectiveness α [9-12]:

$$E[R]=\left(\frac{C+V_s}{\lambda(\alpha,V_s)}+\Delta r\right)\left(1-e^{-\lambda(\alpha,V_s)t_k}\right)=E(\alpha,V_s), \qquad (1)$$

where: C – rate of taxation payment and other operational expenditures; $\lambda(\alpha,V_s)$ – failure rate:

$$\lambda(\alpha,V_s)=\lambda_{\min}+\frac{\lambda_0-\lambda_{\min}}{1+\alpha V_s}, \qquad (2)$$

where: $\lambda_{\min}$ – minimal achievable for the accepted aircraft airworthiness support technology level of failure rate; λ_0 – failure rate without the specialized accepted aircraft airworthiness support technology application;
Δr – cost of unexpected onetime operational risk, i.e. losses due to possible aircrash.

Model (1), (2) is a simplified and rough one and it implies α coefficient to be pertaining to each of the alternative aircraft airworthiness support technologies which considered being a set of the separate or discrete alternatives. On the other hand the cost rate parameter V_s of the aircraft maintenance quality is reckoned to be a continuous value alternative in each of those discrete alternatives.

Using the subjective entropy maximum principle (SEMP) of the subjective analysis theory we get the so-called canonical distributions of individual preferences $\pi(V_s)$ for each of the technologies and corresponding maintenances rates in the view of preferences functions distributions densities:

$$\pi(V_s)=\frac{\exp[-\beta E(V_s)]}{\int\limits_0^{100}\exp[-\beta E(V_s)]dV_s}, \qquad (3)$$

where: β – endogenous parameter of the system active element's psych reflecting the person's cognitive attitude to the considered reachable alternatives; $[0\ldots100]$ – possible range of V_s variation.

Numerical modeling with the data: $\alpha\in[0\ldots1]$; $\lambda_0=1\cdot10^{-4}$; $\lambda_{\min}=1\cdot10^{-5}$; $C=1\cdot10^2$; $t_k=1\cdot10^2$; $\Delta r=1\cdot10^6$; $\beta=3\cdot10^{-3}$ shows the sought optimal values represented in the diagrams of fig. 1.

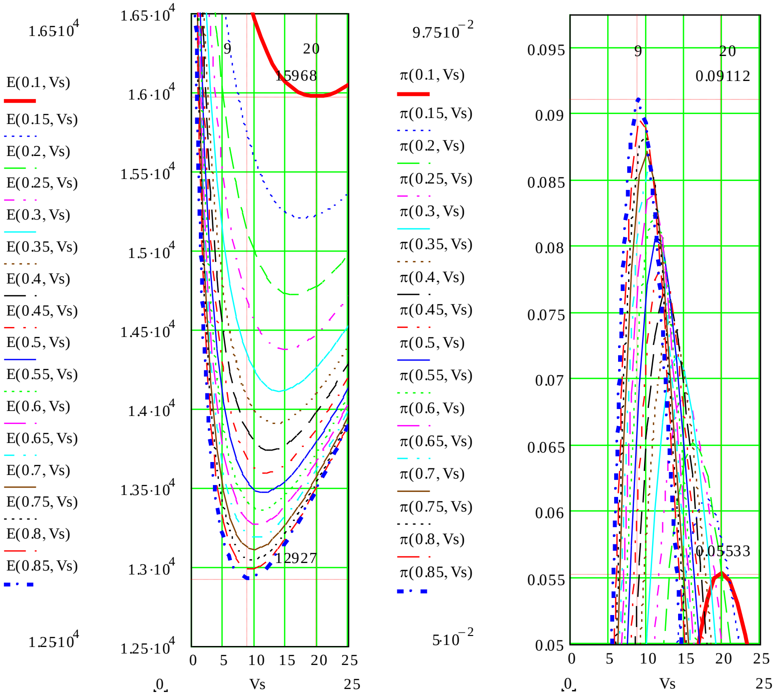

Fig. 1. Objective effectiveness *a)* and subjective preferences *b)* functions values

The preferences distributions densities (3) are obtained as an optimal solution for the postulated with SEMP functional:

$$\Phi_\pi = \int_0^{100} \left[-\pi(\bullet)\ln\pi(\bullet) - \beta\pi(\bullet)E(\bullet)\right]dV_s +$$

$$+\gamma\left[\int_0^{100}\pi(\bullet)dV_s - 1\right] - \ln\Delta V_s, \tag{4}$$

where: γ – one more structural parameter of the active element's psych (endogenous parameter analog to β and uncertain Lagrange multiplier for the normalizing condition $\int_0^{100}\pi(\bullet)dV_s - 1$ respectively to its individual perception);

ΔV_s – degree of accuracy at the subjective entropy of the preferences (the first underintegral member) determination.

Thus, the extremal in the view of (3) yields the conditional maximum to the subjective entropy of individual preferences and simultaneously it is the conditional, upon a certain technology discrete alternative value of α, preferences distribution density, for the continuous alternative value of V_s, obtained on the basis of SEMP postulated operational purpose functional (4). The optimal values of the aircraft airworthiness support technologies intensity V_s coincide for the corresponding values of the maximal preferences densities $\pi(V_s)$: $\pi(\alpha = 0.85, V_s = 9) = 0.09112$; $\pi(\alpha = 0.1, V_s = 20) = 0.05533$ and minimal expectations of the purpose functions, i.e. objectively existing operational effectiveness functions $E(V_s)$: $E(\alpha = 0.85, V_s = 9) = 12927$; $E(\alpha = 0.1, V_s = 20) = 15968$ (see the marked coordinates crossings in the diagrams plotted in fig. 1).

Conclusions

In view of the considered problem setting involving SEMP the recommended criteria can be applied as some certain flight safety management purpose assessment parameters required by ICAO to evaluate or compare qualitatively and quantitatively the necessity and expediency of the considered aircraft airworthiness support technologies usage, of modern or/and "obsolete" types, periodically amended by ICAO to the Chicago Convention with corresponding SARPs. The substantiation of such approach is proven on the basis of the postulated concept and made assumptions.

The results of the executed calculation experiments stipulate further development of the theory with the help of the subjective entropy of individual preferences paradigm.

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UDC 629.735.083.02/.03.004.58 (075.8)

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Distinguishing minimal engineering diagnosis risks via preferences functions

In this report we discuss some usage of subjective entropy paradigm as a tool to elaborate proper, in a certain respect, criteria for estimating an optimal decision making threshold in problems of engineering diagnosis risks with the help of preferences functions distributions densities for the corresponding continuous alternative values. Numerical simulation is illustrated with plotted diagrams.

In problems of engineering diagnostics dichotomy, like in described in works [1, 2], there arises a situation when in methods of statistical decisions making a decisive rule is chosen following some optimal conditions. One such of these very important conditions of optimality is a condition of a minimal expectation of a wrong decision risk [1, 2].

Thus, we encounter a problem of an optimal decision making threshold, with respect to a certain characteristics related with corresponding factors influencing two hypothetically considered diagnoses, assigning. Solution of such problem implies taking into account a system of preferences of the decision making person acting in conditions of uncertainty [2].

The theory of subjective analysis developed in monographs [3-8] proposes a convenient tool for taking subjective preferences into account explicitly. This allows finding explainable subjectively optimal decisions which do not contradict or disturb and distort objectively existing optimums [9-12]. On the contrary, it makes the objectively optimal values be subjectively comparable with the help of the individual preferences in a relative and normalized way. The core of the theory is a concept of the subjective entropy maximum principle (SEMP) which reflects optimality at the process of a decision making in conditions of uncertainty of individual preferences in relation with and distributed upon a set of achievable alternatives. The latest researches deal with and cover the ideas of discrete and continuous alternatives [10-12].

The presented report is dedicated to distinguishing minimal engineering diagnosis risks via the preferences functions. The point is that there might be a situation when the optimal risk area is of a flat shape (at such circumstances it is hard to say which value has to be chosen as the decision making threshold).

In general case the expectation of the risk R (the mean risk) is [1, 2]:

$$R = C_{11} P_1 \int_{-\infty}^{x_0} f\left(x \middle| D_1\right) dx + C_{21} P_1 \int_{x_0}^{\infty} f\left(x \middle| D_1\right) dx +$$

$$+ C_{12} P_2 \int_{-\infty}^{x_0} f\left(x \middle| D_2\right) dx + C_{22} P_2 \int_{x_0}^{\infty} f\left(x \middle| D_2\right) dx, \qquad (1)$$

where: C_{ij} – "prices" of decisions H_{ij} , $(i,\ j=1,2)$ (the first subscript designates the accepted diagnosis, the second – indicates the real state), made with the rule [1]:

at $x < x_0 \quad x \in D_1$, at $x > x_0 \quad x \in D_2$, (2)

where: x – parameter for making the decision; x_0 – value of the threshold for making the decision; D_1 – class of the up state; D_2 – class of the down state; $P_1 = P(D_1)$, $P_2 = P(D_2)$ – priory probabilities of diagnoses D_1 and D_2 correspondingly (deemed to be known on the basis of the preliminary obtained statistical data); $f(x|D_1)$, $f(x|D_2)$ – statistical conditional distribution densities of parameter x depending upon corresponding factors related with the diagnoses [1, 2].

The minimal average risk method for (1), (2) involves first and second order conditions [1, 2]:

$$\frac{f(x_0|D_1)}{f(x_0|D_2)} = \frac{(C_{12}-C_{22})P_2}{(C_{21}-C_{11})P_1}, \qquad \frac{f'(x_0|D_1)}{f'(x_0|D_2)} < \frac{(C_{12}-C_{22})P_2}{(C_{21}-C_{11})P_1}. \tag{3}$$

If distributions $f(x|D_1)$ and $f(x|D_2)$ are one-modal, then, at

$$\bar{x}_1 < x_0 < \bar{x}_2, \tag{4}$$

where: $\bar{x}_1$, $\bar{x}_2$ – mean values of the corresponding density distributions, the conditions of (3) are actually realized.

However, as that was described above, the relatively flat segment at the extreme point makes it indistinct to decide which value x_0 should be chosen as the threshold.

Let us illustrate these speculations with the mathematical modeling. Supposing relations for densities

$$f(x|D_1) = \frac{\exp[-ky_1(x)]}{F_1}, \qquad f(x|D_2) = \frac{\exp[-ky_2(x)]}{F_2}, \tag{5}$$

where: k – coefficient; $y_1(x)$, $y_2(x)$ – functions modeling corresponding factors influences; F_1 , F_2 – corresponding normalizing constants:

$$F_1 = \int_A^B \exp[-ky_1(x)]dx, \qquad F_2 = \int_A^B \exp[-ky_2(x)]dx, \tag{6}$$

where: A , B – range of variable x change.

Models for $y_1(x)$, $y_2(x)$ functions from densities (5) are assumed to be

$$y_1(x) = x^2 - 40x, \qquad y_2(x) = x^2 - 140x. \tag{7}$$

Accepted calculation data are $A = 0$, $B = 100$, $k = 0.03$, $P_1 = 0.7$, $P_2 = 0.3$, $C_{11} = -10$, $C_{22} = -100$, $C_{21} = 10$, $C_{12} = 1000$.

The average risk calculated by the expectation method (1) is graphically illustrated in fig. 1.

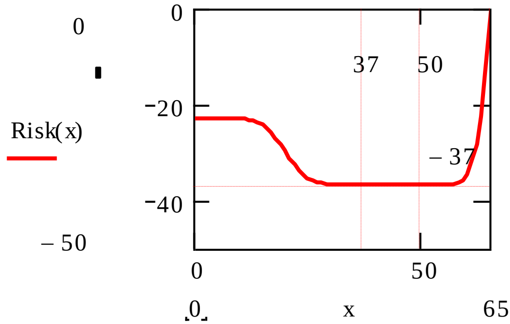

Fig. 1. Expectation of the risk

From fig. 1 it is visible that in the diapason of $[37...50]$ it is quite difficult to chose the threshold value x_0. More or less precise value of that can be found with the use of the first condition of (3). Nevertheless, it is still unclear how much the sought value is more or less preferable than the other indistinguishably close to that one.

To solve this problem we propose to apply SEMP [3-12]. Expressions for preferences distribution densities are

$$\pi(x_0) = \frac{\exp[-\beta R(x_0)]}{C}, \tag{8}$$

where: β – endogenous parameter of the decision making system active element's psych reflecting the person's cognitive attitude to the considered reachable alternative values of the threshold x_0 and the risk as its function $R(x_0)$; C – corresponding normalizing constant:

$$C = \int_A^B \exp[-\beta R(x)]dx. \tag{9}$$

In the presented problem setting in equations (8), (9) $\beta > 0$ and the sign "minus" is used before it since the minimal values of the expected losses are to found.

With the cognitive parameter values $\beta = 0.03;\ 0.3;\ 3;\ 19$ and other data used above, the results of simulation for preferences densities in the procedure covered with expressions (1)-(9) are represented in fig. 2.

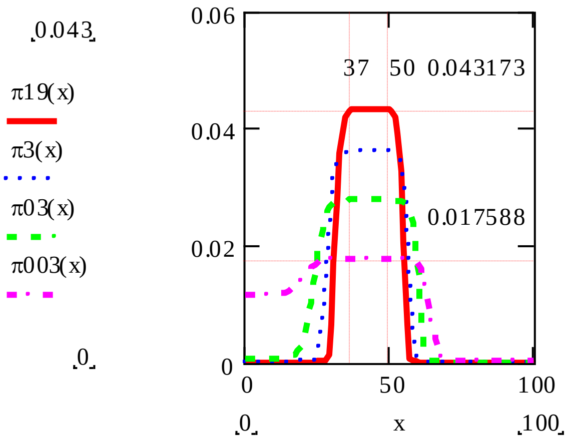

Fig. 2. Preferences densities

From the diagrams plotted in fig. 2 it is visible that increasing the parameter of the density distributions β it makes, at the same time, the preferences density, obtained with the help of SEMP, of a sharper type. Therefore, the flat region or segment of indistinctness (fuzziness) gets narrower in the variable range of $[37 \ldots 50]$. Hence, the optimal threshold decision becomes clearer and more explainable. Moreover, this required and subjectively assessed decision converges to the objectively found solution $x_0 \approx 43.947$ yielded from conditions (3).

Conclusions

In view of the considered problem setting involving SEMP the recommended approach can be applied as some certain aid to evaluate or compare qualitatively and quantitatively the necessity and expediency of the optimal decision making threshold assigning, made with respect to a certain characteristics treated as a continuous alternative value related with corresponding factors influencing two hypothetically considered diagnoses.

The results of the executed calculation experiments stipulate further development of the theory with the help of the subjective entropy of individual preferences paradigm.

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Modeling aviation legislation influence upon airworthiness support technologies via preferences functions

In this report we discuss some usage of subjective entropy paradigm as a tool to elaborate proper, in a certain respect, criteria for estimating an optimal aviation legislation evolution process purposed upon airworthiness support technologies development in corresponding multi-alternative situations. Necessary numerical simulation is illustrated with plotted diagrams.

In problems of airworthiness norms and their legislative fastening, like in prescribed in documents of the International Civil Aviation Organization (ICAO) or described in paper [1], there arises a situation when in interrelationships between airworthiness and its fixed norms there is some kind of inter-influence between evolution of technologies of airworthiness support and corresponding normative developed and accepted or approved by ICAO. The process of this progression has some attributes of a cyclic nature, that is, at a certain period and circumstances the airworthiness support technologies stipulate the development and acceptance of the related international Standards and Recommended Practices (SARPs) which are the Annexes to the fundamental in civil aviation the so-called Chicago Convention, however the SARPs in turn stimulate further development of the technologies themselves and it makes the next curve of a spiral advancement.

Such procedures have to be rational with respect to some criteria; therefore corresponding optimums need to be found.

Let us consider the problem at the angle of quantity into quality transition. Assume that there is some kind of a consumptive resource (described mathematically as an independent variable) utilized for aircraft airworthiness support (the airworthiness level is characterized with a discrete alternative value) and characterizing a scalar continuous parameter (a function of that variable). For the model discussed in this report we suppose them (the variable and the function) to be connected with the discrete alternatives (the airworthiness levels) by differential effectiveness functions. Corresponding integral functions represent the discrete alternatives airworthiness support technologies legislative effectiveness functions.

Preferableness of the alternatives, the subjective preferences uncertainties degrees, directions of the preferences certainties with respect to specified by individuals' preferences of available and achievable or attainable alternatives, conflictions situations are modeled in terms of subjective entropy maximum principle (SEMP) of subjective analysis [1-11].

Let the scalar continuous functions for two desired separate levels of airworthiness are described with the model expressions

$$y_1(x) = -x^2 + 40x, \qquad y_2(x) = x^2 - 120x, \tag{1}$$

where: x – resource of a corresponding sort.

The differential effectiveness functions supposedly represented with the equations of

$$f_1(x)=\frac{\exp[ky_1(x)]}{F_1}, \qquad f_2(x)=\frac{\exp[-ky_2(x)]}{F_2}, \tag{2}$$

where: k – coefficient; F_1, F_2 – corresponding normalizing constants:

$$F_1=\int_A^B \exp[ky_1(x)]dx, \qquad F_2=\int_A^B \exp[-ky_2(x)]dx, \tag{3}$$

where: A, B – range of variable x change.

The corresponding integral functions are

$$Int_1(x)=2\int_A^x f_1(x)dx, \qquad Int_2(x)=3\int_A^x f_2(x)dx, \tag{4}$$

The preferences functions, obtained with the help of SEMP [2-7], are

$$\pi_1(x)=\frac{e^{\beta Int_1(x)}}{e^{\beta Int_1(x)}+e^{\beta Int_2(x)}}, \qquad \pi_2(x)=\frac{e^{\beta Int_2(x)}}{e^{\beta Int_1(x)}+e^{\beta Int_2(x)}}, \tag{5}$$

where: β – endogenous parameter of the legislative decision making system active element's psych reflecting the person's cognitive attitude to the considered reachable alternative values.

The subjective preferences uncertainties degrees, directions of the preferences certainties are proposed to be measured with the relative entropy hybrid function [8]:

$$Hr(x)=\frac{\ln 2-H(x)}{\ln 2}\frac{\pi_1(x)-\pi_2(x)}{|\pi_1(x)-\pi_2(x)|}, \tag{6}$$

where: $\ln 2$ – maximal value (in case of the two distinct alternatives) of the individual's preferences subjective entropy $H(x)$ [2-7]:

$$H(x)=-[\pi_1(x)\ln\pi_1(x)+\pi_2(x)\ln\pi_2(x)]. \tag{7}$$

Accepted calculation data are $A=0$, $B=100$, $k=0.03$, $\beta=0.03;\ 0.07$. Results of simulation with the procedures of the expressions of (1)-(7) are shown in fig. 1-4.

Indications in fig. 1 are as follows: $\mathrm{Int1(x)}$ for $Int_1(x)$; $\mathrm{Int2(x)}$ – $Int_2(x)$. In fig. 2: $\mathrm{PtInt103(x)}$ – $\pi_1(x)|_{\beta=0.07}$; $\mathrm{PtInt203(x)}$ – $\pi_2(x)|_{\beta=0.07}$; $\mathrm{PtInt1003(x)}$ – $\pi_1(x)|_{\beta=0.03}$; $\mathrm{PtInt2003(x)}$ – $\pi_2(x)|_{\beta=0.03}$.

Such models are applicable in economics planning, military-political doctrine creation, educational situations and their development. Conflictions can be modeled at every stage of the approach (1)-(7) as contradictions of the corresponding values.

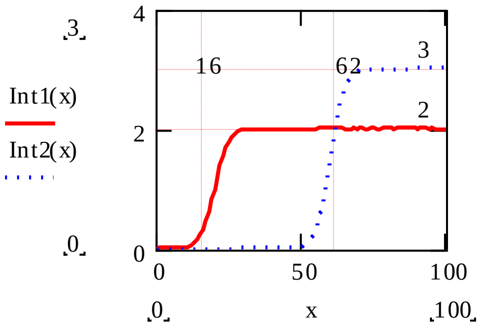

Fig. 1. Integral functions representing the discrete alternatives airworthiness support technologies legislative effectiveness

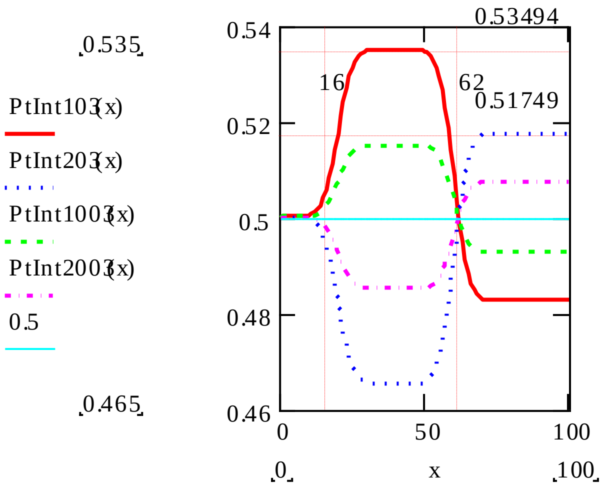

Fig. 2. Preferences of the alternatives

Indications in fig. 3: $\mathrm{H003(x)}$ – $H(x)|_{\beta=0.03}$; $\mathrm{H03(x)}$ – $H(x)|_{\beta=0.07}$. In fig. 4: $\mathrm{Hr003(x)}$ – $Hr(x)|_{\beta=0.03}$; $\mathrm{Hr03(x)}$ – $Hr(x)|_{\beta=0.07}$. Traditional entropy (7) does not show what alternative the active element of the aviation legislative system prefers (see fig. 3). Unlike its hybrid function (6) (compare fig. 3 and 4).

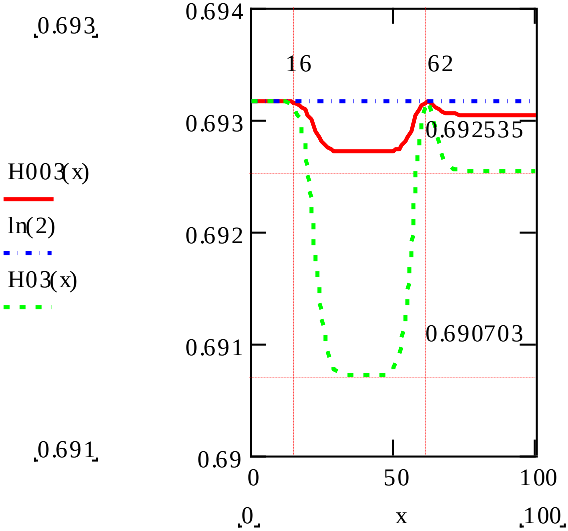

Fig. 3. Entropies of the preferences

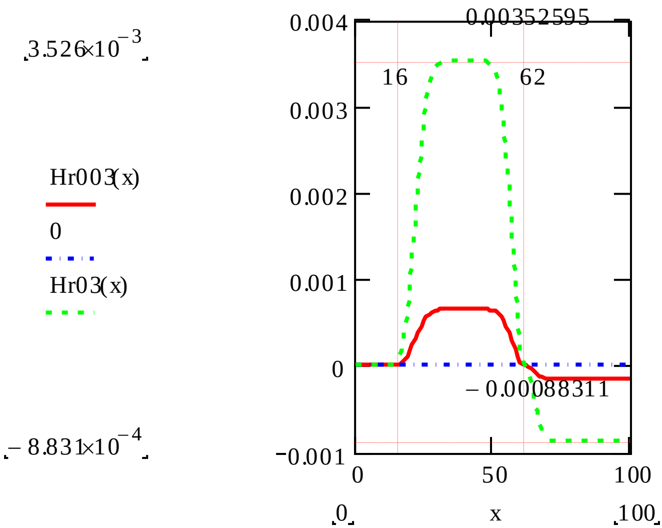

Fig. 4. Relative entropy hybrid functions

Conclusions

In view of the considered problem setting involving SEMP the recommended approach can be applied as some certain aid to evaluate or compare qualitatively and quantitatively the necessity and expediency of the airworthiness support technologies legislative approval on the multi-alternative basis. The results of the executed calculation experiments stipulate further development of the theory with the help of the subjective entropy of individual preferences paradigm.

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AFM study of microstructure role in the fatigue of martensitic steel

The paper presents the description of FSMs (fatigue slip markings) and the evaluation of cyclic plasticity markings of a 12%Cr martensitic steel by AFM surface analyses. The primary FSMs, appeared in the first fatigue cycle, are likely to be localized at the packet and block boundaries, while the secondary one (appeared later at 44% of lifetime) are at the lath boundaries or in the laths.

Introduction. The hierarchical microstructure is a unique feature of martensitic steels leading to their high strength. The complex martensitic microstructure is represented by four elements, the dimensions of which are in the Fig. 1 [1].

Element	Size [µm]	Disorientation angle
Grain	10-60	HAB (high angle boundary) >15°
Packet	4-24	HAB
Block	0.7-4	HAB
Lath	<1	L (low) AB <3°

Fig. 1. Material microstructure features

But the precise role of the different interfaces representing those different hierarchy elements of martensitic steel in its cyclic plasticity is not well studied. So the objective of the research is to better understand the different interfaces impact on the cyclic deformation localization of a 12%Cr martensitic steel. The experimental studies on the morphology of FSMs and calculation of the surface plasticity by measuring the FSMs height evolution may allow us achieving this objective. This should help in the future to understand better the mechanism of cyclic plasticity.

Material and Experiment. The material, 12%Cr (X19CrMoNbVN11-1) steel, has been studied in the as-received condition: quenching in air after 1 hour solution treatment at 1110°C and then tempering 4 hours at 680°C at the production plant. A low cycle fatigue (LCF) interrupted test and a rupture test were performed under total strain control $\Delta\varepsilon_t$=1.2% on the mechanically polished flat specimens at room temperature and in air. The triangular signal at strain rate $4\cdot10^{-3}$ s^{-1} and strain ratio R_ε=-1 was imposed. The interruptions were performed at ½ cycle, 100 cycles, 500 cycles and 1130 cycles (end of lifetime) for surface relief analysis by AFM. Ten permanent zones were observed after each interruption (each zone area was 80*80 μm^2). It should be noted that the surface roughness measured by AFM of freshly polished specimens was on average 2 nm.

Results. The AFM topographic analysis showed that after the interruption at ½ cycle the FSM profiles represent the local surface level fall or rise resembling stair steps (Fig. 2a). The heights of those *steps* do not exceed 10 nm. After the interruption at 100 cycles it was noticed that all the observed steps developed into *extrusions* (usually higher than 10 nm) (Fig. 2b). These extrusions were defined as the *primary* extrusions. So, these primary extrusions and steps can be grouped as the primary FSMs. They are rather long and high and their length and the distance between two parallel extrusions are equivalent mainly to the sizes of packets; however their width is rather equivalent to the width of one average lath. With the increase of number of cycles the height along one extrusion fluctuates importantly. The primary extrusions observed on the investigated material are not continuous and represent a broken line. The ends of primary extrusions seem to be just little prolonged after 100 and 500 cycles. And those prolongations of extrusions from both sides are not high (rarely exceed 10 nm). These observations are consistent with [2, 3].

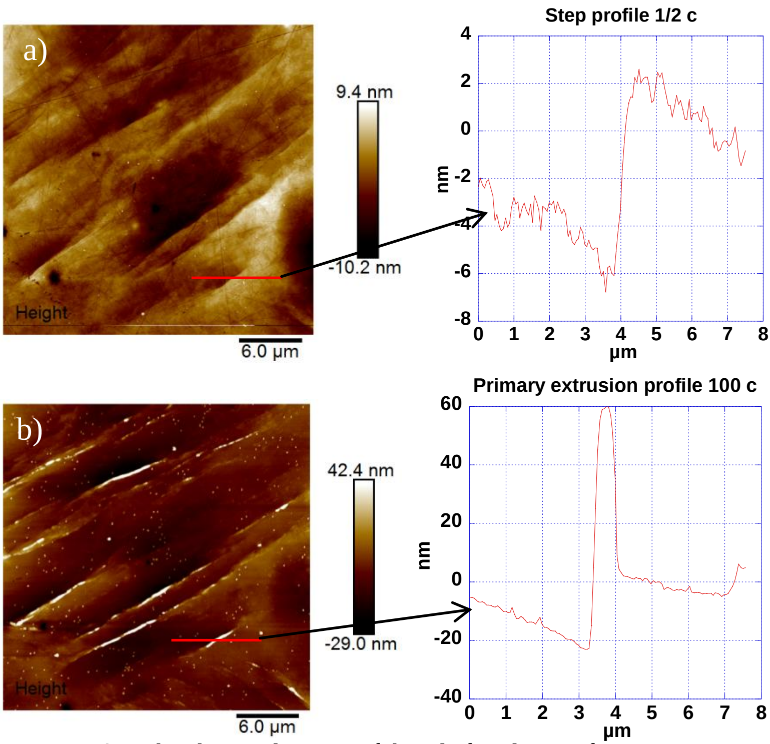

Fig. 2. AFM height signal images of the relief evolution of a same zone at different interruptions and correspondent profiles: a) ½ cycle; b) 100 cycles. The loading axis is vertical

The different works [4, 5, 6] were used in order to classify the observed primary extrusions according to their shape on the AFM images. A primary extrusion is usually long (order of packet size) and the higher magnification observations allow distinguishing the different types: band-like, cord-like, tongue-like, ribbon-like, and protrusion (Fig. 3, 4). Band-like extrusions (Fig. 3) are compact and their height is more or less uniform along the FSM. Cord-like extrusion (Fig. 4a) has a surface which is considerably rugged and folded and thus the height of extrusions along the FSM varies markedly. Tongue-like extrusion height periodically decreases and increases along the length up to zero or up to a negative value; i.e. they alternate with intrusions so that tongues of extruded material appear quasi-periodically along a FSM. Ribbon-like extrusions are often accompanied by one or two parallel intrusions running at the intersection of slip band with surface. Their height can fluctuate. Protrusion (Fig. 4b) represents a few superimposed individual extrusions and intrusions.

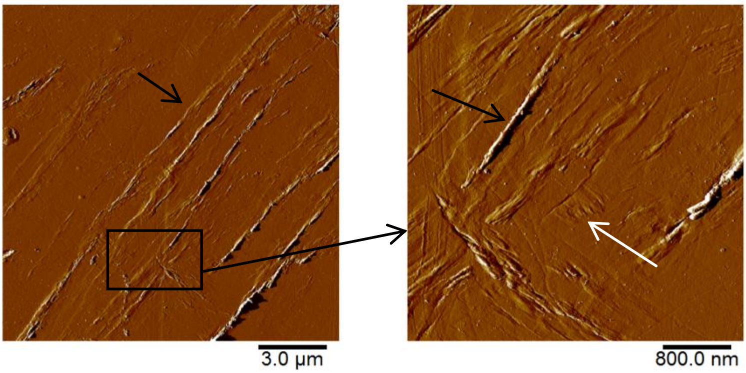

Fig. 3. AFM signal error images of band-like (black arrow) and set of parallel secondary extrusions (white arrow) at 1130 cycles. The loading axis is vertical

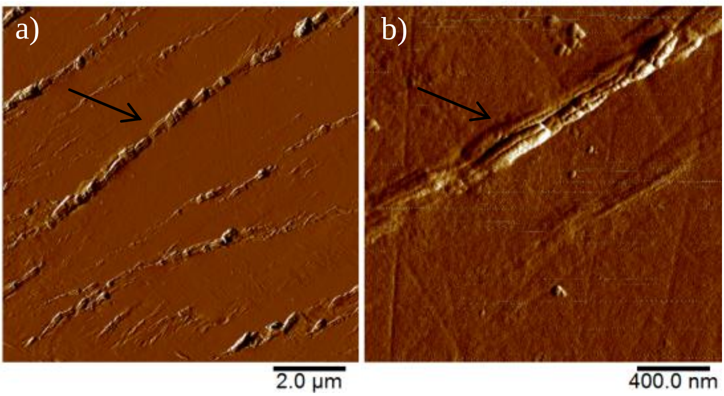

Fig. 4. AFM signal error images of different types of extrusions: a) cord-like, 100 cycles; b) protrusion, 500 cycles. The loading axis is vertical

Others, the secondary extrusions, appeared later (at 500 cycles) than the primary ones. They are low-height and short compared to the primary ones. It seems that the secondary extrusions accompany the primary one (Fig. 3b). They may be grouped in a set of many parallel secondary extrusions (area of fine roughness), in this case they more often are perpendicular to the primary extrusion. It seems that the primary extrusion restricts them from further growth over or through this primary extrusion. Also there is a secondary individual extrusion; it is usually parallel to a primary extrusion. The number of secondary extrusions increases with number of cycles of loading but the height increases as well.

It is supposed that the secondary extrusions having the dimensions equivalent to laths appear at the lath boundaries or in the laths, while the primary extrusions are likely to appear at the packet or sometimes block boundaries. Partially the same phenomena were observed by [3, 7].

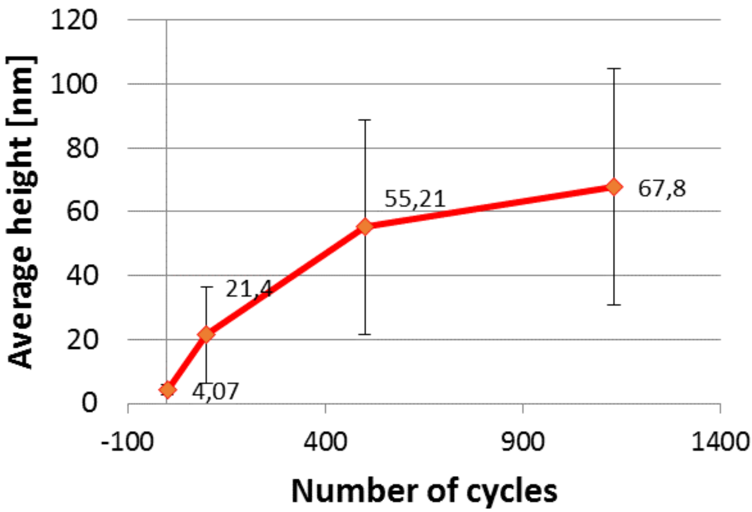

Fig. 5 . Evolution of primary FSMs average height with an increase of number of cycles

Height estimation. The average height of primary extrusions grew approximately from 4 nm at the first interruption to 68 nm at the end of life (Fig. 5). The average deviation of measured values from an average value is very high at the last interruption. The reason for it is that the primary extrusions have prolonged in their length too with an increase of number of loading cycles; also the speed of growth of extrusions is not constant along the whole length of an extrusion.

As for the secondary extrusions their heights were measured just at 500 cycles and in the end of fatigue life, because after 100 cycles there were just a few of them. So the average height of secondary extrusions has changed from 11 nm at 500 cycles to 18 nm at the end of fatigue life.

Conclusions

1. Classification of FSMs for 12%Cr martensitic steel is proposed. The heights of FSMs are measured. The average height of FSMs increases constantly during LCF cycling.
2. Probably the primary FSMs appear at the packet and sometimes block boundaries, while the secondary extrusions are at the lath boundaries or in the laths.

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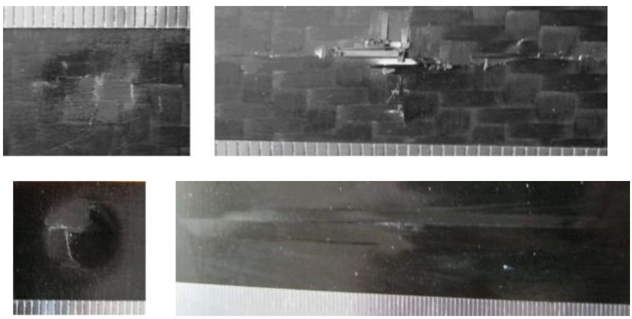
Deformation and damage of modern composites at low velocity impact event

Deformation and damage of polymeric composites namely carbon fiber reinforced plastics, glass fiber reinforced plastics and TWINTEX thermoplastics from a low - velocity drop-weight impact event have been investigated. Results of investigation are presented by photo of damages and graphs of the parameters of damage from impact energy. Conclusion about resistance of composites to impact loading was made.

Composite materials (CM) successfully replace traditional metals in structures of modern aircraft of both military and civil purposes, which allowed to significantly improve their efficiency. If in the construction of military aircraft CM practically replaced the traditional metal [1], in the advanced B.787 CM weight reached 50%, while the A350 comes to 53%. In the construction of modern aircraft are used primarily polymeric composite materials (PCM) that are technologically far more than comparable metal and have 40% less weight, but they are considerably more expensive. Most PCM used in the construction of aircraft are sensitive to impact damage, resulting in service. Especially, it concerns carbon fiber reinforced plastics (CFRP), which are the most common PCM in the aircraft constructions due to their great rigidity. Due to this feature PCM, an important problem is to study the deformation and damage of composite materials in low velocity impact with small energy. With this impact on the front surface effects shot is not visible (photo of fig. 1a), and on the back - is substantial damage (Fig. 1b).



a ***b***

Fig. 1. View from the front damaging CFRP (***a)*** and backward (***b)*** sides

In [2] the results complex investigations of resistance to CFRP damage with different matrices and various fiber volume content. The impact of different energy impact on various damaged of CFRP using the method of computer tomography, ultrasonic testing method and optical thermography considered in [3]. Detailed analysis techniques, equipment and specimens by different testing standards for PCM in low velocity impact and following tests on compression presented in the presentation [4]. In the previous work the authors [5] was described installation that was developed in the mechanics department research laboratory of National Aviation University, for testing in low velocity impact according to the standard ASTM D7136 [6]. As in this case, as in almost all other standards specified in [4] method of testing is to strike falling from a height h load with a spherical 16 mm striker mass *m*. Impact energy is calculated by the formula

$$E = mgh,$$

where *g* is gravity acceleration. Tested specimens have 100×150 mm^2 sizes and are fixed on impact support fixture base with a rectangular cut-out with sizes of 75×125 mm^2.

To compare resistance to low velocity impact and to investigate deformation and damage composites were chosen three different, but the same thickness PCM: CFRP, glass fiber reinforced plastics (GFRP) and TWINTEX thermoplastic carbon. With CFRP and GFRP epoxy-based bonding and thermoplastic TWINTEX based on polypropylene were produced three series of specimens thickness approximately 2.0 mm. Test specimens conducted by causing damage impact falling load with a given similar energy and further the parameters of determining the received damage.

The first series of testing was conducted with the GFRP plates with average thickness 1,95 mm, fiber volume fraction 55%. These plates were manufactured by VARI (Vacuum Resin Assisted infusion). As for second series CFRP was used with epoxy-base bonding agent with average material thickness of 2 mm. This material was made by RTM technology. The third series of specimens is made of modern TWINTEX material, the base of which is fiberglass connected by polypropylene matrix. This material is produced by lining layers of a special fabric which is webbed from twisted beams of glass and polypropylene fibers with further thermopressing at temperature of about 200° C. The particular series of specimens were tested with the following range of impact energies: 4.01 J, 6.06 J, 12.4 J and 24.8 J. View from the front of the damaged specimens after impact are presented in fig. 2.

The main parameters that characterize the deformation and fracture the specimen after the impact is damage diameter as the largest size visible damage to the plane, and the deepest damage. Also may be establish the dimension of damage on the back of. These parameters can be determined by visual measurement using special devices and instruments. The results of measurements are rather subjective because they depend on specialist training that makes measurement and diligence of their conduct. To reduce the subjective component in the results of these studies all measurements performed one specialist.

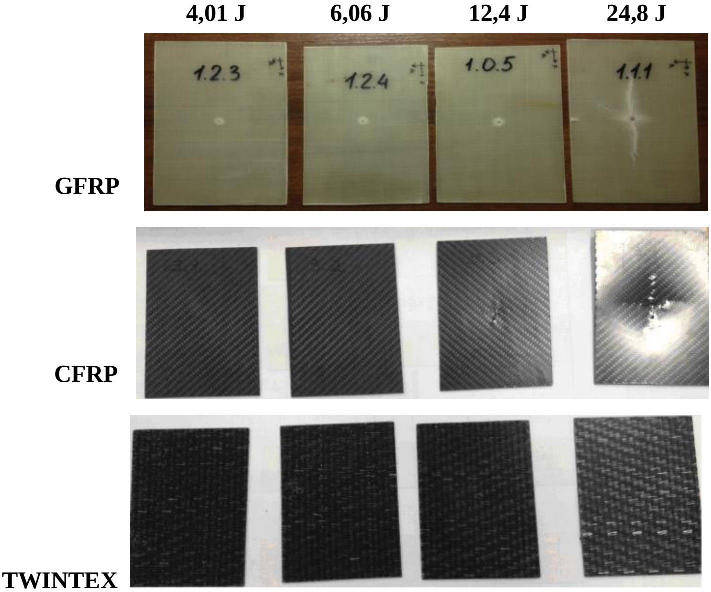
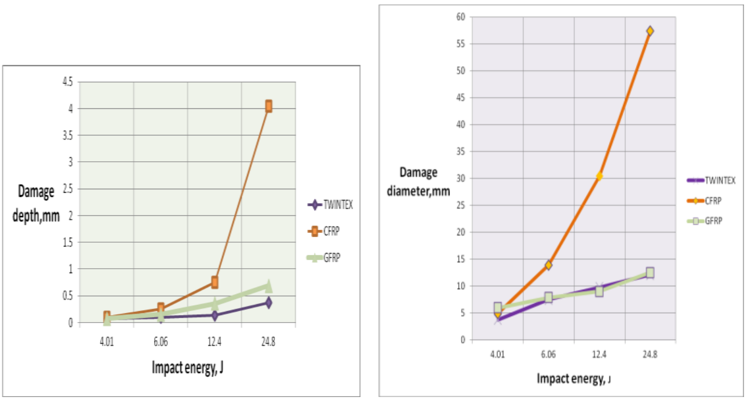


Fig. 2. View of specimens of composites damaging the front side

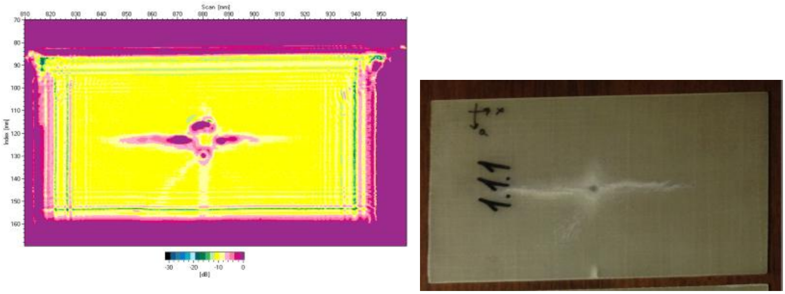
Using a special device with precise clock type indicator was measured depth all damaged specimens. The diameters of lesions were measured digital caliper. The results of measurements depths and diameters damage represented as a graph of the data values of impact energy in Fig. 3a and Fig. 3b, respectively.



a ***b***

Fig. 3. Graph of depth (***a)*** and diameter of damage (***b)***

The main methods other than visual inspection that can be detected of damage in the PCM is non-destructive testing methods using ultrasound or computed tomography scan. Fig. 4 shows the result of ultrasound scanning GFRP specimen with damage from the impact of energy 24,8 J.



a ***b***

Fig. 4. Ultrasonic scanning (***a)*** of GFRP specimen with damage (***b)***

In the analysis of the third series of specimens of PCM TWINTEX, it was difficult to assess the damage by ultrasound method because there was no visible damage. This can be explained that the own energy in the sound waves must be adjusted. Thus computed tomography was used to identify the type of material damage. With certain of non-destructive testing method there were only analysed a specimen of damage to the energy of 24.8 J, as the other three specimens showed a depth of damage (less than 2% of the total thickness). View of the last specimen section using computed tomography scan shown in Fig. 5.

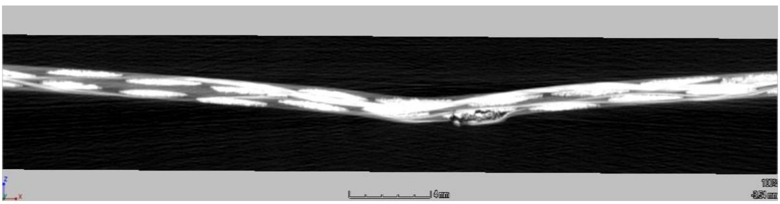


Fig. 5. View cross section ZX-direction of the tested specimen (TWINTEX) using computed tomography

In this computer tomograms clearly visible fiber bundles and breaks on the back side of the point of impact of the specimen. Asymmetric character damage caused by heterogeneous structure PCM TWINTEX with a sufficiently large width of strands.

Conclusions

Parameters of deformation and fracture of specimens from low-speed impact, which are the depth and diameter of the damage is much greater for specimens from carbon fiber (CFRP) compared to fiberglass (GFRP), and especially the material TWINTEX with the same impact energy. This is due to greater rigidity carbon fibers of CFRP compared to other PCM in this study.

The depth of the damage to the specimens of CFRP more than the specimens of GFRP from 1.2 to 6 times, and for TWINTEX from 1.5 to 10 times with the same impact energy. And little difference corresponds to the low impact energy 4,01 J and the difference is increasing at higher energy of low-speed impact, reaching a maximum at 24,8 J.

The diameters of GFRP damage and TWINTEX about the same over a wide impact energy range. Diameter damage of CFRP is the same at low impact energy 4,01 J with damages GFRP and TWINTEX, but with increasing impact energy to 24,8 J, the difference increases to 5.5 times.

Carbon fiber reinforced plastic showed considerable sensitivity to low-speed impact. The value of ballistic limit for CFRP greater than impact energy 24.8 J at a specimen thickness of 2 mm and is much higher for CFRP and TWINTEX.

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Features of fatigue lifetime calculation method application for standardized variable amplitude spectrum

Specific of equivalent stress estimation for fatigue lifetime calculation method is represented. The effect of variable amplitude loads of standardized MiniTWIST spectrum is shown.

Introduction

The main problem that should be solved before aircraft lifetime calculation is taking into account impact of variable amplitude loading on fatigue process.

The lack of reliable fatigue damage accumulation model leads to the Palmgren-Miner rule or non-liner models of damage accumulation applying with some specific "safety factors" [1-3].

For aircraft structure where weight is the one of the main factor of economic efficiency unfounded safety factor increasing is unreasonable. On the other hand, low structure strength has direct effect on the safety of flight.

So, lifetime estimation connects not only with calculation of fatigue damage accumulation but also with determination of:

- structure fatigue characteristic;
- operational loading spectrum;
- methods of operational loading spectrum transformation for typical loads and etc. [4].

According to the last one, in this work some factors which act on the calculations accuracy will be analyzed.

Variable amplitude spectrum analyses

In variable amplitude loading processes (as wing load spectrum), that have complicate form the loading cycle couldn't be definitely identify. That's why it is necessary to transform process with complicate form into simple form process with equivalent damage effect of material for next fatigue life calculation.

One of the calculation methods is based on conditional fatigue damage value under variable amplitude spectrum that is represented in form of “full cycles” sequences.

The "full cycles" could be calculated through a cycle counting methods [5] that are used to summarize irregular load-versus-time histories by providing the number of times cycles of various sizes occur. The definition of a cycle varies with the method of cycle counting.

The rain flow counting method allows to analyze the loads independently without influence of loading order and it is more preferable for stress-strain analyses.

Next, according to Oding’s equations [6] “full cycles” are transformed to equivalent of zero-to-tension stress cycles:

$$\sigma_{0i} = \begin{cases} \sqrt{2\sigma_{ai}\sigma_{\max i}} \quad for\, \sigma_{m\ i} \geq 0; \\ \sqrt{2}(\sigma_{ai} + 0{,}2\sigma_{m\,i}) \quad for\, \sigma_{m\ i} < 0\ and\, \sigma_{max\ i} > 0; \\ 0 \quad for\, \sigma_{\max\ i} \leq 0. \end{cases}$$

where:

σ_{ai} is amplitude of *i*-load;

σ_{mi} is mean value of *i*-load;

$\sigma_{\max i}$ is maximum value of *i*-load;

σ_{0i} is equivalent of zero-to-tension stress cycle.

Using Palmgren-Miner rule for equivalent of zero-to-tension stress cycles sequences it is possible to calculate stress value σ_{eqv} with equivalent damage effect:

$$\sigma_{eqv} = \sqrt[m]{\sum \left(n_i\, \sigma_{0i}^m\right)},$$

where:

n_i is number of zero-to-tension stress (σ_{0i}) cycles;

m is coefficient of S-N curve. For aluminum alloys it could be taken *m* = 4.0, for steel *m* = 3.5 [1].

In this work the MiniTWIST spectrum [7] is taken as basic for next comparison of the results.

The MiniTWIST spectrum consists of blocks, each with 4 000 flights of different load intensity. There are 10 types of flights, the load intensity is determined by the number and value of the load, which in turn were reduced to 10 types from σ_a / σ_m = 0.222 to σ_a / σ_m = 1.6, where σ_a is the stress amplitude in the cycle; σ_m is mean stress value in the spectrum (Fig. 1).

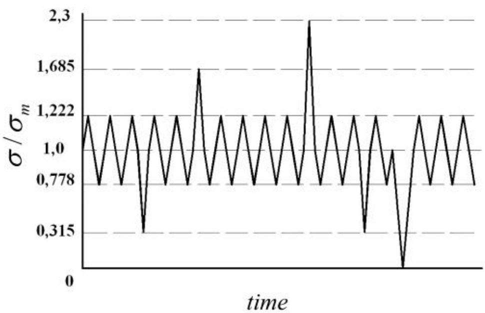

Fig. 1. Fragment of MiniTWIST spectrum

The load spectrums are generated by special developed in MatLab algorithm, that allows to avoid the same sequences generation. Then, the sequences are analyzed by rain flow counting method. Some results are represented in table 1.

Table 1.

Results of MiniTWIST spectrum rainflow counting

Sequences 1			Sequences 2			Sequences 3		
Range	Mean	Cycles	Range	Mean	Cycles	Range	Mean	Cycles
3.378	0.911	1	3.278	0.861	1	3.378	0.911	1
3.278	0.861	1	3.225	0.988	1	3.278	0.861	1
3.125	0.937	1	3.125	0.937	1	3.125	0.937	1
3.078	0.761	3	3.078	0.761	3	3.078	0.761	3
2.928	0.686	7	2.928	0.686	7	2.928	0.686	7
2.925	0.837	2	2.925	0.837	2	2.925	0.837	2
2.775	0.762	10.5	2.775	0.762	8.5	2.775	0.762	10
2.773	0.609	23	2.773	0.609	21	2.773	0.609	21
…	…	…	…	…	…	…	…	…
1.5	0.25	3721	1.69	0.53	736.5	1.47	0.265	34
1.47	0.265	36	1.69	0.685	11	1.38	0.685	46.5
1.38	0.685	50.5	1.69	0.84	0.5	1.38	0.84	1
1.38	0.84	2	1.625	0.187	42	1.315	0.343	8
1.315	0.343	3.5	1.535	0.608	136	1.225	0.762	17
1.23	0.915	2	1.535	0.763	4	1.16	0.42	2
1.225	0.762	16	1.535	0.917	0.5	1.075	0.838	5
1.16	0.42	1	1.5	0.25	3683	0.875	0.937	2
1.085	1.143	1	1.47	0.265	47	0.775	0.988	1
1.075	0.838	3	1.38	0.685	47			
1.005	0.497	1	1.38	0.84	1			
0.875	0.937	2	1.315	0.343	5			
			1.225	0.762	16.5			
			1.16	0.42	1			
			1.075	0.838	5			
			0.875	0.937	2			
			0.775	0.988	1			

This table actually shows from sequence to sequence that rain flow counting method gives at the end:

- a number of zero-to-tension stresses with different ranges;
- different number of zero-to-tension stress cycles.

Conclusion

The results of this work show necessity to take into account the variability of the data that are obtained by cycle counting methods spectrum transformation for further equivalent stress estimation.

The level of effect on equivalent stress estimation should be analyzed statistically more carefully.

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Direct optical biaxial fatigue monitoring

A new approach to fatigue life assessment of the alclad aluminium alloy components subjected to biaxial loading is proposed in this paper. The method for the accumulated biaxial fatigue damage analysis is based on the proven early for uniaxial loading relationship between the intensity of surface deformation relief and remaining life. The conducted and following experiments are expected to be basis for the development of new criterion for the biaxial fatigue.

Introduction

Modern theories and practical methods for stress-strain analysis and fatigue life prediction for the components subjected to multiaxial fatigue can be grouped into the following categories: stress-based approaches, strain-based approaches, energy-based approaches, critical plane models.

In practical tasks the most popular technique of calculations is based on application of the Octahedral shear stress theory (von Mises criterion).

After the equivalent stress assessment, the further analysis and fatigue life prediction can be provided by application of the S-N diagram.

Newest multiaxial fatigue criteria are discussed in papers [1-5]. Among the works devoted to aircraft biaxial fatigue the papers [6-8] should be mentioned.

In the paper [6] fatigue crack growth was studied in specimens of 2024-T3 alloy sheet cruciform specimens under a modified TWIST spectrum superposed with axial and transverse loads to simulate fuselage cabin pressure. The paper shows the importance of biaxial test for the adequate assessment of fatigue crack rate prediction but doesn’t throw the light on incubate stage of fatigue process. It is shown in the paper that known analytical studies as well as experimental data on fatigue crack growth under biaxial loading are rather limited. In the work [7] the study of practical value for aircraft manufacturing process has been presented. Authors of the paper tested bolted joints with different torque tightening and revealed the effect of tightening torque on the fatigue strength. While conducting the results analysis different multiaxial fatigue criteria were compared.

In the paper [8] the aircraft wing skin was studied. The multiaxial fatigue effects were considered by combining the flight measurement results with FE method and engineering judgement. It was shown that the fatigue assessment should include the multiaxial loading effects.

It should be mentioned that with the introduction of composite materials the problem of multiaxial fatigue assessment still remains actual. As an example of the correspondent research the work [9] is presented hear. The report deals with the stresses and stress concentration phenomenon around the doors and windows of Boeing 787TM aircraft. The paper emphasises the opportunities of the Finite Element Analysis of the ANSYS.

As it is shown above, nowadays the multiaxial fatigue criteria are under the active development. New works in this area are motivated by the variety of the materials, loads spectra and constructions. Presented short list of papers devoted to the multiaxial fatigue of aircraft structures indicates the actuality of the problem as well as a necessity to extend bank of experimental data.

Experiments and results

The presented experiments were aimed on the data accumulation for the development of the new biaxial fatigue criterion and method for the residual life duration of the alclad aluminium alloys.

For the monitoring of accumulated fatigue damage and correspondent surface deformation relief [10-11] the flat specimens made of D16 AT were used. The dimensions of the specimens 10 x 1,0 x 120 mm. The thickness of the cladding layer close to 0,04 mm on both sides.

Two types of specimens have been tested: a) with the longitudinal axis along the rolling texture; b) with the longitudinal axis normal to the rolling texture.

It should be mentioned here that the foreign analog of D16AT alloy is widely used 2024T3.

For the loading by cyclical bending and combined bending + torsion tests the portable test machine has been developed.

In the discussed tests the following stresses acted in the inspected cross sections of the specimens: when the specimens were subjected only bending mode of loading the maximum normal stresses were equal 80,0 MPa; when the specimens were subjected to the combined bending and torsion the maximum normal stresses were equal to 80,0 MPa, maximum shear stresses were equal to 80,0 MPa.

Two methods have been used for the stress-strain analysis: a) commonly used technique of the strength of materials; and b) finite elements method. Both methods have led to the close values of stresses in the inspected cross sections.

Results of the experiments are shown in fig. 1. The damage parameter *D* indicates the intensity of the deformation relief that is in fact the aggregate of extrusions, intrusions and persistent slip bands. Detailed description of the deformation relief can be found in papers [10-11].

First look on the fig. 1 reveals sufficient difference in the relief evolution for the specimens with longitudinal and transversal rolling texture: specimens with longitudinal rolling texture accumulate surface damage with larger intensity.

Then, shear component of stresses caused by the twisting mode of loading accelerates rate of the damage accumulation.

It should be mentioned also, that the plots show rather low values of ultimate relief intensity. The observed fact may be considered as a particular situation caused by the special structure of investigated specimens.

Crystallographic aspects of the observed phenomenon

Mentioned above approaches for the assessment of fatigue damage under biaxial loading including concepts of critical plane refer to the description of the process and its analysis on macro scale level.

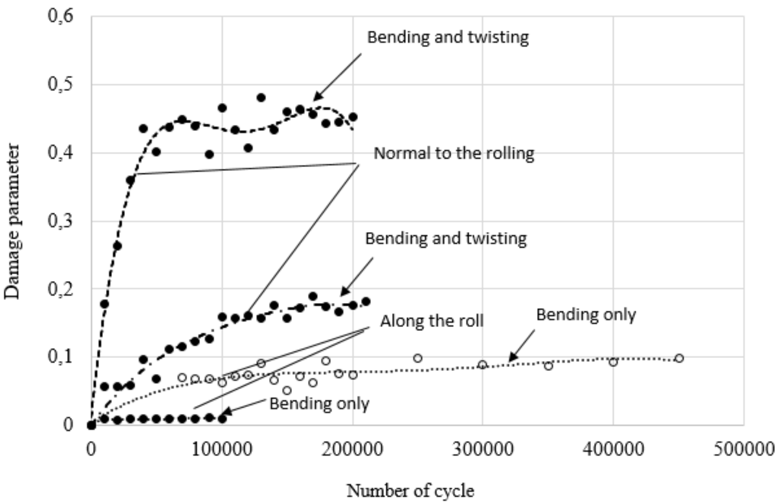

Fig.1. Evolution of the surface relief intensity under the cyclical loading.

For the multiaxial fatigue analysis on the initial (incubate) stage there is a reason to consider the process on the micro scale level, i.e. on the level of the separate grain of polycrystalline or, if the single crystal is investigated it should be done on the scale level of the single crystal.

Forming of the deformation relief which is the component of the plastic deformation and dislocation motion processes occurs as a result of the dislocation movement in the crystallographic planes. The number of actuated slip systems (combination of slip direction and slip plane) depends mainly on the resolved shear stress in the slip system and some another factors [12].

Resolved shear stress is the component of shear stress, resolved in the direction of slip, necessary to initiate slip in a grain:

$$\tau = \sigma \cos \Phi \cos \lambda,$$

where σ - normal stress; Φ - angle between the normal to slip plane and axis of loading; λ -angle between the slip direction and axis of loading.

As the discussed in the paper aluminium belongs to the face centred cubic lattice, there are 12 similar slip systems, however, their actuating depends on the crystallographic orientation.

By the application of standard crystallographic triangle, it is possible to demonstrate the dependence of the actuated slip systems number on orientation (fig.2a) [12]. According to the tendency to slip by single or multiple modes the crystallographic orientations are devised on two categories: “soft” and “hard”. This is reflected by the positioning in the crystallographic triangle (fig.2b) [12].

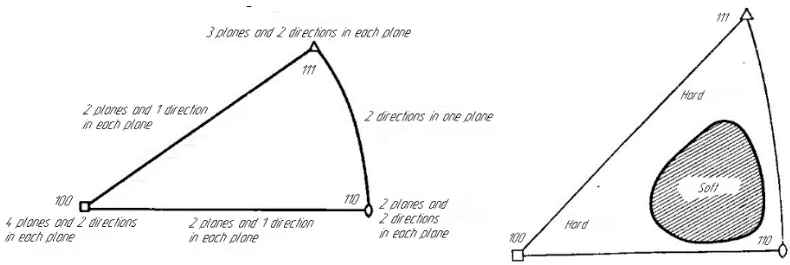

Fig. 2. The crystallographic triangle: a) with indication of equally loaded slip systems; b) with indication of "Soft" and "hard" crystallographic orientations [12]

Apparently, the introduction of additional components of stress and strain due to the multiaxial mode of loading determines the actuation of new slip systems and this process associated with some changes in the morphology of the surface deformation relief. Thus, the intensity of the deformation relief reflects the dislocation micro plastic processes in the slip systems.

At the same time, as it was shown in some researches on single crystals the maximum resolved shear stress in the slip system must not be considered as the only one factor, responsible on the slip activation. Some another factors influence the beginning of the slip. These are shear stresses in another slip system, mutual positioning of the activated slip system and free surface, etc. [13].

Then, as the polycrystalline specimens have been tested, the deformation relief depends on the microstructural texture of rolling. As a result of rolling some grains get preferable orientations, that leads to the domination of curtain crystallographic orientations. The technique of pole figures in the form of stereographic projections is used to represent the orientation distribution of crystallographic lattice planes in texture analysis. Apparently orientation distribution influences surface relief saturation under the uniaxial and multiaxial cyclical loading.

Conclusions

Presented in the paper new experimental data are directed on the development of the method for the assessment of accumulated fatigue damage under the biaxial loading. The method applicable for the aluminium alloys with cladding layer. The intensity of the surface deformation relief is considered as an indicator of fatigue damage. Early, this approach was validated for the uniaxial fatigue of alclad alloy specimens and aircraft structural components.

It is shown that combined action of normal and shear stresses is more damageable than that when only normal stresses act in the surface layer.

The influence of the rolling texture when the specimen subjected to the biaxial loading appeared to be the same as it is under the uniaxial loading. The damage process is more intensive when the rolling texture is normal to the longitudinal axis of the specimen.

Further efforts in the mentioned problem will be directed first of all on the covering wider spectrum of loads. Then, more information about the surface structure morphology should be accumulated for the understanding the problem.

As this paper covers mainly the initial stage of fatigue, more experiments should be conducted to extend discussed concept for all stages of multiaxial fatigue.

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Entropy-energy model of fatigue defects

Based on the principle of maximum entropy there was received relation for distribution of microcracks in classes. It's non-Gaussian nature is consistent with empirical data. In terms of energy balance, formed in the evolution process of fatigue microcracks, relations for growth rate and size were obtained. The fatigue curve formula was derived

A great number of operational destructions have a fatigue character; therefore the problems of the accumulation of damages are the most important and at the same time the most difficult in the theory of Strength. One can see the upward trend of material loading; therefore the life time of some constructional elements became to be limited by small-size defects. Prediction of the development of small-size cracks that are close to the dimensions of the material structure becomes more urgent.

Nowadays there are a lot of models that describe growth process of microcracks. They can be nominally divided into three groups. The models of the first group are based on the construction of calculation schemes of loading with the attempt taking into account the microstructure of the material. The second group is based on the input of formal parameter of damageability and postulation for it some of the evolutionary equation which connects stress and growth rate of damage. In the models of the third group it is assumed that the dynamics of damageability has a certain "thermodynamical" properties, or rather the universal properties found in most complex systems. Approaches used in the present article, tend more to the third group. Here as reference points, variational principle of entropy maximum and the law of energy conservation are used.

The paper [3] suggests an idea - to consider many of self-organized distributed systems, including the microcracks, from a unified point of view, namely, from the perspective that on the set of some of "consumers" is distributed a limited number of "resources" (in particular, on the set of microcracks is distributed the energy of destruction. Moreover, the distribution is carried out not arbitrarily, but according to the so-called "maximum-hyperbolic distribution law", derived in [3] on the basis of the entropy principle. The authors first published their materials of this subject the in May 2012 at the International Conference «ISDMCI '2012» in Eupatorium. [4]

This unified approach allows getting closer to the explanation of the phenomenon known as non-Gaussian (power) distribution pattern in many of, very different by its nature, systems or communities. A review article [5] presents a dozen of various approaches for explanation the mechanism of non-Gaussian distribution patterns.

The entropy principle used herein can be effectively applied to the research of complex hard-formalized systems. It is based on the understanding that some distributed quantity that characterizes the system's conditions (in our case - it is the energy of formation of defects) distributes within the system in the most probable way. Therefore, the entropy of this distribution reaches its maximum value. Maximum entropy appears as the integral criterion, when from a set of options the system is implemented in this particular configuration.

The empirical dependences of fatigue defects quantity from their sizes are given in [1]. Their non-Gaussian characters, as well as the existence of property of self-similarity, are noted there. One of the examples is shown in the figure (Fig. 2).

In the present article it is shown that based on the above-mentioned approach the power (hyperbolic) nature of the experimental curves can be derived.

Under the action of an alternating loading, part of the energy *W* is spent on the formation of fatigue defects. Their total number *N* can be divided into *M* classes; each of them consists of n_i representatives that consume the equal amount of energy ε_i. With such designations, the equalities are obvious:

$$\sum_{i=1}^{M} n_i = N \tag{1}$$

$$\sum_{i=1}^{M} n_i \varepsilon_i = W \tag{2}$$

If it is assumed that the energy of microcracks formation ε_i is proportional to some positive power γ of size l_i,

$$\varepsilon_i = \eta \cdot l_i^{\gamma} \tag{3}$$

Then the expression (2) will get the look:

$$\eta \cdot \sum_{i=1}^{M} n_i \cdot l_i^{\gamma} = W \tag{4}$$

Solution of the problem of finding $n_i=f(l_i)$ is reduced to the search of the distribution of defects quantity over the amount of energy of their formation $n_i=\phi(\varepsilon_i)$. According to the principle of entropy, this dependence will be formed such as that for all selected *M* classes of defects, the distribution of energy $W_i= n_i\ \varepsilon_i$ will be realized with maximum expansion, and therefore will be reached the conditional maximum of entropy. For this purpose it is convenient to use the Shannon entropy:

$$H = -\sum_{i=1}^{M} p_i \cdot \ln(p_i) \tag{5}$$

Here p_i – frequency (probability) of i- event. In the case of energy

distribution $W_i= n_i\ \varepsilon_i$ over the classes it is equal: $p_i = \dfrac{n_i \cdot \varepsilon_i}{E}$.

Thus, the required distribution $n_i=f(\varepsilon_i)$ will be obtained as a result of solving the task on conditional maximum of entropy, written in the following form:

$$H_E(n_i) = -\sum_{i=1}^{M} \frac{n_i \cdot \varepsilon_i}{W} \cdot \ln \frac{n_i \cdot \varepsilon_i}{W} \tag{6}$$

Here (1) and (2) act as requirements.

We use Lagrange multipliers method to determine the conditional extremum. It is known, that if the entropy appears to be the studied function, this approach is sometimes called the Jaynes-Gibbs formalism. Its essence lies in the fact that to achieve the conditional maximum $H_E(n_i)$, is sufficient to solve the problem of finding unconditional extremum of a new function $\Phi(n_i)$ that includes additively H, and constraint equations (1) and (2), weighted by Lagrange's multipliers α and β:

$$\Phi(n_i) = -\sum_{i=1}^{M} \frac{n_i \cdot \varepsilon_i}{W} \cdot \ln \frac{n_i \cdot \varepsilon_i}{W} + \alpha \cdot \left(\sum_{i=1}^{M} \frac{n_i}{W} - \frac{N}{W}\right) + \beta \cdot \left(\sum_{i=1}^{M} \frac{n_i \cdot \varepsilon_i}{W} - 1\right) \tag{7}$$

Having equated to zero partial derivatives:

$$\frac{\partial \Phi(n_i)}{\partial n_i} = -\frac{\varepsilon_i}{W} \cdot \ln \frac{n_i \cdot \varepsilon_i}{W} - \frac{\varepsilon_i}{W} + \alpha \cdot \frac{1}{W} + \beta \cdot \frac{\varepsilon_i}{W} = 0$$

We'll get an expression which brings us to extremum (7):

$$n_i = \frac{C_1}{\varepsilon_i} \cdot \exp\left(\frac{\alpha}{\varepsilon_i}\right) \tag{8}$$

Where $C_1 = W\exp(\beta - 1)$.

The physical meaning of the multiplier α becomes clear after the determination the function extremum $n_i = f(\varepsilon_i)$ given by (8). It is easier to find the extremum of proper continuous distribution $n = \varphi(\varepsilon)$ that is obtained when $M \to \infty$. By assumption

$$\frac{dn}{d\varepsilon} = 0$$

follows, that $\alpha = -\varepsilon$, and constant

$C_1 = n_* \cdot \varepsilon_* \cdot e$, $e \approx 2.718$, and ε_* n_* -

- the coordinates of the point at which the distribution (8) reaches its maximum.

As a result of the distribution $n_i = \varphi(\varepsilon_i)$, can be written following:

$$\frac{n_i}{n_*} = \frac{\varepsilon_*}{\varepsilon_i} \cdot \exp\left(1 - \frac{\varepsilon_*}{\varepsilon_i}\right) \tag{9}$$

Below (fig.1) are given graphs.

Since with the growth of the argument ε_i influence of the exponential multiplier in (9) practically has no effect (leveled), therefore it approaches asymptotically to a power (hyperbolic) dependence:

$$n_i = \frac{n_* \cdot \varepsilon_* \cdot e}{\varepsilon_i} = \frac{C_1}{\varepsilon_i} \tag{10}$$

Therefore, in [3] the relation (9) is called as extreme hyperbolic distribution law. In the present work there are also represented formulas for calculation of parameters n_* and ε_* included in (9).

The distribution of the number of defects n_i on their size l_i can be obtained by substituting the expression (3), which binds the size of the defect with the energy of its formation

$$\varepsilon_i = \eta \cdot l_i^{\gamma}$$ in (14).

We will get sought distribution:

$$n_i = n_* \cdot \left(\frac{l_*}{l_i}\right)^{\gamma} \exp\left(1 - \left(\frac{l_*}{l_i}\right)^{\gamma}\right) \quad (11)$$

Here l_* and n_* – the extremum point coordinates for the curve.

Figure 1 shows the empirical distribution data of fatigue defects, taken from [1]. Calculations by formula (11) corresponds quite well with these curves.

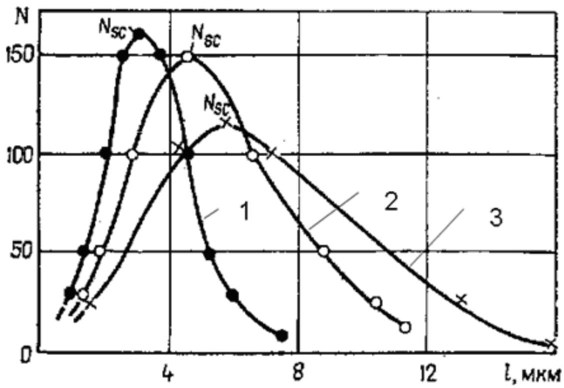

Fig.2. An example of empiric curves of defects distribution [1].

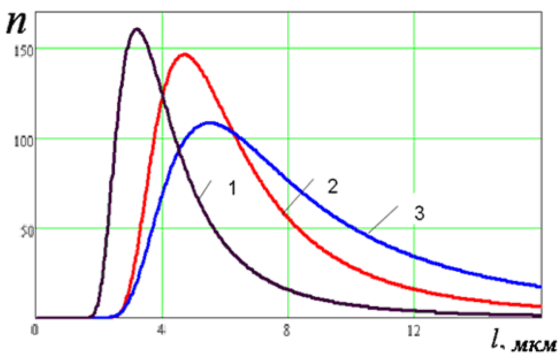

Fig.3. Calculations by formula (11).

In [1] are given distributions of quantity of defects on their size for different ways of loading, different materials and different kinds of deformation. Almost all results are similar to the curves on fig.1. They have strongly marked extremum and their descending branches have hyperbolic shape. The physical sense of this nature becomes clear only within proposed in [3] the extreme hyperbolic law. It turns out that exactly this kind of the curve enables microcracks "to distribute among themselves" the absorbed energy in the most rational way.

Conclusions

There were results obtained in the article - dependence (11) for the distribution of microcracks from the absorbed energy of deformation ni (εi). Given dependence was obtained based on the variational principle of maximum entropy, and has hyperbolic character with a rapidly decreasing exponential factor. The authors called it an extremely hyperbolic distribution law. This law explains the known phenomenon of non-Gaussian nature of the empiric curves.

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A numerical modelling of the fatigue crack growth in a thin isotropic plate under plane stress state

The numerical modelling of the fatigue crack growth in the thin isotropic plate under uniaxial cyclic tension-compression taking into account damage accumulating and the plane stress state at the crack tip is considered.

A numerical solution of the problem of propagation of the fatigue crack in a thin finite isotropic plate under cyclic uniaxial tension-compression is based on the theoretical approach to modeling the fatigue crack growth [1-4]. Fatigue fracture is considered as damage accumulation process and described by a scalar function of damage. The condition of the damage function equality to 1 is taken as the criterion of the fatigue fracture front initiation and movement.

The stress state in structural elements in the aircraft subjected to a complex of static and cyclic loads often is multiaxial. The building of fatigue fracture model taking into account all components of stress tensor at the crack tip- is a very important and actual for prediction of the term of the safe operation of aircraft.

Formulation of the problem

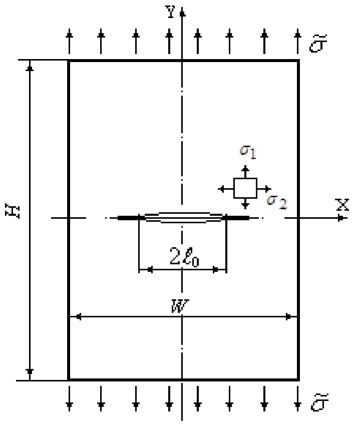


Fig.1

Let's consider a normal tensile central crack with initial half-length ℓ_0 in a thin infinite isotropic plate in plane stress state (Fig.1). The plate is subjected to uniform uniaxial cyclic loading

$$\tilde{\sigma} = \sigma_a g(ft) \qquad (1)$$

imposed at edges plate, the crack faces are free from applied force. There are σ_a – is stress amplitude values according, $g(\cdot)$ – is a known alternating function of a number of cycles n of a change in stresses $(n = ft)$, t – is the physical time, and f – is the loading frequency.

It is assumed in (1) that, the applied stress amplitude σ_a is not time dependent (stationary regime), varies quite often ($f > 10$ Hz), and the maximum stress in a cycle does not exceed the yield point of a material σ_Y (high cycle fatigue).

The contact interaction of crack faces is not taken into account. It is supposed also that, the crack is growing along the $0x$ – axis.

According to modified Dagdale model [5,6] at fatigue crack tip are formed two different plastic zones- monotonic and cyclic, when are concentrated all non-linear effects.

Outside of the plastic zone, the material of the plate is deformed linear-elastically.

The stress distribution in the vicinity of the fatigue crack tip in thin finite plate at any time moment is determined by solving the boundary value problem of elasticity theory with a moving boundary and is considered as

$$\left[\begin{array}{l} \sigma_{yy}(x_j,0,n_i)=\dfrac{\sigma_a\sqrt{\ell(n)}}{\sqrt{2(x_j-\ell)}}F\left(\ell(n)/W, H/W\right) \\ \sigma_{xx}(x_j,0,n_i)=\dfrac{\sigma_a\sqrt{\ell(n)}}{\sqrt{2(x_j-\ell(n))}}F\left(\ell(n)/W, H/W\right) \end{array}\right. , \qquad (2)$$

where- $F\left(\ell(n)/W, H/W\right)$ - correction function [7]

To reduce the biaxial stress state at the crack tip to equivalent linear stress state, the mixed fatigue fracture criterion, taking into account the signs of principal stresses σ_1 and σ_2, is used in the form [8,9]

$$\tilde{\sigma}_{eq}=\left[\begin{array}{ll} \alpha\sigma_{\max}+(1-\alpha)\left(\dfrac{1}{\sqrt{3}}\right)^{\chi}s_i; & \sigma_1>\sigma_2>0; \quad \sigma_3=0 \\ 2\beta\tau_{\max}+(1-\beta)\left(\dfrac{\sqrt{2}}{3}\right)^{\chi}\tau_{oct}; & \sigma_1>0, \quad \sigma_2=0, \quad \sigma_3<0 \end{array}\right. \qquad (3)$$

Here $\sigma_{\max}$, $\tau_{\max}$, s_i, τ_{oct} - are amplitude values of normal stress, shear stress, intensity of shear stress and octahedral shear stress respectively. The material constants α and β characterize the mechanical behavior of a material and reflect the effect of the stress state. The signs of principal stresses σ_1, σ_2 at crack tip coincide. We are using the first equation in (4). Here it is assumed that

$$\sigma_{\max}=\sigma_1, \qquad s_i=\frac{1}{\sqrt{3}}\sqrt{(\sigma_1)^2-\sigma_1\sigma_2+(\sigma_2)^2}\ , \qquad (4)$$

$\chi=2\dfrac{\sigma_2-\sigma_3}{\sigma_1-\sigma_3}-1$ - parameter Nadai-Lode for amplitude values of normal stress

The process of the fatigue microdamage accumulation takes place on the plate and crack front and its extension. The damage level is specified by a scalar damage function $\omega(x,n)$ which accumulation kinetics is given by the differential evolution equation:

$$\frac{\partial \omega(x,n)}{\partial n} = D\left[\frac{\tilde{\sigma}_{eq}(x,n)}{1-\omega}\right]^q \tag{5}$$

The initial and boundary values

$$\begin{cases} \omega(x,0)=0 \\ \omega(x,n_R)=1 \end{cases} \tag{6}$$

Equations (2-5) involve material constant σ_Y and coefficients D , q , α The first group - σ_Y , is determined from stress-strain diagrams in uniaxial tension tests. The second group involves q and D coefficients and characterizes the material resistance to the accumulation of scattered fatigue microdamage. The values of q and D are calculated by results of standard fatigue tests of plain cylindrical specimens under uniaxial reversed tension-compression presented in a form of the Wöchler curve; α - determined from experiments on fatigue of smooth cylindrical specimens under tension-compression and data of a single test under plane stress state, and it varies from 0 to1.

The problem is to numerical simulate fatigue crack growth in the thin isotropic plate under uniaxial cyclic loading and estimate influence of accounting biaxiality stress state that arises at the crack tip.

Numerical simulation of fatigue crack growth

Integrated (5) with taking into account the two-stage character of the fatigue fracture process, initial and fracture conditions we obtain integral equation for fatigue crack front movement

$$\int_0^1 [1-\omega(x_*,n)]^q \, d\omega = D\left[\int_0^{n_*} \tilde{\sigma}_{eq}^q(x_*,n)dn + \int_{n_*}^{n} \tilde{\sigma}_{eq}^q(x_*,n)dn\right], \tag{7}$$

n_* is the duration of the incubation stage.

For numerical solution we consider (7) as superposition of equations for the N discrete time intervals $n_i \le n \le n_{i+1}$

$$\sum_{i=0}^{N}\sum_{j=i}^{N}\int_{\omega(n_i,x_j)}^{\omega(n_{i+1},x_j)} [1-\omega]^q \, d\omega =$$

$$= \sum_{i=0}^{N}\sum_{j=i}^{N} D \int_{n_i}^{n_{i+1}} \left(\left(\frac{1+2\alpha}{3}\right)\sigma_a\sqrt{\frac{\ell(n_i)}{2(x_j-\ell(n_i))}}\cdot F\left(\frac{\ell(n_i)}{W},\frac{H}{W}\right)\right)^q dn, \quad i=0,N; \quad j=i,N \tag{8}$$

where - n_i corresponds to the time when at a point x_j along the fracture front is accumulated fatigue damage

$\omega(n_i, x_j)$; $x_j = \ell(n_i) + \lambda(\ell(n_i))$, $i = 0, N$, $j = i, N$ — the coordinates of the partition plate along the fracture front on the axis $0x$; $\lambda(\ell(n_i))$ — cyclic plastic zone:

$$\lambda(\ell(n)) = \frac{1}{8}\left(\frac{(1+2\alpha)}{3}\frac{\pi\sigma_a}{2\sigma_Y}F\left(\ell/W, H/W\right)\right)^2 \ell(n) \qquad (9)$$

Incubation stage corresponds to the period of cyclic loading $n_0 \le n \le n_1$, when the material of plate is damaged, but not destroyed. The duration of the incubation stage is determined by the expression

$$n_* = n_1 = \left((q+1)D\left[\left(\frac{1+2\alpha}{3}\right)\sigma_a\sqrt{\frac{\ell(n_0)}{2(x_0-\ell(n_0)}}\cdot F\left(\ell(n_0)\right)\right]^q\right)^{-1} \qquad (10)$$

On the stage of fatigue crack growth, each subsequent moment time when the crack jump at the point x_j is determined by the expression

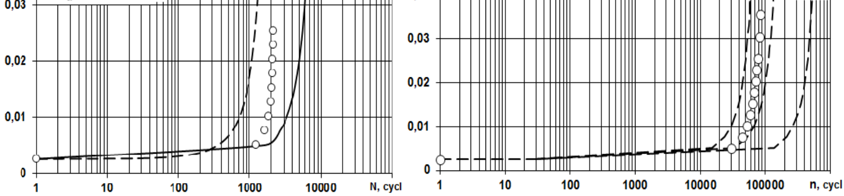
$$n_{i+1} = n_i + \frac{\left[1-\omega(x_i, n_i)\right]^{q+1}}{(q+1)D\left[\left(\frac{1+2\alpha}{3}\right)\sigma_a\sqrt{\frac{\ell(n_i)}{2(x_i-\ell(n_i)}}\cdot F\left(\ell(n_i)\right)\right]^q}, \qquad (11)$$

where damage accumulated along the of fracture front during the time period $n_i \le n \le n_{i+1}$, is determined from

$$\omega(n_{i+1}, x_j) = 1 -$$

$$-\left(\left[1-\omega(x_i, n_i)\right]^{q+1} - (q+1)D\left[\left(\frac{1+2\alpha}{3}\right)\sigma_a\sqrt{\frac{\ell(n_i)}{2(x_i-\ell(n_i)}}\cdot F\left(\ell(n_i)\right)\right]^q (n_{i+1}-n_i)\right)^{\frac{1}{1+q}} \qquad (12)$$

Fig. 2 shows the dependence of the length of the fatigue crack on the number



a b

Fig.2 Dependence of the length of the fatigue crack on the number of cucles.

of cycles for the finite plate (Fig.1) W =0,305m, H=0,891m with central crack ℓ_0 = 0,0025m from aluminum alloy 7075-T6 Stress-strain and fatigue damage characteristics 7075-T6 from [10] are σ_Y =523 MPa, D =3,41·10^{-28}(MPa^q·cycle)$^{-1}$, q =9,23 . On the Fig.2a the numerical calculation results (curve 1) are compared with experimental data (○) [11] and the analytical solution (curve 2). Numerical simulation makes it possible to determine the level of damage accumulation along the crack front at every change of its length. As a result, the velocity of a crack in the numerical solution more than the analytical solution. Fig.2b has illustrated the influence of accounting biaxiality stress state that arises at the crack tip ($\alpha = 1$ - uniaxial stress state - σ_1 ; $\alpha = 0{,}5$ -combined stress state - σ_1 and σ_2 ; $\alpha = 0$ uniaxial stress state –only σ_2). Accounting for the second stress tensor components reduces the rate of crack propagation

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New approach for determination of fatigue process zone parameters by surface nanorelief analysis

Abstract. A new two-step phase shifting interferometry technique for evaluation of a fatigue process zone (FPZ) dimensions near a notch root in metal and alloy specimens is proposed. Obtained experimental results have confirmed an assumption that the surface roughness of notched specimens after cyclic loading reaches its maximum values at the FPZ boundary. The FPZ sizes were measured for notched specimens made of a low-carbon steel and aluminum alloys 2024–T6 and 7075–T3.

Introduction

Study of plastic damage evolution in materials under fatigue conditions is necessary for more deep understanding of different fracture phenomena including fatigue life of notched metal and alloy structural members that are widely used in constructions, vehicles, machines, aircrafts, and so on. Fatigue life Nf can be considered as a two-stage damage process[1] estimated by two periods Ni and Np being defined as the number of cycles Ni before nucleation of a minimum fatigue macrocrack in a material at the first stage and the number of cycles Np during the macrocrack growth at the second one, that is Nf = Ni + Np. Fatigue of notched metal and alloy specimens is conducted by formation of a specific surface zone near the notch root usually named as the fatigue process zone (FPZ), [2–4] in which plastic deformation is localized and structural damages are accumulated due to decreased surface yield stress in compare with material volume and particular free surface. This zone is the localized area of a previously deformed material (concerning further crack formation) at the notch root. Its size d* depends on the mechanical properties of material and its microstructure. This size is a material constant for given test conditions that defines the maximum of the local elastic-plastic stress range Δσy at a critical distance d* from the notch root.[2–4] The distance d* can be compared with distances ρ*, ap, or xeff, and practically is similar to them. Scheme of the FPZ formation and stress distribution at the notch root is shown in Fig. 1. Experimental validation of the developed technique was fulfilled with the help of a hybrid optical digital experimental setup containing a Twyman-Green interferometer with a phase shifter based on a piezoceramic element with a bonded mirror and a single-mode He-Ne laser (λ = 633 nm) with output power Pout = 50 mW. The setup also contains a special jig plate for holding a test CT-specimen, phase shifter controller, digital CCD-camera SONY XCD-SX910 (pixel pitch is equal to 4.65 μm in two orthogonal directions) and PC. Several CT notched specimens of a 4 mm thickness and 1.5 mm notch radius made of a low-carbon steel (24×24×4 mm3) and aluminum alloys 2024–T6 (55×55×4 mm3) and 7075–T3 (55×55×4 mm3) were used for experiments. The specimen surfaces and notch roots were carefully mechanically polished and further superfinished. Low-carbon steel specimen surfaces were superfinished up to R_a < 0.035 μm (ISO Grade

Scale Number 2). Surfaces of specimens made of aluminum alloys 2024–T6 and 7075–T3 were superfinished up to $R_a < 0.065$ μm (ISO Grade Scale Number 3).

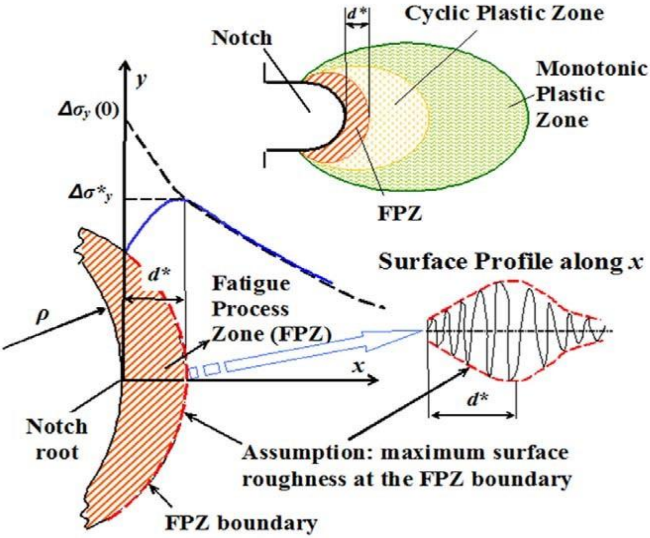
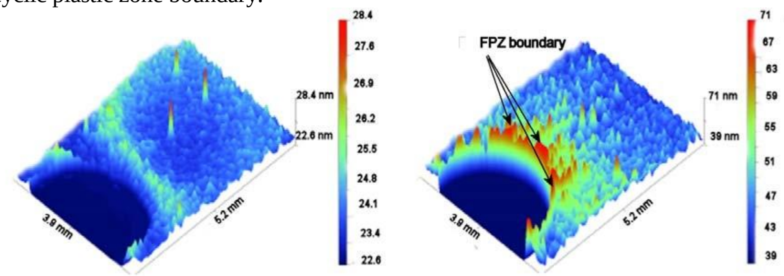


Fig. 1. Scheme of the FPZ formation and stress distribution at the notch root.

Cyclic loading of all specimens was fulfilled at the stress ratio R= Pmin/Pmax = 0.1 and at the stress ranges in the notch root location equal to Δσy(0) = 560 MPa for low-carbon steel specimens, Δσy(0) = 460 MPa for aluminum alloy 2024–T6 specimens and Δσy(0) = 360 MPa for aluminum alloy 7075–T3 specimens.

The Twyman–Green interferometer optical scheme was adjusted to record the studied area surface relief with a sampling interval sufficient for its minute retrieval and satisfying the sampling theorem. Majority of well-known methods for definition of the sampling interval are based on calculation of a cumulative power spectrum and autocorrelation function (ACF). We have chosen the method based on calculation of a correlation length τ0=2.3β* of a random surface profile ACF ρ(τ)=exp(–τ/β*), where β* is the spacing parameter. In this method, the sampling interval τs is defined as a distance that does not exceeds 0.4–0.5β*, that is 0.17–0.21τ0. To define the sampling interval for each specimen surface area near the notch root, we have recorded fringe patterns of low-carbon steel specimens before their fatigue with different lateral magnifications of the interferometer's optical system. Results of the ACF calculations of reconstructed height maps have shown that the correlation length does not change practically if the sampling interval τs=0.2τ0≤ 5.5 μm (τ01≈25 μm if τs1=2.3 μm, τ02≈27 μm if τs2=5.5 μm, τ03≈70 μm if τs3=6.0 μm, τ04≈204 μm if τs4=9.2 μm, τ04≈216 μm if τs4=10.0 μm). Poon and Bhushan [1] have proven that the correlation length of random surfaces remains approximately invariable until the sampling interval increase will not lead to an aliasing noise appearance and growth. If the aliasing noise level increases, the correlation length increases also. Therefore, the sampling interval τs=5.5 μm and a lateral magnification Ml=0.85 were chosen for recording of fringe patterns of low-carbon specimen surfaces before fatigue. The same sampling interval was chosen for recording of fringe patterns of aluminum alloys' 2024–T6 and 7075–T3 surfaces, because these surfaces possessed a larger roughness and respectively a larger correlation length. This sampling interval was also chosen for recording of fringe patterns of studied areas after a given cycle quantity, because the surface roughness develops and increases both in the FPZ and a cyclic plastic zone and the correlation length increases respectively.

Results of retrieval of surface height maps of the CT-specimen made of a low-carbon steel (specimen 1) and aluminum alloys 2024–T6 (specimen 2) and 7075–T3 (specimen 3) before fatigue and after given numbers of cycles indicate higher roughness level at the FPZ boundary after cyclic loads. Example of such maps of the specimen 2 surfaces before fatigue and after 5 000 cycles is shown in Fig. 2. These height maps visually indicate higher roughness level at the FPZ boundary that is marked by arrows in Fig. 2(b) after fatigue loads. Quantitative definition of the FPZs sizes is fulfilled by producing the map of the roughness parameter Ra(i',j'). The sampling square Lx×Ly = 15Δx×15Δy was chosen according to the surface roughness parameter Ra ≤ 0.025 μm (the new ISO (grade) scale number N=1), which corresponds to minimal surface roughness of some areas of studied CT-specimens beyond the cyclic plastic zone boundary.



(a) (b)

Fig. 2 Surface height maps of the roughness parameter R_a(i',j') spatial distribution for the surface area of the low-carbon steel CT-specimen (specimen 1) near the notch root before fatigue (a) and after 10 000 loading cycles (b).

To remove irregularities of the Ra distributions, conventional image smoothing filters, in particular, Gaussian smoothing filters were used. The surface height maps of the roughness parameter Ra(i',j') spatial distribution for the surface area of the CT-specimen 1 near the notch root before fatigue and after 10 000 loading cycles are shown in Fig. 2. Obtained experimental results have shown that roughness parameter Ra for all selected CT-specimens increases sharply near the FPZ boundary and reaches its maximum values at the narrow strip corresponding to the FPZ boundary. Depending from the radius-vector inclination from the notch center to the FPZ boundary, the distance d* was changed rather slightly. The FPZ sizes d* that selected along the notch cutting direction are equal to 2.13 μm for specimen 1, 540 μm for specimen 2, and 310 μm for specimen 3.

Conclusions

In order to evaluate the FPZ sizes in notched specimens, we have developed the new two-step PSI technique. It can be used for solving other different tasks of experimental mechanics and surface metrology due to accurate extraction of surface roughness and waviness from a total surface relief. This technique uses only single wavelength to produce fringe patterns. Therefore, it can be applicable actually only for smooth surfaces, which fringe patterns [5] recorded by matrix detectors that have the distance between adjacent pixels lesser than one-half of a fringe. Nevertheless, the similar two-wavelength two-step PSI technique based on the single-wavelength one that will restore the surfaces possessing much larger roughness also can be developed. Due to the two-step PSI technique, the assumption that the roughness of the notched specimen surface reaches its maximum values at the FPZ boundary has confirmed. Creation of surface height maps of the roughness parameter Ra(i',j') spatial distribution near a notch root for different notched CT-specimens and generation of a FPZ boundary in the form of a narrow strip containing pixels possessing the maximum values of Ra have proven the validity of this assumption. As compared with the two-frame [5-8] interferometric method with a blind phase shift of a reference wave available to evaluate the parameter d* only for metal and alloy notched specimens with high plasticity, this technique allows defining the FPZ size and parameter d* for notched specimens possessing the high, moderate and low plasticity. Results of the parameter d* calculation have good coincidence with results obtained by another destructive and nondestructive techniques.

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Fatigue cracks growth features in aluminum alloy D16AT

This paper investigates the description of the fatigue cracks growth in sheet aluminum alloy D16AT by exponential dependence. The results show that the propagation of all investigated fatigue cracks can be satisfactorily described by this dependence with grate values of the determination coefficient.

Changing of the fatigue crack length a on the number of loading cycles N in a wide size range has a number of unique features. The development of short cracks is not considered in this paper because the scale of the stress intensity factor (SIF) ΔK for them is less than the threshold value ΔK_{th} and it is determined mainly by microstructure factors. The growth of long cracks at $\Delta K > \Delta K_{th}$ is characterized by kinetic diagram of fatigue fracture. The second portion of it is described by the regression Paris' equation:

$$\frac{da}{dN} = C\Delta K^m , \tag{1}$$

where C and m – the regression coefficients that are not associated with materials physical properties (for most metallic materials m varies from 1.5 to 4).

From equation (1) should be dependent a on N, which can be represented implicitly as a

$$\int_{a_0}^{a} \frac{dx}{\Delta K^m(x)} = C(N - N_0) , \tag{2}$$

where a_0 – the length of the initial crack, which was formed at N_0 loading cycles; x – the integration variable.

Function (2) in the approximate shape describes the propagation of a fatigue crack on the number of load cycles, including the stage of its rapid growth (with $m > 2$). However, the regression equation (1), on the basis of which the function (2) is obtained, are not always adequately reflect the characteristics of the crack growth in the early stages and the period of rapid growth is not practically significant in predicting of the structure limit state.

Based on the analysis of methods for describing of fatigue cracks propagation, it is asserted that it is impossible to describe the dependence of crack length on the number of cycles in the whole range of durability until the destruction by a single dependency [1]. Generally, the functional dependencies that describe the propagation of cracks at different stages are different. For example, numerous studies have shown that the initial fatigue crack growth stage, and period of its rapid propagation satisfactorily approximated by an exponential relationship [1]:

$$a = a_o \exp(hN), \tag{3}$$

where h – the kinetic coefficient that depends on the fracture geometry, material properties, and effective stress. It should be noted that the random crack growth, according to the formula (3) is determined by a value of random coefficient h .

Equation (3), which is a special case of regression equation (1) when $m=2$, well describes the propagation of fatigue cracks in the sheet metal aviation structures at operational loading, that is reflected in an exponential model of fatigue cracks growth (Frost-Dugdale model) [2,3].

In this paper it is investigated the description of the fatigue cracks growth in sheet aluminum alloy D16AT by dependence (3).

Experimental studies conducted on flat samples, with thickness 1.5 mm, which had 14 holes with a diameter of 4 mm, which are arranged in three rows. Samples were tested at unidirectional loading cycles with a maximum stress value in the cycle $\sigma_{\max}=80$ MPa, 100 MPa and 120 MPa. Methods of fatigue tests, monitoring of the cracks behavior and crack length measuring are given in [4].

There are three characteristic regions on the typical dependence of a crack length on the number of cycles, which was received as a result of aluminum alloy D16AT fatigue test (Fig. 1). They are linear region (I), which is implemented at the initial stage of crack growth, exponential region (II), which is described by the function (3) and takes up most of the crack propagation time, and accelerated crack growth region (III).

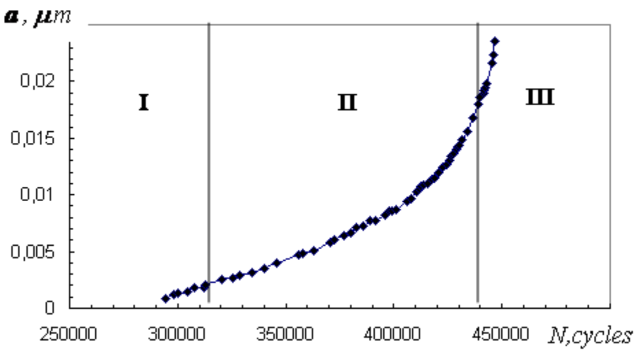

Fig. 1. Typical dependence of crack growth on the number of cycles

The obtained experimental data on the growth of fatigue cracks in the aluminum alloy D16AT samples presented in semilogarithmic coordinates according to the relation (3):

$$\ln a = p + hN, \tag{4}$$

where p – the regression coefficient (Fig. 2). In an ideal exponential growth of cracks $p=\ln a_0$, however, value of the coefficient p is not related uniquely to the initial crack size a_0 because of the natural variation of the experimental data from the exponent.

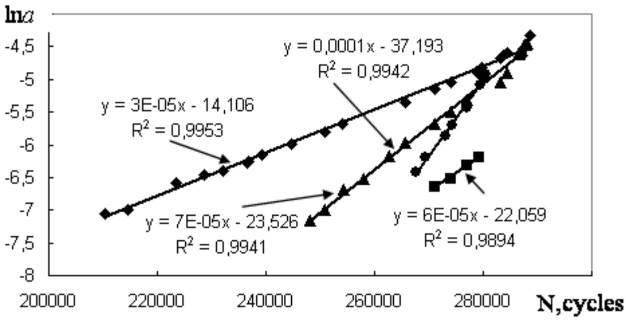

Fig. 2. Dependences of the logarithm of the fatigue cracks length on the number of load cycles with a maximum stress in the cycle $\sigma_{max} = 80$ MPa

Presented in Fig. 2 dependences shows that crack growth is satisfactorily described by an exponential function (3). Linearity regression (Fig. 2) is characterized by relatively high values of the determination coefficient (R^2). Similar results were obtained for cracks when $\sigma_{max} = 100$ MPa and $\sigma_{max} = 120$ MPa (Table 1).

Table 1.

Values of the coefficients p, h and R^2 for cracks in experimental specimens

p	h	R^2	p	h	R^2
$\sigma_{max} = 80$ МПа					
-23,526	0,00007	0,9941	-44,852	0,0001	0,9992
-30,537	0,00009	0,9998	-13,517	0,00003	0,9986
-22,059	0,00006	0,9894	-18,42	0,00004	0,9996
-37,193	0,0001	0,9942	-14,106	0,00003	0,9953
-37,43	0,0001	0,9818	-10,905	0,00002	0,9968
-25,358	0,00006	0,9926	-27,674	0,00005	0,9961
-11,357	0,00002	0,9934			
$\sigma_{max} = 100$ МПа					
-11,427	0,00003	0,9998	-22,002	0,00006	0,9888
-9,264	0,00002	0,9993	-37,515	0,0001	0,9893
-14,593	0,00004	0,9843	-34,022	0,00009	0,9965
-12,873	0,00003	0,9983	-23,631	0,00006	0,9941
-10,686	0,00003	0,9856	-11,689	0,00002	0,9783
-15,518	0,00005	0,996	-13,517	0,00004	0,9965
-12,619	0,00003	0,9759	-11,328	0,00002	0,9936
-12,812	0,00003	0,9926	-14,233	0,00003	0,9986

-13,458	0,00003	0,9921	-27,863	0,00009	0,9945
-10,258	0,00001	0,891	-23,725	0,00008	0,9986
-15,539	0,00003	0,9607	-20,629	0,00007	0,9972
-20,42	0,00005	1,0000			
$\sigma_{\max} = 120$ МПа					
-10,99	0,00005	0,9993	-24,276	0,0001	0,9954
-15,545	0,00009	0,9985	-16,881	0,00007	0,9845
-18,996	0,0001	0,9954	-15,078	0,00006	0,9913
-14,14	0,00006	0,9987	-15,462	0,00006	0,9985
-23,965	0,0001	0,9900	-22,273	0,0001	0,9942
-24,246	0,0001	0,9311	-24,83	0,0001	0,9964
-12,93	0,00005	0,9982	-19,029	0,00008	0,9997
-17,365	0,00008	0,9946	-13,39	0,00005	0,9967
-18,239	0,00008	0,9987	-13,813	0,00005	0,9987
-14,981	0,00006	0,9990			

Conclusions

The results show that the propagation of all investigated fatigue cracks can be satisfactorily described by an exponential dependence of the length on the number of load cycles. The values of the determination coefficient for the exponential dependence of all cracks is not less than 0.9, and the average value of R^2 is equal to 0.99075.

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Analysis of the fretting process of surface layers based on the energy model of triboprocess

By the theoretical analysis methods and methods and experimental result of research within the framework of power model of formation particles of wear the estimation of destruction process superficial ball is done in the behind covering areas of pair friction. The presence dependence sizes particles of wear is set from mechanical properties of material.

Introduction

The elaboration of analytical and computational methods for assessing the wear resistance or forecasting the characteristic life of friction pair materials is an important aspect of the general issue of the reliability of a tribo-mechanical system. First of all the complexity of this issue involves finding neutral approaches to the analysis and mathematical modeling of all the processes and phenomena responsible for the occurrence of events of friction deterioration of the surface layer material. The most methods proposed today for calculation of wear parameters are based on mathematical approximation of experimental study results, on idealized models of frictional contact interaction between friction bodies and on solving the problems of the elasticity theory and of the contact damage mechanics.

The energy models based on the analysis of the structure of the energy balance in tribo-systems and on the energy concept of the strength of solids are gaining more and more attention. The deterioration process in energy-based models is considered to be the final step of the multi-stage discrete process of accumulation of lattice damage. It occurs as the increase in internal energy of the crystal surface deformed by friction [1 - 3]. This approach to the modeling of tribo-processes enables, on the uniform theoretical basis using general terms and laws of thermodynamics of irreversible processes, to describe and analyze the changes in the physical state of the surface layer material and to determine the energy criteria of its deterioration under any conditions of exposure to external energy.

In this paper based on the energy model of tribo-process, a an analytical study of conditions for forming worn particles was performed, and the possibility of applying the energy approach to assess the wear resistance of surface layers suffering fretting damage was examined.

Tribo-process model and its analysis. It's known that the internal energy of a crystal depends on both interatomic forces in the material lattice and the joint effect of various processes, such as mechanical, thermal, diffusion, chemical, acoustic, electromagnetic processes etc. The relation between the energy parameters of a tribo-system and its wear resistance is determined by the ratio of the fraction of dissipated energy, converted into heat, to the fraction of absorbed energy, accumulated by the material as potential internal energy that directly initiates the occurrence of surface deterioration events. This paper [4] shows that the gain in the crystal internal energy with time under the effect of external mechanical loads in friction pairs occurs according to the law similar to the linear one. Deterioration of the material occurs on reaching some critical value of the material internal energy (energy of damage activation). Therefore, the friction deterioration act can be defined as a consequence of instability of some volume of the material surface layer after reaching the critical value of its internal energy density.

When considering an infinitely small physical volume of a solid as an open thermodynamic system staying in the state of local thermodynamic equilibrium under stable circumstances, the condition of material deterioration can be presented as follows:

$$\Delta U \geq U_0 . \tag{1}$$

where ΔU – gain in internal energy of the system above its equilibrium value and U_0 – energy of damage activation. The first value is accumulated during the friction process and the latter one is a fundamental energy characteristic of material strength.

The change in the internal energy of the system is described by the fundamental Gibbs equation [5]

$$\Delta U = T\Delta S - P\Delta V + \sum_i \mu_i \Delta w_i , \tag{2}$$

where T – absolute temperature, P – pressure, V – volume, S – entropy, μ_i – chemical potential of i component, the molar fraction of which in the system is equal to w_i. Taking into account the joint effect of the above factors on the change in the internal energy of the system, the condition of deterioration of the near-surface layer of the friction pair material can be presented as follows:

$$TR\ln\left(\frac{t}{\tau_0}\right) + V_m 10^{-6}\left(\frac{\Delta\sigma^2}{2E} + \bar{\sigma}\dot{\bar{\varepsilon}}t\right) + \Delta u_н + \Delta g \geq U_0 . \tag{3}$$

The first addend in (3) stands for the gain in the internal energy of one mole of the substance in the near-surface layer due to increase in the entropy, the second addend – due to increase in the elastic and plastic strain energy of the crystal lattice (the first and the second summands within the brackets, respectively), the third addend – as a result of process treatment of the surface; the fourth one – with due regard to physical and chemical interaction with the environment. Here, R – uniform gas constant, V_m – molar volume, σ – stress, E – modulus of elasticity, $\dot{\bar{\varepsilon}}$ – average rate of inelastic strains, t – time of the system being loaded, a τ_0 – period of thermal vibrations of atoms.

The study of the effect of each addend in the left part of the inequality (3) performed in this paper [3] has shown that it is the deformation fraction that mainly contributes to the material deterioration process, and its share increases monotonically in the course of time close enough to the linear law.

The energy of elastic strains is a function of the instantaneous stress value, so it does not accumulate in the material with time. To assess it in the presence of dynamic effects in the form of periodical loads, the maximum stress value is adopted as the effective value $\Delta\sigma$:

$$\sigma_{\max} = E \cdot \varepsilon_{\max} . \tag{4}$$

In the friction processes, the deterioration event occurs within a small volume of the near-surface material area that separates in the form of a worn particle when reaching the critical stress values. The critical stress values depend on the conditions of deterioration. So, worn particles are formed in a volume of the separated fragment subject to an inequality similar to (3)

$$U_{def} \geq U_s, \tag{5}$$

where U_{def} – excessive internal energy, accumulated due to strains, in a volume of the separated fragment and U_s – energy of activation of deterioration of the fragment of this volume.

To assess the size of the worn particle we assume that it is enclosed in a hemisphere of radius $d/2$, where d is the diameter of the contact area [6]. So, its volume is considered to be equal to $\dfrac{\pi d^3}{12}$. If ν is a quantity of moles of the substance in this volume, then the worn particle will be formed provided that the following inequality is satisfied

$$U_{def} = \frac{\pi d^3}{12}\left(\frac{\sigma_{\max}^2}{2E} + \sigma_{\max}\bar{\dot{\varepsilon}}t\right) \geq U_s, \tag{6}$$

where

$$U_s = U_a - \nu[TR\ln(\frac{t}{\tau_0}) + \Delta u_н + \Delta g] \tag{7}$$

– energy of activation of deterioration, which value depends on cohesive properties of the material (the first addend) and on the change in its internal energy due to the increase in entropy, the effects of surface process treatment and the processes of its physical and chemical transformation.

Change in the internal energy as a result of entropy, surface process treatment and interaction with the environment (for example, oxidation) can lead to decrease in the energy of activation of deterioration, that's why the second addend in the equation (7) can be both added and subtracted. The system temperature during the period of its being under loaded condition can increase. On the assumption that this change is linear we should substitute (7) as follows:

$$T = T_0 + \alpha t .$$

Provided that $t < t_{cr}$, where t_{cr} – duration of the friction process before the worn particle starts separating, the condition (7) is not satisfied.

Taking into account that about 25% of elastic strain energy are transformed into local plastic strain energy during the friction process (residual energy is dissipated in the form of thermal vibration energy) [3], and the maximum stress value $\sigma_{\max}$ decreases with the increase of tribo-contact cycles, we can estimate the temporal change in the strain component of internal energy U_{def}. When analyzing time dependence of U_{def} and U_s values within the specific tribo-system, we can determine the time interval before the beginning of the deterioration process at the surface.

Since the deterioration involves breaking of interatomic bonds and forming of new free surfaces, it might be natural to assume that the energy $U_a = \nu \cdot U_0$ is proportional to the area of the new free surface which depends on the size of the separated particle. If the separated particle consists of the same substance as the main volume of the body, then

$$U_a = 2\gamma\pi d^2, \tag{8}$$

where γ is effective surface energy of the ultimate internal stress (specific cohesion energy) [7], which depends on the cohesion properties of the substance.

The deterioration event requires some work of external forces that can be determined through the energy relations of the general energy balance in tribo-systems. The energy spent on the friction of solids during their relative movement in a time *t* is defined by the sum of its quantities transformed during this time by all elements of body 1 and body 2 which are frictionally bonded [8]. In each cycle of interaction of the frictionally bonded elements, a part of the delivered energy is used to increase the internal potential energy in the near-surface layers of the material, another part is consumed for heat generation and such tribo-effects as acoustic emission, energetic and magnetic field excitation, formation of tribo-structures etc., the share of which is extremely small compared to heat generation [9]. If friction occurs at a constant rate and external shear force is used only to overcome bodies' friction, then the work of this force on the travel path will be equal to the dissipative mechanical energy.

If friction occurs under condition of fretting and full slip in a tribo-contact, we can ignore the expenditures of energy during the cycle of pre-submission [10]. Then, the total external mechanical energy spent on friction will be as shown

$$\overline{W} = A_{\mathrm{FR}} = 2\mathrm{A} \cdot \mathrm{P} \cdot \mu \cdot \mathrm{N}, \tag{9}$$

where A_{FR} is work of friction force, equal to the dissipative mechanical energy, A – full slip amplitude, μ – friction factor of the tribo-pair, N – number of fretting cycles.

Assuming that the gain in the internal energy of the material subjected to friction is mainly due to the strain component, and n_r i.e. number of equivalent elements of working area, is simultaneously in frictional interaction and the same portion from the total supplied mechanical energy is transformed in friction bodies, thus, in view of the general energy equilibrium in tribo-system the following can be written:

$$U_{def} \cdot n_r = \frac{\overline{W}(1-\frac{\theta}{\overline{\overline{W}}})}{2} = \frac{A_{\mathrm{FR}}(1-K)}{2}, \tag{10}$$

where θ – total dissipative heat; $K = \frac{\theta}{\overline{\overline{W}}}$ – factor characterizing frequency of energy consumed for heat generation.

Throwing away the second addend (7) we suggest that:

$$U_s \approx U_a = 2\gamma\pi d^2 . \tag{11}$$

Then the condition (5) can be presented as follows:

$$\frac{A_{FR}(1-K)}{2n_r} \approx 2\gamma\pi d^2 . \tag{12}$$

Which is used to determine the influence of work of friction force on surface deterioration with separation of a worn particle:

$$A_{FR}^P \approx \frac{2\gamma\pi d^2 \cdot n_r}{(1-K)}, \tag{13}$$

and taking (9) into account, a number of fretting cycles before deterioration can be obtained:

$$N_\phi^P \approx \frac{\gamma\pi d^2 n_r}{AP\mu(1-K)}, \tag{14}$$

or

$$N_\phi^P \approx \frac{4\gamma S_\phi}{AP\mu(1-K)}, \tag{15}$$

where $S_\phi = \frac{\pi d^2}{4} \cdot n_r$ – area of actual contact.

Strain energy, accumulated in the material of the surface layer immediately before its deterioration, is as follows:

$$U_{def} \approx \frac{\sigma_{\max}^2}{2E} \cdot \frac{\pi d^3}{12} \tag{16}$$

In typical cases of strongly reinforced surface states all critical stresses (yield strength, elastic strength, and etc.) are the values of the same order of magnitude [7]. At the stage of equating inequalities of contact surfaces, the stress in the area of microcontact $\sigma_{\max}$ has the same order of magnitude as the hardness, which is proportional to the modulus of elasticity [7] in many metals. In this case, by equating (16) to (11), assessment of the size of the worn particle is obtained:

$$d \sim \frac{\gamma}{E} \tag{17}$$

Summary. Thus, the analysis of the relations (14), (17) obtained shows that, under other equal conditions, the surface deterioration will be achieved the sooner (under fewer fretting cycles), the smaller the cohesive strength of the material is, the smaller the area of actual contact is, the bigger the friction factor of the tribo-pair and lesser the ability of a material to dissipate in the form of heat delivered mechanical energy are. The size of the worn particle will be smaller in case of material with bigger modulus of elasticity, but will be bigger in case of material with higher cohesive strength. As far as in the accepted model the volume of the separated elementary surface fragment and the volume of the worn particle are identical and proportionate to the diameter of a single contact area, having determined from the equation (14) a number of cycles before deterioration N_{ϕ}^{P}, the intensity of material wear can be estimated.

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Initiation andpropagation of microcracks in aluminum

There were discussed effects of microstructure and grain size on fatigue behaviors such as fatigue strength, crack initiation and propagation behaviors. Data about lengths of microcracks which appear during a loading before revealing of a macrocrack, growth rates of cracks and a kinetics of growth microcracks are obtained.

Essence of a problem. Accumulation and association of dissipated short cracks concerns one of leading mechanisms of damageability and realisation of a limiting condition of it designs, it is necessary to consider at forecasting of their resource.

According to the results of research fractographic breaks of samples with high-cycle fatigue, as well as the results of the study of the kinetics of the process crack growth under cycle fatigue may be considered as a jump process.

For metals micron-sized microcracks formation and coalescence occur in the plastic zone as a result of dislocation-activity and stress concentration.

To understand such fracture behaviors, it is necessary to establish a method to detect microcracks which are undetectable by the existing technologies. Microscopically, fracture can be classified into shear and tensile separation. When a macrocrack propagates, microcracks coalesce three-dimensionally in front of the macrocrack, and fracture resistance (toughness) varies depending on whether the coalescence process is of shear type or tensile type. In effect, it is necessary to classify both microscopic and macroscopic fractures into shear and tensile types, and the formation speed of microcracks can serve as an evaluation parameter of ductility and brittleness.

For macroscopic understanding of fractures, it is necessary to define the propagation of the main crack associated with the material structure. As the main crack often propagates non-uniformly, it is necessary to define the length corresponding to the non-uniform propagation of the crack.

It is known, that process of fatigue of metals is localised in a blanket [1]. With increase in quantity of cycles in all materials the characteristic strip structure - strips of the steady localised shift develops. The substructure in sliding strips can be different depending on material type. Borders of strips and especially their joints often become places of fatigue cracks origin. Transformations in dislocation arrangement which are realised in the course of fatigue tests, have character of "phase transition" in a defective subsystem and occur, as a rule, at achievement of certain ("critical") density of dispositions.

Thus microcracks in plastic materials arise in steady strips of sliding. Therefore the surface is a data carrier about dynamics of exhaustion of carrying ability of constructional elements. Estimation of the blanket condition is considered as a way of fatigue damage diagnostics.

One of fundamental features of multiple destruction of materials is the multystage. Each stage of the destruction process is characterised by separate dimensional level. At each stage there is an origin and growth of the dispersed defects (cracks, pores). Thus transition from a stage of destruction with lower dimensional level of damages on following on which damages have the big sizes, occurs by accumulation of defects in limiting concentration. Such scheme of destruction is inherent practically in all constructional materials and arises at various kinds of power interaction [2].

Stages of damageability at fatigue failure can be write down, as [1-3].: the Stage 1 - accumulation of separate micropores and microcracks statically distributed in volume of metal; stage 2 - development of cracks on borders of grains, twinnings and sliding strips; stage 3 - development of the main crack in a material, with existing system of microcracks.

One of displays of the machine details damage at a cyclic loading is presence of disseminated on the limited surface area the short cracks. Destruction of materials, is caused by the continuous in time processes of cracks origin, growth and association, it is considered universal [4], is called as plural and is characteristic for many damaging factors, for example, for fatigue [5-7], cyclic creep and corrosion.

The quantity of experimental data on plural destruction is very limited. It is connected with labour of input identification and complexity of supervision at the behaviour of a considerable quantity of small defects on a surface of samples.

At presence on the limited area of a surface or in material volume even a small amount of microcracks (MC) which sizes is in an interval 0,1... 10^3 the micron [1-7], always exists final probability of their association. Association of MC carries danger of sudden occurrence of macroscopical defect. Therefore the initial estimation of a limiting condition at a stage of development MC should be made taking into account the factor of association of dissipated defects.

Technique and essence of experiment. Nondestructive evaluation comprises the steps of (1) detecting the presence of defects in materials, (2) locating the position, (3) classifying the type, (4) determining the size and shape of each defect, (5) clarifying the mode of cracking and other characteristics, (6) determining the mode of fracture by considering external load and environmental conditions, and judging the degree of the severity of the defects by using an analysis based on fracture mechanics, (7) making an ultimate judgment on acceptability or, in other words, implementing material screening, and then, (8) for materials that have proved acceptable, evaluating its safety factor and service life. Here, the steps (1) to (5) for detecting defects are in the category of nondestructive test and inspection, while nondestructive evaluation includes the steps (6) to (8) as well. In applying such nondestructive evaluation, therefore, it is necessary not only to enhance the accuracy of nondestructive inspection techniques for detecting defects but also to consider (1) undetectable defects, (2) correspondence between the size of the detected defects and the size of defects leading to fracture, (3) fracture models (representing formation, growth and coalescence processes of micro defects).

The detection of microcracks is indispensable to non-destructive evaluation. Although various microcrack-detection methods, including X-ray, ultrasonic, microfocus X-ray based on electromagnetic equipments, high-frequency ultrasonic and ultrasonic microscope are being developed, it is still impossible to detect internal defects finer than several tens of microns, and there is no method to evaluate the mode of fracture. Although electric resistance, ultrasonic and acoustic emission analyses are used for the detection of microcracks.

Standard corset specimens cut out from sheet aluminum alloy Д-16АТ with the thickness of 1,3 mm with a plating layer, the average grain size on the plating layer is 47 μm. They were loaded on hydro-pulsating machine MUP - 20. The maximum loading in the minimum section was equaled to 250 MPa at frequency of a loading of 11 Hz. A loading cycle - sinusoidal, zero. The base of tests was not less 10^5 cycles. In the present study the fatigue tests were carried out in laboratory air (temperature 16–25 ^{0}C, humidity 40–70%).

After the next stage of a loading the specimen tacked away from loading machine and parameters of microcracks were measured, further the specimen passed the next loading.

The program of tests of specimens on a low-cycle fatigue included research of accumulation processes and development of short cracks before occurrence of a macrocrack, their association and definitive destruction of the specimen.

Identification of cracks, definition of their co-ordinates on the specimen surface sand measurement of it sizes was carried out visually by means of microscope ММР-4 ЛОМО and with application an eyepiece of a micrometer with which it is completed microhardnessmeter ПМТ-3.

After the control of a surface of the specimen the gain of quantity and length of cracks for a stage of tests, density of cracks on the surface area, growth rate of cracks was estimated.

For each microcrack was defined it growth speed $\Delta h = \Delta l / \Delta N$, where Δl - a gain of length of a crack for ΔN loading cycles.

Experimental data and their discussion. Figure 1 shows the relation between the crack length 2*a* of main cracks and the relative number of cycles to fracture cycles $N=N_f$ for two specimens in both alloys. From the figures, the crack propagation curves showed almost similar tendency in both alloys. Plural number of cracks occurred at each specimen, but crack didn't coalesce each other during the fatigue process and each main crack propagated individually. The cracks initiated at very early stage from inclusions near surface, but they propagated very slowly during the early stage.

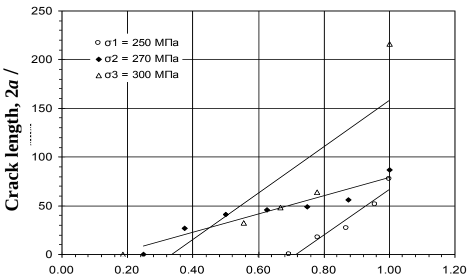

Fig. 1 Relation between crack length 2*a* and ratio of number of cycles to failure $N=N_f$

Process of accumulation of multiple damage can be characterised as formation at first a considerable quantity of small cracks, their gradual growth, and already then their gradual, and subsequently avalanche merges in cracks with much big sizes. The size of the microcracks arising in superficial plated layer of aluminum alloy Д-16АТ proportional to size of structural elements of a material.

Thus microcracks which arise on steady strips of sliding in the middle of grain, extend within grain with certain speed then meeting structural barriers in the form of border of grain they stop or become such that do not extend. Thus a share of cracks which do not grow, or have very small growth rate - considerable (fig. 3). After the crack will overcome border of grain speed of its growth increases, except own growth also at the expense of association with the next cracks. On the basis of the examined laws it is possible to draw a conclusion on casual character of MC growth rate (fig. 2).

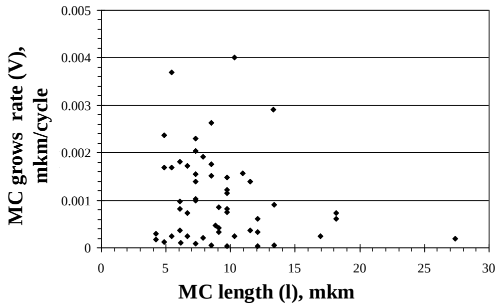

Fig.2. Dependence of the MC grows rate to their length

The quantity of new MC arising for surfaces of the specimen decreases up to a stage before destruction. It confirms the fact of prevalence of process of association MT on the big operating time.

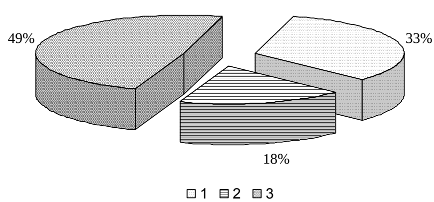

Fig.3. Percentage of MC quantity: 1 – *Δh=0*;
2 – which are disappeared; 3 – which are growing nonstop

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At a cyclic loading dependence of dissipated microcracks quantity from quantity of cycles of a loading as a rule is linear. Thus the final stage of the damage connected with formation of cracks of higher dimensional level, is characterized by reduction of quantity of dissipated defects because of their intensive association. In some cases it leads to reduction of speed of accumulation of cracks and a deviation of corresponding dependence on the linear.

Conclusions

The question of MC growing is investigated. Namely growth rate of cracks and a kinetics of MC growth. Thus received, that on a surface of the specimen the part of cracks grows with constant speed, a part - in steps, the part does not extend, and the part from them disappears, i.e. so-called "healing" MC is observed.

At statistical processing of empirical histograms of crack quantity to their speeds distribution it has been received, that the given distributions are approximated by the indicative law (fig. 3).

The major factor defining destruction at multiple damaging, is association of dispersed cracks, especially at a finishing stage which makes, approximately, 30 % from the general durability. At this stage of growth of the largest crack it is carried out exclusively at the expense of its association with other cracks along a distribution trajectory.

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Noncircular-screw gears

Mathematical model of synthesis of circular-screw gears with asymmetric function of transmission ratio based on the offered main and additional conditions of synthesis is stated in the article. The advantage of application of transmissions by noncircular gears for struggling against resonance oscillations that allows extending the possibility of their application is shown in this work.

Itroduction, Purpose and research problems statement. Creation of reliable and durable transmission gears is the important scientific and practical problem of modern machine-building industry which possible to be solved on the basis of gear transmissions improving by toothing synthesis. One of the ways of gear transmission development by toothing synthesis extending their functional capabilities is designing of gears with a variable transmission ratio (transmissions by noncircular gears).

Experience of such kind of gears implementation created on the base of involute mesh showed the advantage of their using in chain mechanisms and drives of machines for equalization of chain link speeds and elimination of their internal dynamic loads.

In full measure, it is reasonable to apply this method for improving the anti-resonance stiffness of circular-screw gears which have the high load-carrying capacity and widespread in reduction gearboxes of heavy engineering industry. Practice shows that 3 – 5 % of reduction gears failures concerned with any types of vibrations and resonance phenomenon.

However, the development of gearing by synthesis of efficient toothing geometrics with variable transmission ratio providing the assigned transformation law of motion demands the decision of a number of questions such as selection of transfer function ratio, determination of main and additional conditions of transmission by noncircular gears, elaboration of mathematical model of synthesis of efficient geometrics of circular-screw toothing and estimation of their influence upon gearing working capacity etc.

At present time the circular-screw gears which offer the high load-carrying capacity become prevalent for using in reduction gearboxes of heavy engineering industry; development of these gears can be done by means of synthesis of efficient toothing geometrics.

Analysis of Publication, Materials. The scientific works of M.L. Novikov, R.V. Fedyakin, V.A. Chesnokov, A.F.Kirichenko, A.V. Pavlenko, V.A. Krasnoshekov, V.N. Sevruk, V.M. Gribanov, V.P. Shishov and others dedicate to the problems of synthesis of circular gears with circular-screw toothing.

N.I. Mercalov, M.A. Skuridin, O.A. Pyj, N.A. Gaevskiy, N.I. Kolchin, F.L. Litvin, R.S. Varsimashvili, N.L. Ututov, D. Gunter, B. Raingard, M. Kanchiti, I. Kisuko and other made a considerable contribution in research of gearing with variable transmission ratio. They laid the foundation for developing of gearing with noncircular gears and considered the examples of their practical use.

The scientific works of B.M. Abramov, E.L. Airapetov, M.D. Genkin, A.I. Petrusevich A.P. Fillipov, V.K. Grinkevich, S.S. Gutyrya, T. Toshima, K. Masan, D. Wallas, A. Seireg, G. Opits and others dedicated to studying of problems of vibroactivity reducing of gearings with circular gears. It is shown in these works that existing various methods of resonance vibration control of reduction gearboxes (designation of supercritical and subcritical shaft rotational speeds; rise of manufacturing accuracy of gearing production and assembling; modification of construction of gears, housings and shafts; application of special covering of reduction gearbox parts; using of dynamic dampeners and so on) lead to rise in price of construction, increase of mass and size, and for many cases these methods are ineffective and unreliable [1, 3, 4].

Main Chapter. It is determined by investigations that the solvation of anti-resonance stiffness problems of circular-screw gears is possible by using the variable transfer function which allows extending of noncircular gear application including the resonance vibration control of gears. In this case the function of transmission ratio has to have the asymmetric law of variation.

One of the types of asymmetric function of transmission ratio, which provides assigned transformation law of motion, can be obtained as following:

$$i(\varphi_1) = \frac{r \cdot [\xi + \cos(j_1\varphi_1)] + B \cdot \sin(j_1\varphi_1)}{u \cdot r \cdot [\xi + \cos(j_1\varphi_1)] - B \cdot \sin(j_1\varphi_1)}, \qquad (1)$$

which has three main indexes of asymmetric function of transmission ratio: ζ, j_1 and B characterize the degree of asymmetry, frequency and magnitude of transmission ratio changing respectively.

In function (1) i and u are the transmission ratio and transmission number of noncircular gear; r is the mean radius of driving gear centrode; φ_1 is the turning angle of driving noncircular gear; j_1 is the coefficient of asymmetric function of transmission ratio which equals the quantity of maximum values of centrode radius of driving noncircular gear.

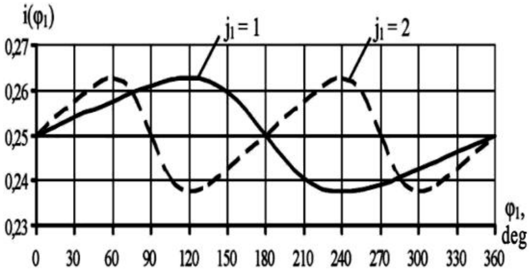


Fig. 1. Charts of asymmetric function of transmission ratio

Figure 1 represents the transmission ratio i – turning angle of driving gear φ_1 diagram.

Mathematical analysis $i(\varphi_1)$ (see fig. 1) shows the following: function (1) is asymmetrical in regard to it's one-half period under $\xi > 1$ and recommended value ξ should be 2; j_1 is whole number. It is recommended to take the quantity of maximum values of centrode radius $j_1 \geq 2$ in order to avoid the mass imbalance.

Making the mathematical analysis of index B which characterizes the variation value of transmission ratio it is possible to determine the dependence of index B from the transmission number of gearing u, the center-to-center spacing aw, and the coefficient of nonuniformity of mechanism motion δ:

$$B = \frac{a_w u\sqrt{3}}{\delta \cdot (u+1)} \cdot \left(\sqrt{u^2 + 2u + \delta^2 + 1} - u - 1 \right). \quad (2)$$

Numerous investigations show that for existing dimension-type reduction gearboxes the values B lie in the range $0 \leq B \leq 13{,}74$ mm.

Thus, under the assigned parameters u and aw the relation (2) allows to select the efficient value B subject to required coefficient δ from additional synthesis criterion $B \leq B_\delta$ where B_δ is index of asymmetric function for required δ.

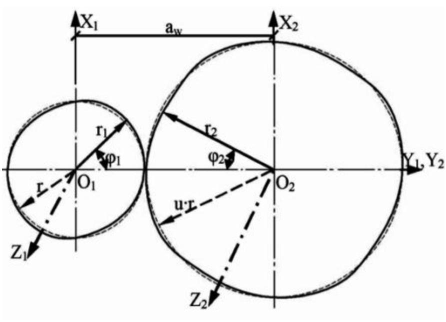
Figure 2 shows the gearing centrodes which radii described by the equations:

for driving gear $$r_1 = r + \frac{B\sin(j_1\varphi_1)}{2+\cos(j_1\varphi_1)}; \quad (3)$$

for driven gear $$r_2 = u \cdot r - \frac{B\sin(j_1\varphi_1)}{2+\cos(j_1\varphi_1)}. \quad (4)$$

In order to estimate the strength factor of gearing we determine the sizes of contact area by the tooth length:

$$C = \frac{\{r[2+\cos(j_1\varphi_1)] + B\sin(j_1\varphi_1)\}(\varphi_1^* - \varphi_2^*)}{[2+\cos(j_1\varphi_1)]\sin\beta}, \quad (5)$$



where φ_1^* and φ_2^* are the angles which count out from straight lines normal to lines which connect the gear's centers.

The analysis of relation (5) shows that contact patch moves around of tooth on the constant distance along it's height and maximum change of contact patch sizes in toothing does not exceed 4,2% from value of other circular

Fig. 2. Gearing centrodes in a fixed coordinate system $X_1Y_1Z_1$ and $X_2Y_2Z_2$ under j_1 2: = r and $u \cdot r$ are the mean radii of centrodes of driving and driven gears

gears.

Using the geometrical-kinematic criterions and forced factors it is possible to realize the theoretical estimate of working capacity of synthesized circular-screw gearings with asymmetric function of transmission ratio by means of their comparison with other types of gearings which have a constant transmission ratio.

Dependance of absolute value of motion relative speed of mesh point from turning angle of driving gear describes by equation:

$$V_C = \frac{\sqrt{K_{VC}}}{r^2\left[2+\cos\left(j_1\varphi_1\right)\right]^2\left(u+1\right)^2\left\{u\cdot r\cdot\left[2+\cos\left(j_1\varphi_1\right)\right]-B\sin\left(j_1\varphi_1\right)\right\}^2},$$

where K_{VC} is the coefficient of absolute value of motion relative speed of mesh point.

Mathematical analysis shows that traverse speed of mesh point along contact line is the variable quantity and depends on the turning angle of gears and value B; changing of value V_C does not exceed 5,7% relative to values for circular gears.

In order to evaluate the wear we generate relations for determination of teeth slip coefficients ϑ_1 and ϑ_2 :

for driving gear $$\vartheta_1 = \frac{\sqrt{K_{VCX}^2 + K_{VCY}^2}}{\left\{u\cdot r\cdot\left[2+\cos\left(j_1\varphi_1\right)\right]-B\sin\left(j_1\varphi_1\right)\right\}\sqrt{K_{VK1}}}; \quad (7)$$

for driven gear $$\vartheta_2 = \frac{\sqrt{K_{VCX}^2 + K_{VCY}^2}}{\sqrt{K_{VK1}}}, \quad (8)$$

where K_{VK1} is the coefficient characterizing absolute value of motion relative speed of mesh point of teeth along contact line of driving gear; K_{VCX}, K_{VCY} are the coefficients of absolute value of motion relative speed of mesh point relatively the axes of coordinates.

Changing of slip coefficients ϑ on the driving and driven gears is equally and directly proportional to value B, and does not exceed 4% relative to values ϑ for circular gears.

Taking into consideration that rotational speed of driving gear ω_1 and moments of inertia of gear's reduced mass $I_{red.1}$ and $I_{red.2}$ are constant, the equation of motion of machine with noncircular gears [5] becomes as following:

$$T_{mot.} = \left[T_{u.r} + T_{add.}\right]\cdot i\left(\varphi_1\right), \quad (9)$$

where $T_{mot.}$ is the moment of motive force on shaft of driving noncircular gear; $T_{u.r.}$ is the moment from forces of useful resistances on shaft of driven noncircular gear; $T_{add.}$ is the additional moment caused by variability of transmission ratio and determined by relation

$$T_{add.} = I_{red.2}\varepsilon_1 \frac{r\cdot\left[2+\cos\left(j_1\varphi_1\right)\right]+B\sin\left(j_1\varphi_1\right)}{u\cdot r\cdot\left[2+\cos\left(j_1\varphi_1\right)\right]-B\sin\left(j_1\varphi_1\right)} + \frac{I_{red.2}\omega_1^2 B j_1 r\left(1+u\right)\left(1+2\cos\left(j_1\varphi_1\right)\right)}{\left[u\cdot r\cdot\left(2+\cos\left(j_1\varphi_1\right)\right)-B\sin\left(j_1\varphi_1\right)\right]^2} +$$

$$+\frac{1}{2}\frac{dI_{red.2}}{d\varphi_1}\left[\frac{\omega_1\{r\cdot[2+\cos(j_1\varphi_1)]+B\sin(j_1\varphi_1)\}}{u\cdot r\cdot[2+\cos(j_1\varphi_1)]-B\sin(j_1\varphi_1)}\right]^2, \qquad (10)$$

where ε_1, ε_2 are the angular accelerations of rotation of driving and driven gears.

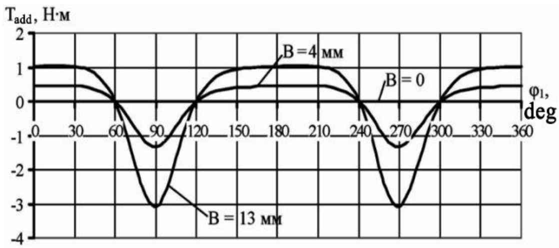


Fig. 3. Additional moment $T_{add.}$ – turning angle φ_1 relation

Analysis of results represented on Fig. 3 shows that change of additional moment $T_{add.}$ per one rotation of driving gear does not exceed 5,8% from the value of external loading moment.

Equation for normal force determination in toothing for driving and driven circular-screw gears looks as the following:

$$F_{N1(N2)}=\frac{T_{Z11(Z22)}[2+\cos(j_1\varphi_1)]\sqrt{K_{1N(2N)}}}{p\{r[2+\cos(j_1\varphi_1)]+B\sin(j_1\varphi_1)\}\sqrt{A_1}\sin\lambda_{1(2)}}, \quad (11)$$

where T_{Z11} and T_{Z22} are the total moments acting upon driving and driven gears respectively; K_{1N} and K_{2N} are the coefficient of normal vector scalar for teeth surface, λ_1 and λ_2 are the turning angles of tool tips under cutting of driving and driven gears; p is the helix parameter.

Mathematical analysis shows that in gearing with asymmetric function of transmission ratio the normal forces in gears mesh under $T_{mot.}$ = const and $T_{u.r.}$ = const have variable values; at the same time a change of F_N in gears mesh per one revolution of driving gear becomes no more than 3,7% from the magnitude for circular gears.

According the results of conducted comparative analysis for synthesized gearing with circular gear transmissions we conclude that there is a possibility to use the circular-screw gearing with asymmetric function of transmission ratio for application in reduction gearboxes of heavy engineering industry.

Field experience [1, 3, 4] confirms that impulse excitation (teeth concussion at the time of input and output out of mesh) is the main reason for vibration onset provoking in gearing. In reduction gearboxes the first pass of gearing is a most vibro-active zone. Under the coincidence or multiplicity of frequency of natural and forced vibrations the resonance occurs.

Analytical dependence for finding a frequency of natural vibrations of transmission by noncircular gears has the following type:

$$f_c = 3{,}15 \cdot 10^5 \cdot \frac{(1+u)\cdot\sqrt{1+u^2}}{2a_w u}. \quad (12)$$

Equation for determination of tooth mesh frequency of forced vibrations of transmissions with asymmetric function of transmission ratio under the impulse excitation obtained as follows:

$$f_z = \frac{\omega_1 a_w \{r\cdot[2+\cos(j_1\varphi_1)]+B\sin(j_1\varphi_1)\}}{286{,}5\cdot m\cdot(u+1)\cdot r\cdot[2+\cos(j_1\varphi_1)]}, \quad (13)$$

where ω_1 is the rotational speed of driving gear; m is the toothing module.

Taking into account (12) and (13), the resonance (critical) frequency of noncircular gear expressed by relation:

$$\omega_{1crit.} = 8{,}8\cdot 10^4 \cdot \frac{m\cdot r\cdot[2+\cos(j_1\varphi_1)]\cdot(1+u)^2\sqrt{1+u^2}}{a_w^2 u\cdot p\cdot\{r\cdot[2+\cos(j_1\varphi_1)]+B\sin(j_1\varphi_1)\}}. \quad (14)$$

The graph of $\omega_{1crit.} - \varphi_1$ curve is represented on the figure 4.

The analysis of equations (12) – (14) shows that critical rotational speed of shaft ω_{1res} with noncircular gear changes for its one revolution, B is the variation value of critical rotational speed (see Fig. 4). It is determined that in transmissions by means of noncircular gears the tooth mesh frequency f_z of forced vibrations is variable value, and does not coincide and multiple its natural frequency f_{nat} of vibrations. Conducted theoretical investigations of resonance vibrations of transmissions by means of noncircular gears came to conclusion that asymmetric law of changing of transmission ratio function prevents from resonance occurrence.

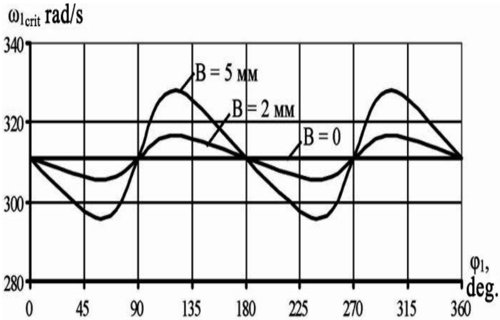


Fig. 4. Resonance rotational speed of driving gear from impulse excitation

In order to decrease the resonance [3] risk of rotational speed ω_1 of driving noncircular gear it is necessary to follow the criterion:

$$\begin{cases} \omega_1 \ge (1+K)\cdot\omega_{1crit}^{o} \\ \omega_1 \le (1-K)\cdot\omega_{1crit}^{o} \end{cases}, \quad (15)$$

where K is the coefficient which define margin of resonance origin zone, $\omega_{1crit.}^{o}$ is the resonance rotational speed of driving gear of transmissions by means of noncircular gears, which determined by relation:

$$\omega^{o}_{1crit} = 8{,}8 \cdot 10^4 \cdot \frac{m \cdot (1+u)^2 \sqrt{1+u^2}}{a_w^2 u \cdot p}. \qquad (16)$$

Considering (14) – (16) and using mathematical transforms, the equation for $B_{crit.}$ definition will have the type:

$$B_{crit} = 0{,}82 \cdot K \cdot \frac{r \cdot [2 + \cos(j_1\varphi_1)]}{\sin(j_1\varphi_1)}. \qquad (17)$$

Therefore, value B has to satisfy conditions of additional synthesis matter: $B \geq B_{crit}$.

Thus, value B of function $i(\varphi_1)$ which characterises variation value of transmission ratio, is chosen from condition $B_{crit} \leq B \leq B_{\delta}$.

Experimental investigations for determination of coefficient K and comparative tests of gearing by means of noncircular gears with asymmetric function of transmission ratio and transmissions by means of circular gears were conducted. Experimental investigations provided with the purpose of practical approbation of results and conclusions which derived under theoretical study of toothing and contain the following: control of transmission ratio, comparative assessment of vibration resonance of transmissions by noncircular gears with asymmetric function of transmission ratio (under the different meanings of coefficient K) and transmissions by circular gears. For these:

– device for gear-milling machine 5K32 which makes the teeth cutting of noncircular gear is engineered and manufactured;

– according results of theoretical calculations, the experimental noncircular gears with circular-screw toothing for double-reduction gearbox are synthesized and produced;

– measurement complex including the stand for inspection of centrode production accuracy and transmission ratio accuracy is prepared;

– complex for vibration measurement of gearbox under rotational speed of driving shaft up to 356 rad/sec is prepared;

– procedure of experimental investigations of resonance vibrations of gearing is developed;

– bench tests of experimental gearings and circular gearings, as well as their comparison characteristics are presented.

Experimental gearings made by steel 40X GOST (State Standard) 4543-71. Heat treatment: pinion gear – refining up to HB 269…302, gearwheel – refining up to HB 235…262. Characteristic of transmissions is represented in Table. 1.

Table 1.

Characteristic of experimental transmissions

<table>
<tr><th rowspan="2">Designation of parameter</th><th colspan="4">1st pass</th><th colspan="4">2nd pass</th></tr>
<tr><th colspan="3">Non circular</th><th>Circular</th><th colspan="3">Non circular</th><th>Circular</th></tr>
<tr><td>Normal module m_n, mm</td><td colspan="3">3,0</td><td>3,0</td><td colspan="3">3,0</td><td>3,0</td></tr>
<tr><td>Transmission ratio u</td><td colspan="3">2,0</td><td>2,0</td><td colspan="3">2,0</td><td>2,0</td></tr>
<tr><td>Number of teeth:
–pinion gear z_1
– gearwheel z_2</td><td colspan="3">
21
42</td><td>
21
42</td><td colspan="3">
32
64</td><td>
32
64</td></tr>
<tr><td>Axle base a_w, mm</td><td colspan="3">100</td><td>100</td><td colspan="3">150</td><td>150</td></tr>
<tr><td>Coefficient K</td><td>0,06</td><td>0,08</td><td>0,15</td><td>0</td><td>0,06</td><td>0,08</td><td>0,15</td><td>0</td></tr>
</table>

On the Fig. 5 the transmission with noncircular gears is obtained.

Estimation of transmission's transmission ratio of experimental gearings and gearbox in whole was conducted under the testing (Fig. 6).

Fig. 5. Double-reduction gearbox with noncircular gears

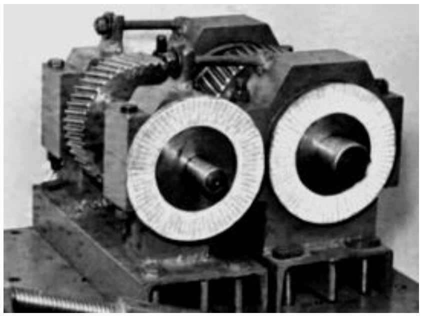
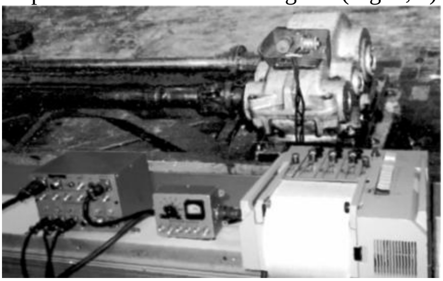


Fig. 6. Stand for transmission ratio inspection

In result of conducted experiment the following conclusion was made up: change of transmission ratio strictly corresponds to relative change of centrode radius of noncircular gears. At the same time, the maximum discrepancy between theoretical and experimental results of transmission ratio values of gearbox amounts to 6%.

In order to define the vibration level in gearbox with noncircular gears, the stand with closed-loop power was engineered; vibration-measuring apparatus ВИ6-6ТН together with self-recording instrument Н 327-3 was used for experiments (Fig. 7). On the housing of research gearbox the following objects were set up: vibration detector ДВ-1СГ for detection of vibration in horizontal plane and ДВ-1-СВ – for vertical plane. Testings were carried out in regime of smooth variations of rotational speed of driving shaft ω_1 from 0 to 356 rad/sec, and vibrations recorded by using self-recording instrument H 327-3. According results of conducted experiment the following things were determined: with the same character of vibrations, the vibration amplitude in vertical plane is much greater of vibration amplitude in horizontal plane; in gearbox with circular gears under ω_1 = 298 rad/sec, the sharp increase of vibration amplitude Y (Fig. 8, a) has been stated; in gearbox with noncircular gear under K = 0,15 on the full scale of rotational speed of driving gear, the increase of vibration amplitude has not been observed (Fig. 8, d); under K = 0,08 the maximum magnitude of vibration amplitude comparing with magnitude under K = 0,15, has increased 1,5 times in speed range ω_1 from 272 up to 323 rad/sec (Fig. 8, c); under K = 0,06 the maximum magnitude of vibration amplitude comparing with magnitude under K = 0,15, has increased 3,5 times in speed range ω_1 from 281 up to 315 rad/sec, and at the same time the maximum values of amplitudes approached to amplitude values for circular gears (Fig. 8, b).



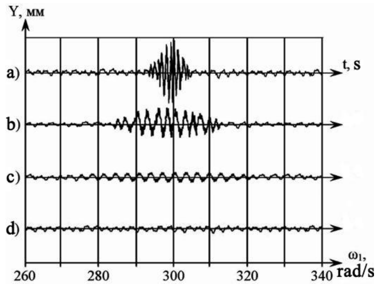


Fig. 7. Stand for measurement of gearing vibrations

Fig. 8. Oscillogram of vibrations in gearboxes

a) with circular gears; b) with noncircular gears under K = 0,06; c) with noncircular gears under K = 0,08; d) with noncircular gears under K = 0,15

Graphs analysis (Fig. 8) showed that border of resonant zone appearance observes under K = 0,08. It allows giving the recommendations by definition of index B in asymmetric function of transmission ratio.

Realized testing of two-stage gearbox with noncircular gears and common constant transmission ratio for recommended value K = 0,08 under B from 2 up to 7 mm has showed the following: at a full range of rotational speed of driving shaft there was no increase of vibration amplitudes to be observed, which conforms the theoretical background

Conclusions

Submitted results of conducted theoretical and experimental researches which let us to come to following conclusions:

1. Mathematical model of synthesis of circular-screw gears with asymmetric function of transmission ratio is developed. The efficient geometrical parameters of toothing (upon proposed supplementary conditions of synthesis) which secure the operating regime of gearing with no resonance effect ($B \geq B_{crit}$) and required

coefficient of nonuniformity of motion δ ($B \leq B_{\delta}$) are determined on basis of synthesis task solution.

2. Theoretical analysis of working capacity of synthesised gearings by means of comparing with gearings with constant transmission ratio is carried out.

3. Estimation of resonance vibrations of transmissions with noncircular gears with asymmetric function of transmission ratio from impulse excitation is carried out. Dependances for definition of border of resonant vibrations zone appearance are detected.

4. Experiment-calculated works for the purpose of transmission ratio control and estimation of resonance vibrations of gearings by noncircular gears with circular-screw mesh are carried out. As a result of testing it was determined that in gearbox with noncircular gears with symmetric function of transmission ratio in a whole range of ω_1 for recommended value K, the increasing of vibration level has not been observed.

5. One of the ways of circular-screw gears development by synthesis of rational mesh geometrics with asymmetric function of transmission ratio which guarantees the specified low of energy conversion and expanding the functional capabilities of application of transmissions with noncircular gears for resonance vibrations struggling is proposed.

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Power losses of gear systems

This paper provides a review of experimental investigations and available models of gear load-independent power losses (windage losses, churning losses and air-oil pocketing power losses) for spur, helical, and bevel gears. The aim of the review is to provide a comprehensive compilation of published information on gear load-independent power losses to assist gearbox designers in identifying relevant experimental and modeling information. While it is clear from the review of published work that the rotational speed, gear geometrical parameters, degree of confinement, and density of the fluid surrounding the gear are important, the degree of effect and general solutions for reducing power loss are less clear. The motivation for this is that for some applications, this power loss can be a significant component, particularly lightly loaded high-speed applications.

Introduction. Environmental awareness is pushing mechanical engineers to develop mechanical systems, and in particular gear units, that have lower environmental impact. Such objective can be reached through different perspectives: reduce gear power loss and improve efficiency, reduce gear operating temperature, reduce friction between gear teeth, reduce gear load-independent power losses. The losses associated with meshing gears are important in the design of many industrial, marine, and gas turbine situations. Gearbox efficiency varies from 98% to 99% for the best designed high power applications. The highest rated gearboxes now exceed 100 MW [Weiss, T., and Hirt, M., 2002], so for such a gearbox a 1 per cent power loss equates to 1 MW and this is not insignificant.

Power losses of a gearbox containing several gear pairs that are supported by shafts and rolling element bearings can be classified into two groups. The first group is comprised of load-dependent (friction-induced) power losses caused primarily due to contacting surfaces of gears and the bearings. The losses in the second group are independent of load and are often referred to as spin power losses. There are many sources of such losses, the primary ones being oil churning and windage that are present as a result of oil/air drag on the periphery and faces of the gears, pocketing/squeezing of lubricant from the cavities of the gear mesh, and viscous dissipation of bearings. While losses from these two groups are often comparable under high-load, low-speed conditions, the spin losses were shown to dominate over the load-dependent power losses at higher operating speed conditions. Of the total losses, for a typical gearbox, 40 per cent come from meshing, 50 per cent from bearings, and 10 per cent from windage and churning [Lord, A. A., 1998]. Windage power loss (WPL) is defined as the power loss due to the fluid drag experienced by the gear when it is running in air or an air-oil mist. Churning power loss (CHPL) is defined as the power loss when a gear is running in an oil bath or is dipping into oil “slugs.” During the meshing of high-speed spur or helical gears, the mixture of air and lubricant is successively compressed and expanded in the intertooth spaces giving rise to significant heating and power loss named as air-oil pocketing power losses.

Windage Power Losser. Estimates on the percentage effect of windage vary as the value is dependent on a number of different parameters. One of the critical parameters is the pitch line velocity; obviously, high velocities ([Townsend, D. P., 1992] suggests 51 m/ s, and [Diab, Y., Ville, F., and Velex, P., 2006] suggests tangential speeds greater than 90–120 m/ s) produce greater stirred motion, so large gears rotated at high rotational rates are particularly vunerable. Additionally, the lubrication flow rate and scavenge design are critical as these directly affect the properties of the fluid surrounding the gear [Townsend, D. P., 1992], [Akin, L. S., and Mross, J. J., 1975]. So, in a case where you have a high level of lubricant suspended around a gear with high pitch velocity, as is the case of an aero-engine, windage becomes a significant contributor to the power loss. It may only account for a few percent, but this can be critical. Traditionally, there have been two approaches to reducing WPL; the first is to use a shroud or baffle to enclose gears and the second is to positively pump the oil and air from the gearbox casing. Pumping from the gearbox casing is known as evacuating the gearbox [Weiss, T., and Hirt, M., 2002], and allows a reduction of fluid density within the casing. This can result in up to 1% improvement in efficiency but can only be used in a limited number of situations.

Published gear windage power losses experiments, which have been few and far, can be grouped based on their primary focus. One group of studies focused on the measurement of air windage losses [Dawson, P. H., 1984] by measuring the deceleration of a single gear or disk rotating in air, and then applying the kinetic energy theorem to obtain power loss from air drag. [Diab, Y., Ville, F., Velex, P., and Changenet, C., 2004] used the tool of dimensional analysis to define an empirical windage moment coefficient in terms of speed, oil properties, Reynolds number, gear size, tooth parameters, and the geometry of nearby fluid flow obstructions such as close-fitting gear case walls. While applicable to a single disk or gear rotating in air, these models did not consider the effects of a meshing gear or impinging oil jet, and so cannot be validated using geared transmissions.

As an alternative, [Ariura, Y., Ueno, T., and Sunaga, T., 1973] and [Anderson, N. E., and Loewenthal, S. H., 1981], [Anderson, N. E., and Loewenthal, S. H., 1982] developed empirical models for meshed spur gears based on pitch radius, face width, rotational speed, and viscosity of the ambient fluid. Likewise, [Mizutani, H., 1999], based on measurements of high-speed, long addendum spur gears, reported that windage power loss was proportional to the 2.8th power of the rotational speed and also that the inertial losses resulting from the impinging oil jet were linearly proportional to the rotational speed. Here, the inertial losses from the impinging oil jet were shown to increase with oil jet pressure, and composed a significant portion of load-independent power loss.

Table 1 is divided into experimental and modeling studies into WPL for spur, helical, and bevel gears.

Oil churning power losser. Most of experimental studies considered a single gear, disk, or bladed rotor immersed in oil [Daily, J., and Nece, R., 1960], [Mann, R., and Marston, C., 1961], [Soo, S. L., and Princeton, N. J., 1958]. These oil churning studies were also devoted to developing empirical equations to obtain a dimensionless churning moment coefficient. [Daily, J., and Nece, R., 1960] proposed four different flow regimes around a rotating disk fully submerged in fluid and correlated these flow regimes to Reynolds number and enclosure effects based on experimental results. Mann and Marston [Mann, R., and Marston, C., 1961] studied friction drag of bladed and unbladed disks and related experimental results to a moment coefficient based on Reynolds number and axial clearance with the chamber, etc.

However, in the case of gears, there are fewer empirical models and, because of experimental difficulties, measurements of thermal performance and power losses have been limited. The first in situ temperature measurements date back to the classic works by [Blok, H., 1937], [Niemann, G., and Lechner, G., 1965], while the specific studies on churning losses comprise those of [Terekhov, A. S., 1975], [Lauster, E., and Boos, M., 1983] and, more recently, [Boness, R. J., 1989] and [Changenet, C., and Velex, P., 2007].

[Terekhov, A. S., 1975] developed empirical relations for a dimensionless moment coefficient from numerous experiments on gears rotating partially submerged in a fluid and identified separate power loss equations for meshed gears rotating upward or downward in an oil bath. [Boness, R. J., 1989] conducted friction torque tests with a simple bench setup using smooth disks of various diameters and face widths, which were partially submerged in high-viscosity oil, and compared these results to experimental observations with a gear (See table 2).

More recent efforts using similar methods include that by [Höhn, B.-R., Michaelis, K., and Vollmer, T., 1996], [Luke, P., and Olver, A., 1999], and [Changenet, C., and Velex, P., 2007].

[Luke, P., and Olver, A., 1999] performed a number of experiments to determine churning loss in single and meshed spur gear pairs. They compared their experimental observations on spin power losses with the empirical formulations of [Boness, R. J., 1989] and [Terekhov, A. S., 1975] and found that contrary to what Bones had predicted, the spin power losses were not strongly affected by the viscosity of the lubricant. Furthermore, their observations called into question the attempt used to characterize spin power loss based on a Reynolds number dependent on lubricant viscosity.

[Ariura, Y., Ueno, T., and Sunaga, T., 1973] measured losses from jet-lubricated spur gear systems experimentally. They proposed an analysis of the power required to pump the oil trapped between mating gears.

[Akin, L. S., and Mross, J. J., 1975], [Akin, L. S., Townsend, J. P., and Mross, J. J., 1975] analyzed the effect of rotationally induced windage on the lubricating oil distribution in the space between adjacent gear teeth in spur gears. The purpose of their study was to provide formulations to study lubricant fling-off cooling. They proposed that impingement depth of the oil into the space between adjacent gear teeth and the point of initial contact was an important aspect in determining cooling effectiveness.

[Pechersky, M. J., and Wittbrodt, M. J., 1989] analyzed fluid flow in the meshing zone between spur gear pairs to assess the magnitude of the fluid velocity, temperature, and pressures that result from meshing gear teeth.

A more recent study by [Changenet, C., and Velex, P., 2007] investigated the influence of meshing gear on oil churning power losses by performing a number of gear oil churning experiments to come up with empirical formula for power losses. Parameters included were gear module, diameter and face width, speed, and lubricant viscosity. Their empirical formula (See table 2) suggested that the influence of viscosity on oil churning loses is insignificant with regard to viscosity at high speeds of rotation for single gears, corroborating similar findings from the experimental observations of [Luke, P., and Olver, A., 1999].

Another relevant work by [Höhn, B.-R., Michaelis, K., and Vollmer, T., 1996] also stresses this apparent lack of dependence of oil type on load-independent losses. In their experiments, [Höhn, B.-R., Michaelis, K., and Vollmer, T., 1996] measured gear and bearing power losses, and forged a balance between generated heat in the gearbox due to gears and bearings and the dissipated heat in the form of free and forced convection and through radiation as well, from housing and rotating parts, to calculate mean lubricant temperature.

Conclusions

This review describes a number of studies that have investigated gear windage and churning power loss. While it is clear from all of these investigations that the rotational speed, gear geometrical parameters, degree of confinement, and density of the fluid surrounding the gear are important, the degree of effect and general solutions for reducing power loss are less clear. The majority of the modeling methodologies are experimental correlations derived from specific experiments that have unique elements, making a general conclusion regarding the best methodology difficult. The methodologies do allow a general assessment of the expected levels of gear windage and churning present in a specific design and possible routes to reducing gear windage and churning power loss. It is clear from this review that a modeling methodology capable of being used for all gear types and configurations is required, which allows analysis of the fluid dynamics phenomena.

Nomenclature

d = pitch diameter (m)
β = helix angle (deg)
b = face width (m)
r = pitch radius (m)
m = tooth module
z = number of teeth
N = rotational speed (rpm)
ω = speed (rad/s)
Re = Reynolds number
Fr = Froude number
h = immersion depth of a pinion (m)
S_m = immersed surface area of the pinion (m^2)
ρ = density
V_0 = oil volume (m^3)

i = current (amps)
v = voltage (volts)
μ = dynamic fluid viscosity
ν = kinematic viscosity (m^2/s)

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Table 1.

Experimental studies of windage power loss

		Authors	Object	Design parameters test spur gears	Conclusions	Empirical models: Determination of WPL
1	2	3	4	5	6	7
Spur Gears	windage due to single spur gears in isolation	[Dawson, P.H., 1984, 1988]	WPL vs speed, size, gear geometry, and shrouding for single spur gears in air	37 gears of root diameter 300–1160 mm with face widths of 32–187 mm and tooth modules of 2–24 mm	• Main contributors to WPL were the teeth. • Teeth may be acting as a centrifugal fan drawing in air axially at the ends of the teeth and ejecting it radially toward the middle of the face.	$N^{2.9}(0.16d^{3.9}+d^{295}b^{0.75}m^{1.15})*10^{-20}\Phi\ \lambda$ Φ=1-oil free atmosphere, λ=0.6-0.7-gear in free space, λ=0.6-0.7-gear in a large enclosure, λ=0.5–0.6-“fitting” gear case. $1.12*10^{-8}C^{*}\rho N^{2.85}d^{4.7}\nu^{0.15}\lambda$ C^{*} is obtained from [Dawson, P.H., 1984].
		[Lord, A. A., 1998]	Axial and peripheral shrouding single and meshed gears at speeds ranging from 0 to 20, 000 rpm.	Pitch diameters 200 mm, face width of 40 mm, and modules 1 and 5 Axial clearance from 1 mm to 10 mm	• Maximum WPL was experienced for a spur gear of Module 4 and that the minimum was seen for that of Module 1. • Shrouding a single gear in air reduces WPL to 25% of their unshrouded values. • With a1 mm peripheral clearance, WPL at high speeds was reduced by 75%. • Relationship between WPL and peripheral clearance was approximately linear.	Module 1 $2.9\rho\omega^3r^{3.51}m^{1,06}F^{0.42}$Module 1.25-4 $2.9\rho\omega^3r^{3.51}m^{1,06}F^{0.42}$Module 5 $2.9\rho\omega^3r^{3.42}m^{1,16}F^{0.42}$The predictions from these expressions were found to lie within ±15% of the experimental data.
		[Diab, Y., Ville, F., Changenet, C., and Velex, P., 2004]	Dimensional analysis the gear geometry at speeds ranging from 0 to 12, 000 rpm.	Pitch diameters from 144 mm to 300 mm, face width of 30–60 mm, and modules 4 and 6	• Speed appears as a key factor, since windage losses become very significant at high speeds. • Influence of the teeth is found to be significant with WPL ratio of about 5:1 when comparing a gear and a disk. • Introducing obstacles such as flanges can therefore reduce the air aspiration and ejection by the rotating teeth and modify the corresponding power loss.	$\frac{1}{2}C_t\rho\omega^3r^5$, with:$C_t=C_f+C_l$, C_f - dimensionless moment at the front and rear faces of the gear, C_l - dimensionless moment at the teeth of the gear = $\xi\frac{z}{4}\left(\frac{b}{r}\right)\left[1+\frac{2(1+x)}{z}\right]^4(1-\cos\phi)(1+\cos\phi)^3$ $C_f=60Re^{-0.25}\left(\frac{b}{r}\right)^{0.8}z^{-0.4}\left\{\left(\frac{h_1}{r}\right)^{0.56}+\left(\frac{h_2}{r}\right)^{0.56}\right\}$ h_1,h_2- characteristic the presence of a deflector, a flange

1	2	3	4	5	6	7
1	Closed-loop systems	[Anderson, N. E., and Loewenthal, S. H., 1983]	WPL vs speed, size, gear geometry,		•' developed empirical models for meshed spur gears based on pitch radius, face width, rotational speed, and viscosity of the ambient fluid	$2.82 * 10^{-7} N^{2.8}\left(1+2.3\frac{b}{r}\right)(0.028\nu+0.019)^{0.2}$
		[Petry-Johnson, T., Kahraman, A., Anderson, N. E., and Chase, D. R., 2008]	WPL at speeds from 0 to 10, 000 rpm.	Number of teeth 23 and 40, face widths of 14,7; 19.5 and 26.7 mm and tooth modules of 2.32 and 3.95 mm	•The 23-teeth gear pair, with *m* = 3.95 mm, is predicted to have more windage power loss than the 40-teeth gear pair having *m* = 2.32 mm. • Variation of the total WPL with face width is primarily due to the windage pocketing power loss	$0.025\pi\rho\omega^{2,86} r_a^{4.72}\mu^{0,14}$

Table 2.

Experimental studies of windage power loss (continued)

		Authors	Object	Design parameters test spur gears	Conclusions	Empirical models: Determination of WPL
1	2	3	4	5	6	7
Helical Gears	windage due to single spur gears in isolation	[Dawson, P.H., 1984, 1988]	Effect of vary-ing helix angle for a single gear	Helix angle from 0 deg to 50 deg Diameter of 0.514 m and a face/diameter ratio of 0.364	• power loss reduces with helix angle up to the 50 deg	$1.12 * 10^{-8} C^{*}\rho N^{2.85} d^{4.7}\nu^{0.15}\lambda C^{*}$ - shape factor, related to the number ofteeth, face width to diameter ratio of the gear
		[Handschuh, R. F., and Kilmain, C. J., 2003]	efficiency of high-speed helical gear trains	Speeds were varied up to 15,000 rpm and loads up to 3.7 kW Number of teeth 50, 51 and 139, face widths of 67,2 mm and tooth module of 3.033 mm, helix angle 12 deg	• High gearing system rotational speed has a drastic effect on the efficiency of high-speed gear trains. • Windage losses will dominate the performance when light loads and high speed is applied to the gear meshing system. • When their gear system was operated in the range of 33–100% of full load and 83–100% full speed, the losses and, thus, efficiency were significantly influenced by windage, with WPL being nearly equal or exceeding those due to meshing.	$32C_2N^3r^5+16C_3N^3r^4b\left(\frac{R_f}{\sqrt{\tan\beta}}\right)$ C_2, C_3 – constants; R_f - is the rough surface adjustment factor Dawson's [Dawson, P.H., 1984, 1988] and Townsend's [Townsend, D. P., 1992] empirical models with correlations for windage, but made no comment on the accuracy of the correlations as their experiments measured total power loss rather than isolating windage.

1	2	3	4	5	6	7
		[Lord, A. A., 1998]	windage and meshing losses	Pitch diameters 200 mm, face width of 40 mm, and modules 1 and 5 Axial clearance from 1 mm to 10 mm	• WPL for a helical gear was lower than for a comparable spur gear. • reduction in WPL was due to the air motion around the gear teeth, with the flow into and out of spur teeth requiring a change in direction of 90 deg while the helical gear required a shallower change of direction.	Module 1 $2.9\rho\omega^3 r^{3.51} m^{1,06} F^{0.42}$ Module 1.25-4 $2.9\rho\omega^3 r^{3.51} m^{1,06} F^{0.42}$ Module 5 $2.9\rho\omega^3 r^{3.42} m^{1,16} F^{0.42}$
		[Diab, Y., Ville, F., Velex, PM., 2005]	influence of the proximity of a flange	Pitch diameters 288 mm, face width of 30 mm, and modules 4 mm, helix angle 15 deg	• The influence of rotation direction was noted, with a reduction of 38% noted for anticlockwise rotation for the best performing flange gap, while a 15% reduction was seen in the clockwise direction.	$\xi \frac{z}{4}\left(\frac{b}{r}\right)\left[1+\frac{2(1+x)}{z}\right]^4 (1-\cos\phi)(1+\cos\phi)^3(1-\sin^2\beta)$
Bevel Gears		[Winfree, D. D., 2000]	shrouding (baffling or containment) of a single spiral bevel gear	15 in. gear constructed from a rigid urethane compound	• Gears traveling over 51 m□□s must be shrouded. • Spiral bevel gear rotating direction has no effect on baffle design and that bevel gears pump from the inside to the outside across the tooth • Closing the gear inlet end reduces windage, churning, and power usage.	$\frac{v\times i}{745.7}$ with i - current (amps), v - voltage (volts). $C_f = \frac{P_W\times 10^{17}}{N^3 d^5 b^{0.7}}$ - windage correction factor

Table 2.

Experimental studies of churning power loss

Authors	Object	Design parameters test spur gears	Conclusions	Empirical models: Determination of CHPL
1	2	3	4	5
[Terekhov, A. S., 1975]	Dimensional analysis the gear geometry.	High viscosity lubricants (from 200 to 2000 Cst), Low rotational speeds, and tested gears with	• Churning power loss is independent of gear tooth geometry. • Churning power loss depends on the flow regime. • Churning power loss were not strongly affected by the viscosity of the lubricant.	$P_{ch} = \rho\omega^3 b r^4 C_m$ For laminar flows (10$< Re <$2250), if $Re^{-0.6}Fr^{-0.25} > 8.7\times 10^{-3}$ $C_m = 4.57 Re^{-0.6} Fr^{-0.25}\left(\frac{h}{r}\right)^{1.5}\left(\frac{b}{r}\right)^{-0.4}\left(\frac{V}{V_0}\right)^{-0.5}$ For turbulent flows otherwise

1	2	3	4	5
		modules ranging from 2 to 8 mm.		(2250$< Re <$36$C_m = 2.63Re^{-0.6}Fr^{-0.25}\left(\frac{h}{r}\right)^{1.5}\left(\frac{b}{r}\right)^{-0.17}\left(\frac{V}{V_0}\right)^{-0.73}$,000)$C_m = 0.373Re^{-0.3}Fr^{-0.25}\left(\frac{h}{r}\right)^{1.5}\left(\frac{b}{r}\right)^{-0.124}\left(\frac{V}{V_0}\right)^{-0.576}$
[Lauster, E., and Boos, M., 1983]	CHPL vs speed, immersion depth, gear geometry	Specific case of truck transmissions	• Churning power loss is independent of gear tooth geometry and flow regime.	$P_{ch} = \rho\omega^3 br^4 C_m C_m = 2.95Re^{-0.15}Fr^{-0.7}\left(\frac{h}{r}\right)^{1.5}\left(\frac{b}{r}\right)^{-0.4}\left(\frac{V}{V_0}\right)^{-0.5}$
[Boness, R. J., 1989]	drag torque generated by discs and gears rotating in water, or in oil	Disks of various diameters and face widths	• Drag torque increases with an increasing Reynolds number. • Low viscosity lubricants generate higher losses.	$P_{ch} = \frac{1}{2}\rho\omega^3 S_m r^3 C_m$For laminar flows ($Re <$2000) $C_m = \frac{20}{Re}$For laminar flows (2000$< Re <$100,000) $C_m = 8.6 \times 10^{-4} Re^{1/3}$For turbulent flows (100,000$< Re$) $C_m = \frac{5 \times 10^8}{Re^2}$
[Changenet, C., and Velex, P., 2007]	100 experiments influence of temperature on lubricant viscosity	Number of teeth 20 - 102, face widths of 14 and 24 mm and tooth modules of 1.5 - 5 mm	• To minimize energy losses, one possible way to improve churning losses consists in changing the shape of the casing. • Total loss is not equal to the sum of the individual losses associated with the pinion and the gear when considered apart	$P_{ch} = \frac{1}{2}\rho\omega^3 S_m r^3 C_m$If $\omega rb/\nu = Re <$6000 $C_m = 1.36Re^{-0.21}Fr^{-0.6}\left(\frac{h}{d}\right)^{0.45}\left(\frac{V_0}{d^3}\right)^{0.1}$ If $\omega rb/\nu = Re >$ 9000 $C_m = 3.644Fr^{-0.88}\left(\frac{h}{d}\right)^{0.1}\left(\frac{b}{d}\right)^{0.85}\left(\frac{V_0}{d^3}\right)^{-0.35}$

UDC 621.314; 621.391

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The principles of the organization of nondestructive testing at the enterprise.

Considered structure of divisions of testing NDT on aviation companies, relationships of testing services with other divisions of the enterprise, account and registration of testing results.

The organization of testing service of quality covers practically all spheres and stages of a production activity of the air enterprises. Quality testing is a component of a quality testing system. The service structure substantially depends on structure and type of the air enterprise and its production tasks.

The organization of quality testing of VS is called the system of the technical and administrative actions aimed at providing a standard level of quality; studying of object of testing, i.e. nature of quality of materials and products; providing the level of quality and reliability of products, first of all by active impact of testing on technological process; assistance for development of a conscientious attitude to work at constantly operating and accurate system of encouragement for high quality of work; ensuring independence of bodies of acceptance and technical testing from the production personnel; unconditional observance of requirements of standard documentation.

The developer establishes high requirements to quality of VS and performance of technological works. Observance of requirements has to be provided whenever possible at the minimum expenses of time and funds for testing performance. Testing services of quality have to promote product quality testing by systematic and purposeful impact on conditions and the factors influencing quality of production.

The main objectives of testing service are: systematically, in due time and objectively to check quality of arriving materials and products, quality of technological (assembly) works, quality of produced production, technical condition of products in use, to use effective ways and control devices according to the requirements of existing documentation; to prevent transfer of defective production for performance of the subsequent technological operations or customer delivery; to promote improvement of design quality, technological, installation, repair and other works; to make acceptance of the executed operations and works with registration of necessary technical documentation and to participate in delivery of materials and products to the customer; to develop the organizational and technical actions directed on prevention of marriage and improvement of development and production quality, and also on increase of a technological level of VS operation; to carry out laboratory researches on nondestructive control, durability and tightness of materials and products; to develop, improve methods, testing devices and quality estimates; to organize quality testing at production, operation, service and VS repair.

***Structure of divisions of testing*.** At the modern enterprises uniform complex departments (laboratories) of nondestructive testing are created. The approximate structure of department of the NDT is given in fig. 39. All groups which are a part of division, have to take place territorially in the general complex. Use of sources of ionizing radiation causes need of creation of protective equipment and safe conditions for work of operators and the persons which are in the neighboring rooms. Therefore when developing the NDT department (laboratory) project it is necessary to be guided "By the basic health regulations during the work with ionizing radiation" OSP-76.

Planning of rooms for NDT, is identical to the majority of air and machine-building enterprises. Generally testing of materials and products all methods of NDT have to hold services of defectoscopy. In this regard in the department it is necessary to provide console and hardware for the radiation equipment, rasshifrovochny and photorooms.

The electrophysical group including electromagnetic, magnetic, optical, ultrasonic and other control methods, place in two adjacent rooms. The capillary methods connected with application of toxic components, require the certain room with the dark room where luminescent lighters are established.

As a part of laboratory it is necessary to provide the storeroom of a workshop for preparation of samples, repair of the equipment, production of adaptations, and also rooms for design group which is engaged in modernization of the equipment and automation of testing processes, etc. The locker room and other household rooms can be the general for all complex.

At a large-lot production the laboratory can be organized on a concrete site, for example in foundry shop where cast products of various form and the sizes, or in large thermal shops, etc. The number of rooms thus can be smaller. It should be noted that in spacious light shifts of testingers labor productivity and quality of control increase.

At construction of the new laboratory room or at re-equipment of the oldone for performers the specification is issued. It is formed on the basis of sanitary standards of design of the industrial enterprises and "The basic health regulations during the work with ionizing radiation" OSP-76. The specification together with planning is approved by the chief engineer or the director of the enterprise, previously having coordinated it with departments of capital construction and safety measures. The part of the specification relating to radiation methods will be coordinated with city or regional sanitary-epidemiological station.

If objects for control are located at considerable distance and on various production sites, organize basic laboratory which serves on a departmental or territorial sign. In this case or products deliver in laboratory, or the workers leave on object. Most rationally in these conditions is to create mobile express laboratory. Such defektoskopic laboratories are created on the basis of the bus or the closed car.

The defectoscopy department (laboratory) of the aviation or machine-building enterprises is a part of service of the chief metallurgist or the central factory laboratory, sometimes Quality Department. Considering a great influence of results of testing work services on quality of production, it ist the most expedient to subordinate them to the deputy head of the enterprise for quality or the chief engineer. Costs of their development, the organization and acquisition of the equipment should be carried on manufacturing prime cost of products. It reaches increase of responsibility of workers and the accounting of expenses for production becomes simpler. The structure of department of the Tax Code can be various depending on conditions of production and requirements to quality.

In physical laboratories (groups) works on development and setup of the equipment and development of techniques, and also on their introduction are carried out. All mastered devices and development are transferred to control services of shops. NDT special group as a part of services of the shop testing, working under the methodical management of department of the Tax Code is in certain cases created. At the head of separate divisions of NDT and in their structure by all means there has to be an engineer with the corresponding specialty.

If the department of defectoscopy isn't included in the TZL complex, in the staff list it is useful to provide the metallurgist and the chemist. As a rule, in factory laboratories narrow specialization of workers is impossible. Therefore non-destructive testing inspectors have to own all methods (ways) and NDT devices.

Relationships of testing services with other divisions of the enterprise. The structure of quality testing service in industrial (shop) conditions has to provide performance of precautionary and acceptance functions of testing. Therefore along with employees of testing services and non-destructive testing inspectors technologists, designers, workers of a reliability organization and metrologists have to take part in work on quality testing. Their task includes first of all the analysis and elimination of the reasons of emergence of low-quality materials and products. Information on the level of quality of production revealed by non-destructive testing inspectors has to be given technologists quickly. Data on quality at the same time have to arrive to the administrative person responsible for a level of quality of production at the enterprise (organization). These data have to include statistics of shortcomings (defects) surely.

Providing the centralized administrative and methodical management with test laboratories, independence of manufacturers are necessary for effective testing at efficiency preservation in work and existence of the special service of precautionary testing (SPC).

Account and registration of testing results. The main document, being guided which the laboratories carry out quality testing of products, is the testing card. Well made card excludes need of use of working drawings on all nomenclature of controlled products and special magazines for registration of testing conditions. The technical card is made make on each product which is subject to testing, for specific conditions. In case of increased requirements to a product create a reference defectogram with admissible and unacceptable defects which is put to the testing card.

On the products found fit, put the stamp. Results of testing register and if necessary issue the test report. Making the decision on the validity of a product, the operator has to be guided only by indications of the card of testing and links available in it to TU, STU, STP. At testing of single details the decision on the validity of a defective detail is made not by the operator, and the designer, the metallurgist or the technologist as the works are more competent of conditions.

Each product or the lot of products arriving for the analysis, have to be accompanied by the service record of the corresponding form in provided with an article number (details), parties, number of details in parties or number of selection of party. If the detail doesn't correspond to drawings, in the service record specify a material, the places which are subject to control, and a type of estimated defect. According to the service record a lot of products or separate details register in the log. The details arriving on control, have to be cleared of oil, shaving, scales, agnails, etc.

Observance of standards and normative documents is the most important condition of improvement of production quality. Documentation on quality control has to provide observance of standards, accurate system of an assessment of quality, rejection of unusable production, and also possibility of expeditious and active intervention in technology.

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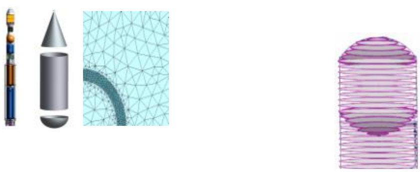
The method of determining the stress-strain state of tanks of rocket constructions

Using the proposed approach, it is possible to calculate casings of rocket constructions of an arbitrary geometric shape and a middle surface, taking into account the nonlinearity of elastic deformation followed by a transition to plastic deformation and destruction. In this case, data obtained by numerical calculation allows to calculate the load capacity of the construction and forecast its performance. The method has a considerable algorithmicity and accuracy.

The current level of technical progress allows to create machines and designs that have high reliability. The basis for this is the complex of measures applied during design, manufacture, installation and operation. At the design stage, this is the choice of rational structural schemes and materials, a proper calculation, taking into account all impacts that may occur during operation. The elimination of latent defects during the running-in and running-in, a maintenance system, that includes a set of diagnostic and preventive measures, allow to minimize the probability of failures in the process of constructions. Thus, the most urgent problem is the problem of forecasting and ensuring the technical operating life of structures. The solution to this problem involves the establishment of qualitative and quantitative rules determining the operating life. To determine the stress-strain state of the casing, the non-moment theory of elastic casings is generally used. There are many methods of calculation of casings of different constructions. Usually they all have very complex analytical or numerical algorithms, a number of assumptions that reduce the accuracy of the determined values. In this paper, we propose a method of determining the stress-strain state of casings based on finite-element breakdown of the construction to the ring elements (Fig. 1), that significantly improves the speed and accuracy of calculations, algorithmicity of transition from one task to another, comparing with the existing methods.



a) b)

Fig.1. Elements of casing constructions (a) and scheme of construction breakdown to the ring finite elements (b)

Knowing the stress-strain state (SSS) of each ring, it is possible to characterize the SSS of the whole casing. To determine the characteristics of the

SSS in an unlimited spatial deformation of the individual rings, a technique developed by Professor V. I. Kravtsov is used [1]. The problem of durability of the tanks of rocket constructions has always been urgent due to continuous improvement of their constructions. To reduce their weight, the work of the plastic material of the tanks in stages to failure is especially important [2]. This necessitates the development of new types of structures, enhancing their strength and reliability. Complex and difficult system modes are associated generally with the need of special study and determine the forces operating on them, given the strong nonlinearity of differential equations, the possibility of loss of stability of equilibrium and demanding study of system behavior in a supercritical state. The study of these processes requires the creation of new and modernization of the known mathematical models and algorithms that, under certain assumptions, allow to quickly determine the stress-strain state using the on-board computer systems. As a rule, rocket tanks are structures with complicated geometrical structure. The complex shape of their axial line at an arbitrary time interval of operation is caused by various factors, in particular by functional purpose of the construction. The solution of such problems is only possible with modern methods of nonlinear analysis, the application of which encourages the selection of modification of differential equations, providing algorithms and efficiency of the approaches. So far these studies have not been developed due to the lack of reliable mathematical models, which could quite simply and effectively be implemented in the form of algorithms and programs for numerical solution of the considered problems [1]. This paper discusses the issues of stress-strain state of the tanks of rocket constructions under static, quasi-static or dynamic loads. As a base model we suggest a methodology of studying the spatial curved deformation of flexible elements, described in detail in [3]. In terms of application of modern computational algorithms it allows to create a unified research methods that allow to take into account:

- the unboundedness of the spatial elastic deformation;
- physical and geometrical parameters of the elements along an arbitrary axis values of the bending and torque rigidities;
- static, quasi-static or dynamic loads, arbitrarily located in space;
- action of random…

The proposed mathematical model is based on known approaches of Lagrange and Euler which describe the equilibrium and the deformation of the flexible element, the external and internal geometry [1]. The method of solving the task, consisting of 18 ordinary differential equations, is based on the combined use of the method of continuation on a parameter, and the method of Newton-Kantorovich. The construction of the Jacobi matrices at each step of variation of the load parameter is performed by the Runge-Kutta fourth order. The number of integration steps and points of discretization along the length of the element depends on many factors: the number and nature of the loads acting along the length, the nonlinearity of the process etc. Practical implementation of the method is carried out in the form of programs calculations on a computer. The time of calculations, depending on the complexity of the task, does not exceed 5-10 minutes for PC RAM 8000 MBt and processor frequency 2100 MHz.

In a fairly large area of integration *ds*, the load will be evenly (or unevenly if required) dispensed. There can be as many of these areas as necessary throughout the interval of integration (Fig. 4).

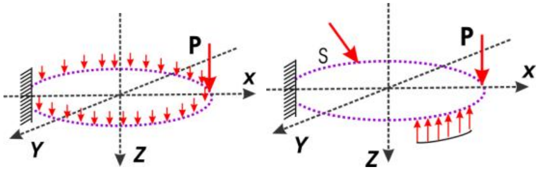


Fig. 4. Possible ways of loading of the ring

The action on the interval concentrated load moment can be interpreted as a pair of forces applied at sufficiently small area of integration. This is achieved in the following way: near the point of application of the concentrated moment a concentrated load is applied to the left and right of it, the magnitude of the moment is defined as the product of force into distance between the forces. To verify the results of numerical investigations of spatial deformation of the ring, the following experiment was conducted. A flexible ring is loaded in the middle by concentrated load at discrete steps.

The object of the experiment was a flexible elastic ring of steel strings. The radius of the ring = 0,1275 m, the cross-sectional diameter D = 0.7 mm. These geometrical characteristics of the ring were chosen to provide sufficient flexibility and also to minimize the influence of gravitational forces, causing it to bend under its own weight, which is still considered in the computational algorithm.

The limit of elastic deformation of the ring was tested by loading to the maximum extent as possible, when the points of the ring moved to the values comparable with its diameter; and after removing the forces causing deformation, the ring was returned to its original position. This indicates the absence of plastic deformations.

The bending of the A and B rings was determined experimentally by the following method. Three straight cantilever rods, made out of the same string as the ring, were loaded by concentrated force at the free end.

At each load stage a counting δh of free end movement was carried out and the values $A{=}B{=}Pl^3/3\Delta z$ were evaluated, where P – value of the force; l – length of the rod. According to the results of a series of measurements and calculations, the actual value of hardness was found as an arithmetic mean: $A{=}B{=}$ 2,5539•10^{-3} N•mm^2. The torque hardness C was not determined experimentally, as for a circular section it can be determined using the dependence of $C = 0.8\ A$, in our case C = 2,0431•10^{-3} N•mm^2. The experimentally found geometrical and physical characteristics of the ring were taken as calculated in numerical study. To determine the deformation of the ring under static load, the method of the experiment was consistent in its load in the middle of the length (s = S/2) by concentrated forces P =

5 G to the total load P = 35G. Loading was carried out by hanging loads at the point of load application. Moving point for s = S/2 after each load was determined by photogrammetrical method. In this way on the photo you can trace the evolution of the spatial deformation at each load step. Measuring in a given scale displacement, it is possible to judge quantitatively about the degree of spatial deformation of a ring.

Fixation of the ring shape after each loading stage was performed at a single physical point, the survey was conducted with a single point. We used photography by overlapping one frame to another, in order to obtain all the shape rings at each load stage at one frame. Measuring in a given scale displacement, it is possible to judge quantitatively about the degree of spatial deformation of the ring. It should be noted that all methods of determining the loads and boundary conditions shown in this section are implemented in computational algorithms, that is, the magnitude of forces and moments, their points of application etc. are determined automatically, the programmer can just specify their size in the original data.

Given that the numerical method allows to investigate the object under unlimited nonlinear deformation, we describe the method of SSS research depending on the diagram of material destruction (Fig. 5).

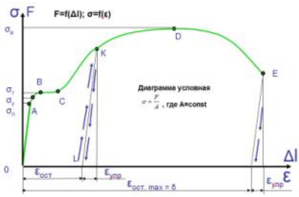


Fig. 5. The curve of material destruction

To illustrate the proposed method of calculation of the elements of tanks of rocket constructions as the axisymmetric casing, the example of determination of stress-strain state in a separate casing element was solved (see Fig. 1). The casing element in the form of a ring was loaded by the most basic load – internal uniformly distributed pressure q.

There is a solution of this problem in the linear statement in the literature. For our case we will take the following initial data: the radius of the ring R = 1 m, the intensity of uniformly distributed load *f*= 0.01 N/m, elastic modulus *E*= 1,96 $\cdot 10^{11}$ N/m^2, modulus of elasticity in torsion *G* = 7,84 $\cdot 10^{10}$ N/m^2, moments of inertia (circular cross section) I_x = I_y = 3125 $\cdot$ 10^{-13} m^4, the polar moment of inertia 6250 $\cdot$10-13 m^4. In this case the bending hardness was taken as $A = B = 6{,}125 \bullet 10^1$ N•m^2, torsional – C=4,9142 $\cdot 10^1$N•m^2.

The solution was obtained as a result of the implementation of one step of the iterative algorithm. Numerical values of internal forces at the points (Fig. 4) were compared with those calculated by the formulas:

$$M_u^K = f_V R^2 = 0{,}01 \text{ N} \cdot \text{м}, \quad M_u^L = f_V R^2 (1-4/\pi) = 2{,}7324 \cdot 10\text{-}3 \text{ N} \cdot \text{м},$$

$$M_w^K = M_u^L \sin\varphi_L + f_V R^2 (\varphi - \sin\varphi_L) = 2{,}975568 \cdot 10\text{-}3 \text{ N} \cdot \text{м}, \quad Q_u^K = f_V R \varphi_K = 1{,}570796 \text{ N},$$

$$Q_u^L = f_V R \varphi_L = 0, \quad Q_u^N = f_V R \varphi_B = 1{,}570796 \text{ N}.$$

The results of analytical and numerical calculations in comparison showed a difference of not more than 0.01%.

Under certain physical and geometrical characteristics of rings and the value of the internal pressure, all the characteristics of the SSS of the ring were determined when the pressure changes from zero to some value. Fig. 7 shows the values of bending moments for some step-by-step pressure values.

Analysis of Fig. 7 shows that with the increase of the internal pressure at some point, the values of the bending moments have a bit nonlinear nature, and the problem requires further study in the framework of the proposed method. It should be noted that any characteristics of SSS in tabular form and in the form of computer graphics, obtained from the results of the numerical solution, can be the source data.

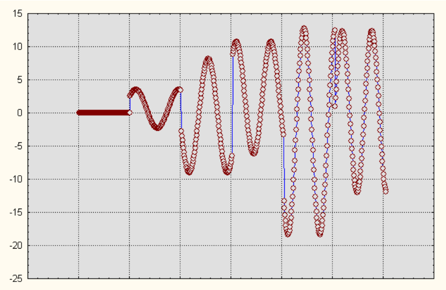


Fig. 7. Bending moments in a single casing element

The reliability of the results is tracked in real time on the display screen; if "something goes wrong", it is immediately noticeable on the illogical arrangement of graphic elements.

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Improve the stability of the cutting tool of steel R6M5 with wear-resistant coatings

The expediency of using wear-resistant coatings to improve wear resistance of the cutting tool and the dependence of physical and mechanical properties of complex coatings and discrete laser treatment on wear-resistance. Results analysis shows that nitrochromized coating on laser treated steel used as coating substrate is characterized by highest wear resistance under sliding friction conditions.

General formulation of the problem.

Cutting is a basic operation in the field of mechanical engineering and material processing. Its efficiency depends largely on the relevant details to high quality standards, continuously growing in terms of scientific and technical progress and a high level of competition in the market. The quality of the detail's surface that is obtained as a result of technological operations of cutting (sharpening, milling, boring and others), the necessity of further treatment of the detail, the expense of a lubricating and cooling liquid and resource of the tool depends on the manufacturing cost of these products and, consequently, its competitiveness. Despite the fact that the processing of a cutting material has been known for more than three thousand years, the mechanism of this process has not been studied enough. Especially it concerns such hard-processing materials.

Tool wear leads to tool failure. According to many authors, the failure of cutting tool occurs as premature tool failure (*i.e.*, tool breakage) and progressive tool wear.

Generally, wear of cutting tools depends on tool material and geometry, work- piece materials, cutting parameters (cutting speed, feed rate and depth of cut), cutting fluids and machine-tool characteristics.

In the automotive and aviation industries is important: the correct cutting tool geometry is selected and the correct tool material is selected less than 30 % of the time. Proper selection of application-specific tool material (coating*)*. Considering performance the energy transmitted through the tribological interfaces in metal cutting, one select a tool material for a given criterion such as tool life, quality of the machined surface, efficiency, etc [1].

Proper selection of tool geometry. It becomes possible as the cutting tool tribology correlates the parameters of tool geometry, as a whole, and the parameters of tool microgeometry, in particular, with tribological processes at the tool–chip and tool–workpiece interfaces, and thus the optimized tribological parameters can be directly used in the selection of proper tool geometry [1].

The efficiency of the cutting tool can be improved by modification of the surface properties of the tool material due to which contact pads of the tool will most effectively resist abrasion, adhesion fatigue, corrosion, and oxidation and diffusion wear resistance. This tool material should simultaneously possess a sufficient margin of safety in compression, bending, application of shock pulses and alternating voltage [2].

Combination of these properties can be achieved by applying of the cutting tool composite coatings to the working surface.

By specifying properties of the coating varying its chemical composition and structure, it is possible to change the characteristics of the basic machining processes and, ultimately, to control the most important output parameters of the process - the wear of the cutting tool and the quality of the surface layer of the work pieces.

At present industry produces a relatively large number of coated cutting tools. However, their effectiveness is still not high enough because of the absence of practical recommendations for the usage of such a tool and in the first place it concerns the machining of polymeric composite materials [3]. Machining PCM has several features that distinguish them from similar treatment of metals. These features are: 1) the anisotropy of the PCM properties; 2) the difficulty of obtaining high quality of the surface layer; 3) low thermal conductivity material; 4) intense abrasive effect of the filler; 5) inability of using the coolants in most cases; 6) specific safety requirements when cutting PCM, due to the release of small particles of material when cutting. It is also significant, that processing of composite materials of one type differs from processing of composites of another type. Reasons for the low quality of the surfaces are chipping matrix, loosening of the reinforcing material and the low accuracy of the surfaces. Special attention is paid to the quality of the surface during drilling [4].

The most common in the metal cutting industry is thin-film hard coatings and thermal diffusion processes. These methods find ever-increasing applications and brought significant advantages to their users. Today, 50% of HSS and 40% of supe-rhard tools used in industry are coated [5]. A great number of coating materials, methods and regimes of application on substrates or whole tools and multi-layer coating combinations are used.

Coatings considerably improve tool life in high productivity, high-speed and high-feed cutting or in dry machining, and when machining of difficult to machine materials. Coatings: provide increased surface hardness, for greater wear; increase resistance (abrasive and adhesive wear, flank or crater wear); reduce cutting forces; reduce friction coefficients to ease chip sliding; prevent adhesion to the contact surfaces, reduce heat generated due to chip sliding *etc*.; reduce the portion of the thermal energy that flows into the tool; increase corrosion and oxidation resistance; improve crater wear resistance and improved the surface quality of finished parts [6,7].

Today electric-spark alloying method (ESD) is a cost-effective and technologically promising in addressing the problems of increasing the performance various machine parts and cutting tool where there is intensive wear. Through the use of a wide range of materials that can be used in ESD, may be significantly change the mechanical, thermal, electrical and other properties working surfaces of parts. The main advantages of the method of ESA: possibility of local processing surface only in the area of maximum wear, high adhesion to the substrate coating, no need to pre-prepare the substrate, process is in the air [8].

Nitriding - Chemical-thermal treatment in which the surface layers are saturated with nitrogen. Nitriding increases not only the hardness and wear resistance, but also increases the corrosion resistance. Advantages of nitriding: carried out after the final heat treatment, therefore, does not require additional manipulation; higher hardness and wear resistance; higher resistance strength; high corrosion resistance; higher operating temperatures [9].

Processing of laser, which allowing to obtain layers thick in some several tens of micrometers, and tool life after laser processing, in some cases several times higher compared to untreated. When exposed of the laser beam on the the metal surface, surface layer is rapidly heated. As beam moving on the other surface areas rapidly cools the heated part. Since hardening of the surface layers takes place as a result of hardening, which leads to a substantial improvement of their strength. Laser hardening allows to increase the strength of just those portions of the surface, which to the greatest extent subject to wear [10,11].

Research methodology, results and discussion.

As the object of study the steel P6M5 was chosen. Complex coatings of Ti-Cr and Ti-N systems are deposited in a closed reaction space under conditions of reduced pressure [12,13]. As a source reagent we used powders of titanium and chromium, charcoal, carbon tetrachloride. Diffusion hardening was performed at 1050 ºC for 2-4 hours with nitrogen saturation occurred at 540 ºC for 21 hours in an atmosphere of ammonia (dissociation degree 40 – 45 %).

The process of complex nitrogen and metals saturation consisted of two consecutive phases: nitriding and subsequent metallization (titanizing and cromizing).

Discrete laser treatment was performed using the installation LATUS - 31, with a specific power of laser beam 10^3-10^5W / cm^2.

Investigation of the durability of coatings in the conditions friction without lubrication was performed using installation M22-M. Friction loading scheme: shaft – insert. Counter specimen material – hardened steel P6M5 (HRC 61-63). Metallographic studies were performed on microscope MBS 9

Also, the applied coating of carbide BK8 on samples of steel R6M5 and $TiCrB_2$ coating on steel 45 by electric-spark alloying and conducted research on abrasion resistance. Experiment to abrasion spent on installation scheme Brinelya-Havorta among quartz sand [14]. Some research results are presented in Fig. 1. Hiking friction after testing shows in Fig. 2. As seen from the survey results, covering systems triboengineering in its characteristics coating TiCrB2 to abrasion wear almost not inferior coated carbide based BK8.Our studies TiCrB2 coatings on Steel 45 showed promising data use coatings and further research their on steel R6M5 [14].

Table 1 displays the results of tribological tests. As a result of testing of steel P6M5 after various types of coatings we found that due to the decrease in the value of the coefficient of friction and wear rate coating can be arranged as follows: nitriding, nitrotitanizing, nitrochromizing. High wear resistance of coating is defined by a set of its properties. First of all, they posses low friction factor and considerable plasticity, what is determined by their low micro brittleness.

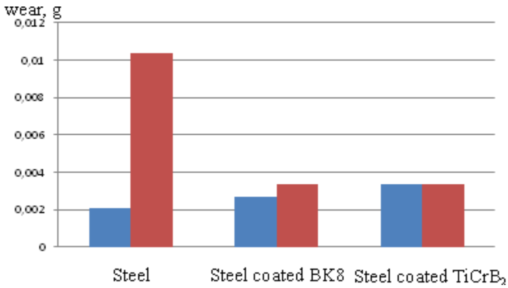

Fig. 1 - The test results of abrasion resistance in a medium quartz sand grain size of 250 microns (line 1) and 500 microns (line 2)

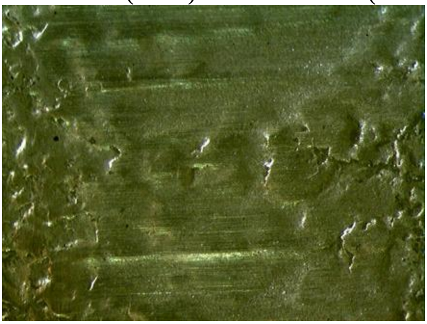

Fig. 2 - Track friction test sample after abrasive wear

Table 1.

Wear resistance of steel P6M5 depending on type of coating and contact load. Slip speed = 0.5 m/s

Coating	Linear wear, μm
	80N
Nitrotitanizing	23,0
Nitrotitanizing + LT	12,3
Nitrochromizing	20,1
Nitrochromizing + LT	10,5

Conclusions.

It was established that wear resistance of steel R6M5 in conditions of friction without lubrication with proposed multicomponent coatings coatings compared to comon nitriding is higher in 1,5 - 2,0 times, and after additional discrete laser processing of steel it increases up to 2.2 - 3.0 times. This is because the discrete layer of laser hardened steel provides a strong substrate for coating, increasing its performance in extreme operating conditions, excludes its chipping and delamination. The results showed that the coating with increased abrasion BK8 1.5 times

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Tribological investigations of composite electrolytic coatings with nickel-eutectic alloy powders

The investigations of structure and properties of areas: matrix-transition zone-particle of composite nickel-based electrolytic coatings are carried out. As a composite coating filler the wear-resistant eutectic alloy powder designed for operation at elevated temperatures is used. Hight wear resistance of designed coatings due to surface wear-inhibiting films formation it is established by tribotechnical investigations.

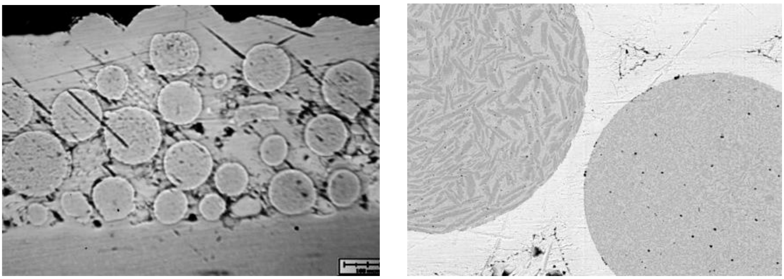
Problem statement. One of perspective methods of the machine elements superficial strengthening is applying of composite electrolytic coating (CEC) [1]. The effective ways of reception of materials with high thermal stability and wear resistance are creation of compositions on the metal basis strengthened by refractory borides and carbides with use of eutectic reaction between them as high heat resistance and thermal stability is defined by their structurally-phase structure [2]. On the other hand the creation of eutectic coatings by a welding method results in non-uniform heating across detail section with a coating and heats on a surface with their sharp reduction to a core that leads to possible change of geometry of a detail and a surface. Besides the given method allows to put a covering only on external surfaces which should be well accessible to processing, and does not allow to put on internal surfaces, especially if details have length greater than diameter. To avoid above mentioned shortcomings is possible by using the electrolytic method. Therefore the task was to develop composite electrolytic coating with eutectic alloy powders as filler to increase the endurance at elevated temperatures and to investigate a structural condition and wear resistance of the received coatings.

Experiment technique. Composite electrolytic coatings are received by settling of electrolytic nickel with eutectic alloy powder specially developed for work at the raised temperatures [3] on the horizontal cathode at pulse moving of electrolyte and density of a current from 5 to 10 $А/дм^2$, PH 3-3, at electrolyte temperature 25-40^o. Thermal processing of samples with a coating was carried out by vacuum annealing at temperatures 950 ºC and 1250 ºC. Microstructure researches are carried out by means of optical microscope NEOPHOT 21 and electronic raster microscope with energy dispersive microanalysis system PEM-106I. Test a material for microhardness are done on device PMT-3. Tribological tests are carried out on installation M 22-M.

Results of researches. Physic mechanical and tribological properties of composite coatings are defined by the intense-deformed state of a coating and its structure. The nature of filler particles, their chemical compound, quantity and the size, character of interaction with a matrix define the future complex of physic mechanical and tribological properties of a composite coating. Technological parameters of processes of galvanic powder coatings sedimentation are chosen to receive a coating with necessary contents of eutectic alloy powder according to recommendations [4] as content of the second phase particles have essential influence on a coating wear resistance.

As CEC filler is used different dispersion eutectic alloy powders developed to work under the raised temperatures. Investigated coatings contain 30-40 vol.% of eutectic alloy powders in a nickel matrix. According to the recommendations of the works [1, 4, 5] such content of filler in the composition allow to achieve the optimum of the intense-deformed conditions, physic mechanical and tribological properties of coatings. As the basic influence of solid particles in a coating is matrix strengthening the presence of rigid impurities strengthens, or reinforces, a matrix by restriction of its plastic current. Thus the zone of the raised pressure tangents which are results of interaction between stress fields of the next particles, goes deep into a material below the particles. As a result a loading on the matrix in area between particles is reduced and provides a positive gradient of pressure from a friction surface to core. At the lower filler content and, accordingly, bigger center distances between particles the durability of a composition decreases due to formation of cracks on the weakened borders the particle-particle. Above mentioned shows that a coating with filler 30-40 vol.% should work effectively in the conditions of a friction and wear process.

The structure of CEC nickel-eutectic alloy is shown on fig. 1.



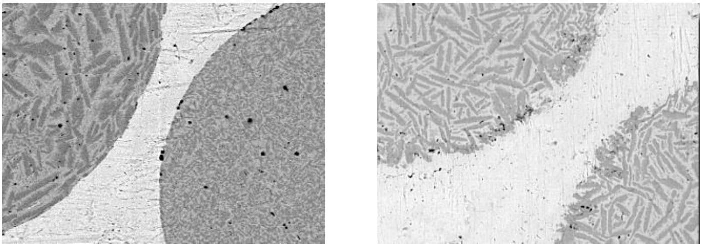
a *b*

Fig. 1. Structure of CEC nickel-eutectic alloy: *a* – × 100; *b* – × 600

Preliminary researches have shown not high enough wear resistance of the given coatings as the given coatings in an initial state have low adhesion to a backing and low cohesion in a coating because of a interstices (fig. 1, *a*) and absence of interaction between a matrix and a filler (fig. 1, *b*), that causes chipping filler particles under tests. That's why a heat treatment (HT) of CEC by means of annealing is recommended.

It has been selected two temperature modes of heat treatment: 1 - in a mode without melting at temperatures about 950 ºC, that is $0{,}8T_{\mathrm{melt}}$ for eutectic powders (30 minutes soaking and cooling with the furnace); 2 - in a mode with melting at temperatures about 1250 ºC (30 minutes soaking and cooling with the furnace).

After heat treatment (HT) by vacuum annealing at temperatures 950 ºC on border a particle - the matrix disappears neat border of phases division (fig. 2), occurs eutectic recrystallization and as a result eutectic crystals of different grains of powder have the identical size (fig. 2, *b*).



a *b*

Fig. 2. Structure of CEC nickel-eutectic alloy, × 1000: *a* – without heat treatment; *b* - after heat treatment in a mode without melting at temperatures 950º C

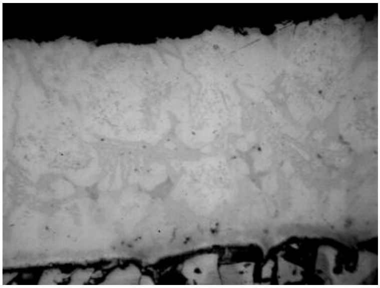


Fig. 3. Structure of melted CEC nickel-eutectic alloy after heat treatment at 1250°C, × 200

The heat treatment results in a matrix strengthen. Microhardness measurements in different coatings areas before and after heat treatment have shown (table 3), that as a result of heat treatment the transitive zone with microhardness $H\mu$=4,5–5,5 GPa between a matrix and filler is arisen. The filler microhardness after heat treatment decreases, as already at temperature 950 °C there is a recrystallization of eutectic alloy filler (fig. 2, *a, b*), and at temperature 1250 °C occurs complete melting of the coatings with eutectic formation (fig. 1).

Table 1

CEC microhardness, GPa

Heat treatment mode	Without heat treatment	Heat treatment at 950°C	Heat treatment at 1250°C
Matrix	3,0-3,2	3,3-4,0	4,0-4,7
Filler particle	8,1-8,9	6,7-7,5	6,0-6,5

Results of tribological tests CEC nickel-eutectic alloy with different dispersion filler are shown at table 2.

Results have shown that the coatings with lager size filler are characterized by lower weight loss and linear deterioration at all test conditions. And, with test temperature increasing the wear resistance for both filler types is increasing due to more intensive oxidation of surfaces and formation of secondary structure films (fig. 4, 5).

Table 2

Tribological tests results for coatings with different dispersion filler

Particle filler size, micron	Heat treatment mode	Tests temperature ,°C	Friction factor	Weight loss, mg	Linear deterioration , micron
20-50	Without heat treatment	room temperature	0,51	82,13	98
80-150	Without heat treatment	room temperature	0,48	71,25	85
20-50	Without heat treatment	500	0,53	52,4	73
80-150	Without heat treatment	500	0,46	33,2	50
20-50	Heat treatment at 950°C	500	0,45	23,9	35
80-150	Heat treatment at 950°C	500	0,42	12,3	15

Fig. 4. Friction surfaces, ×1500

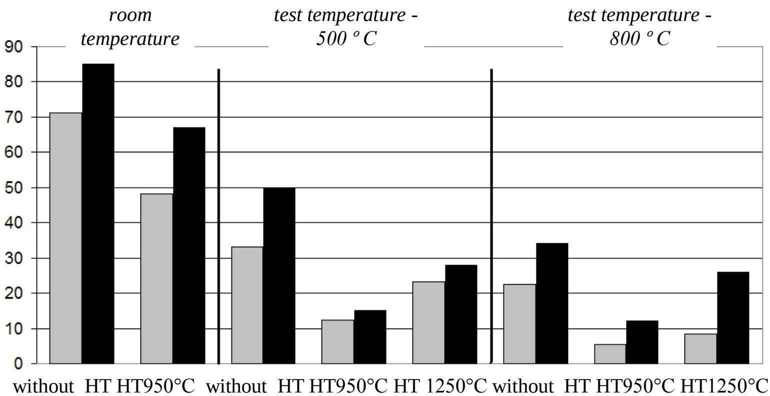


Fig. 5. Results of tribological tests at different temperatures:
□ - weight loss, mg; ■ - linear deterioration, micron.

Following tribological tests were done at loading 0,6 MPa for composite coatings with larger filler (80-150 microns) for the purpose to determine the influence of heat treatment and test temperature on wear resistance of developed coatings. Test results are presented in the form of the histogram (fig. 5). It is thus established, that optimum heat treatment of a composite coating with eutectic alloy powder filler is a mode without melting temperatures 950 °C.

Conclusions

Heat treatment in modes without melting and with melting of composite coatings of system nickel - eutectic alloy essentially changes the structure and element content of coating areas: matrix - transitive zone – particle filler. Necessity of heat treatment is validated by need of increase the mechanical properties of a matrix, increase the adhesion and cohesion. Besides, as the coatings were developed for operation at the raised temperatures the applying of heat treatment at temperatures above than friction units operational temperatures promotes avoidance of uncontrollable structural transformations in a coating at action of operational temperatures. Tribological tests have shown high wear resistance of the developed coatings at the raised temperatures due to the introduction into a nickel matrix specially developed eutectic alloy powder filler. The alloy powder filler content was chosen to form secondary structure optimum films for protection of a surface against wear process at a friction. It is shown, that modes of heat treatment essentially influence on coating wear resistance. It is thus established, that optimum heat treatment of a composite coating with eutectic alloy powder filler is a mode without melting temperatures 950 °C.

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Tribotechnical characteristics of self-fluxing covering in non-stationary condition of friction

The analysis of kinetic changes of physical-mechanical, anti-teasering and anti-frictional properties of self-fluxing coverings based on nickel, which were got during spraying on the contact surfaces the self-fluxing powder ПГ-АН9 is presented in this work. The duration of normal work of covering with maximal thickness at lubricated contact surfaces by transmission oil in condition of systematic increasing of loading was determined

Introduction.

As problem of resource and energy saving is very actual in industry it is economically perspective to develop the complex of technical operations for renovation and hardening of wore details. Recently, many researchers are trying to obtain thin surface coating with thermal spraying from the materials having high hardness and wear resistance [1]. Self-fluxing powders are mostly widespread in the practice of restoration and strengthening technologies. Special advantages of this class of materials is explained by the fact that quality of melting coverings occurs without using additional fluxes or protective surroundings. Due to this price of the restoration is not more than 30 - 50% from new items [2].

State of the problem.

Self-fluxing alloys based on nickel, doped with silicon and boron, characterized with high technological (low temperature of melting, melting in the oxidizing or neutral atmosphere in the dense, non-porous coating; machinability) and operational (wear resistance coating is in 3…5 times higher than hardened instrumental steel) properties [6].

Self-fluxing powders are used for hardening, protection and renovation of parts of the plungers pumps, shafts of gas turbine engines, vehicles (valves, parts of cars coupling shafts, crosses, etc.), road machinery and machine parts, etc. [1, 7].

The widespread use of self-fluxing coatings constrained due to lack of evidence-based recommendations for their application to the various elements of friction pairs, working not only in terms of sliding, but rolling, and, especially, rolling with slippage in the lubricating surrounding. Of particular relevance, this issue takes place due to the lack of any evidence-based recommendations for the use of these coatings for parts of friction pairs and machinery, working mainly in the non-stationary conditions.

Experimental investigations of kinetic changes of physical-mechanical, anti-wearing and anti-frictional properties of self-fluxing coverings based on nickel in the surrounding of transmission oil at the rolling with slippage in non-stationary conditions.

Materials and methods of researches.

Researches of tribological parameters of friction pair were conducted at the facility [8] in non-stationary conditions of friction in the mode of start-stop on the cycle of acceleration in the condition of clear rolling (12,5s) – work in the condition of 20% of slippage (4s) – breaking in the condition of clear rolling (12,5s) – stop (4s).

Contact loading on Hertz (σ_{max}) in the process of testing step-by-step was increased and became: from 1 to 150 cycle – 150 MPa; 151 – 300 cycle - 200 MPa; 301 – 650 cycle – 250 MPa. Maximal amount of revolutions is 1000 and 800 rev/min respectively for leading and trailing surfaces. The final period of tribomating work is determined at the first sign of setting of contact surfaces.

As a lubricating material the transmission oil TC-type (SAE 140 API GL–5) was used, which was made by ТУ 38.1011332-90 on the plant «Ариан» (Ukraine), this oil is intended for the lubrication of spur, spiral bevel and worn gears. The bulk oil temperature was 100^0C.

As the samples rollers from hardened steel 45 (HRC 38) were used, on the working surface of which the self-fluxing granulated powder ПГ-АН9 (ПР-НХ8Д6СРП) (table 1) by means of flame spraying was applied. This powder was created at the Institute of Electrical Welding named after E.O. Poton NAS of Ukraine by the ТУ 374–83 [9]. Particle size distribution of the main fraction of the powder correspond to particle size of 50 - 125 mcm. The thickness of the sprayed layer in a single pass was 0,1 ... 0,25 mm. The total thickness of coating for each pair of the samples after the grinding was 0.3; 0.7 and 1.2 mm.

Results of research and their discussions.

Maximal workability of the investigated covering ПГ-АН9, determined at first signs of setting of contact surfaces in non-stationary modes of friction was 120, 320 and 650 cycles of operation respectively to the thickness of sprayed layer 0,3; 0,7 и 1,2 mm. This correlation shows the duration of the work elements tribomating and contact pressure. For coatings with thickness 0,3 mm set a minimum time before the setting of the contact surfaces with a minimum installed load (σ_{max} = 150MPa), which corresponds to the common path of 4320m friction. Increasing the thickness of the deposited layer increases up to 1,2mm length of a normal work tribomating in 5.42 times (23415m) and is characterized by normal operation with increasing the contact pressure to σ_{max} = 250MPa.

Table 1

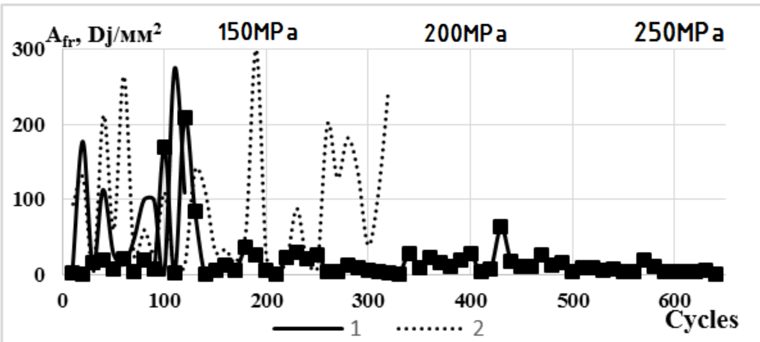
The changes of micro hardness of the covering surface layers (H_{100}) which were sprayed at operating

Steel 45 + powder ПГ-АН9 with the thickness:	Leading (outrunning) surface			Trailing (lagging) surface		
	Initial H_{100}, MPa	After operating, H_{100}, MPa	ΔH_{100}, MPa	Initial H_{100}, MPa	After operating, H_{100}, MPa	ΔH_{100}, MPa
0,3 mm	2377	2318	-59	2370	2171	-199
0,7 mm	4204	3076	-1128	4200	2600	-1600
1,2 mm	6124	5684	-440	6100	5069	-1031

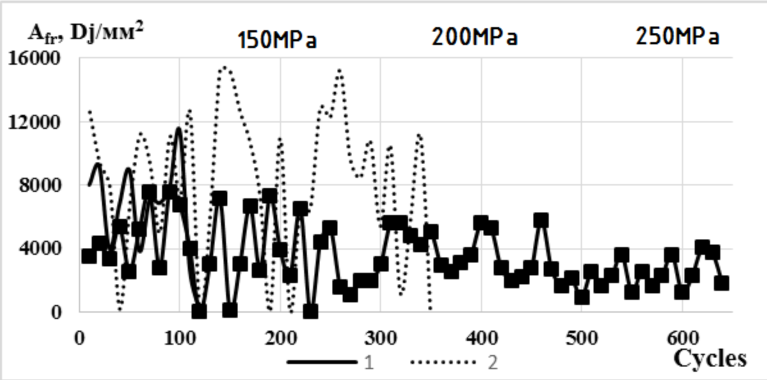
In the process of friction, the general pattern for the leading and trailing surfaces is set - there is softening of the surface layers of the metal at the operating time, which is developed in the reduction of their micro-hardness, but the mechanisms of this process for the friction pairs with different thickness of the deposited layer are different.

The smallest decrease in the micro hardness of the surface layer of metal is set for the minimum thickness of the sprayed layer - ΔH_{100} is 59 and 199 MPa for the leading and trailing surfaces, respectively. These contact surfaces set the highest wear rate, which is associated with the periodic removal of the upper metal layers deformed under dynamic loading. In this specific work of friction in contact is characterized by high levels - in terms of pure rolling this option is 50–250 J/mm^2, in condition of rolling with slippage – 3000–10000 J/mm^2 (pic.4). In such intense activation of surface layers deposited significantly increasing their adsorption activity to the components of the lubricant. However, due to the low content of hardening phases in γ-solid supersaturated solution based on nickel, deformation processes affect the underlying layers of deposited metal, causing them permanent dispersion and increased wear.

By increasing the thickness of the sprayed powder ПГ-АН9 to 0.7 mm in 2.7 times increased time to grasp. At the same time the wear of the contact surfaces is reduced by 4.65 and 1.81 times, respectively, for leading and trailing surfaces (pic.5) and there is softening of the surface layers by friction, which is developed in the reduction of micro hardness on 1128MPa for leading and on 1600MPa for trailing surfaces respectively. The main influence on the plasticization of the surface layers of metal have formed on the surface of activated friction boundary lubricant adsorption layers, characterized by an effective anti-wear properties.

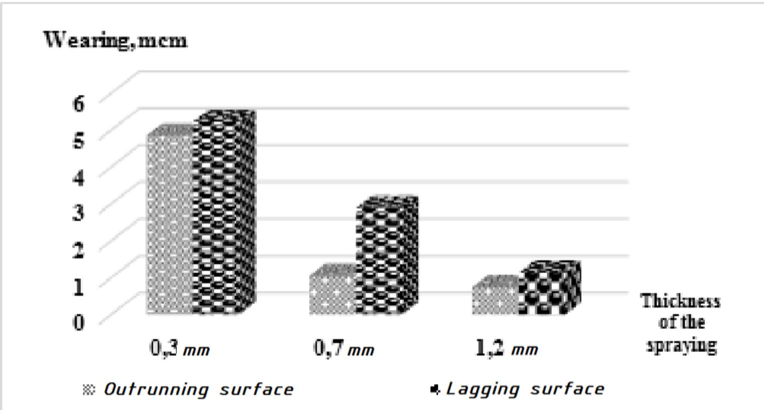


a)



b)

Pic.4. Changes of the specific friction work for contact surfaces in the condition of clear rolling (a) and rolling with sliding (b): 1 – covering with the thickness 0.3mm; 2 – covering with the thickness 0.7mm; 3- covering with the thickness 1.2mm.



Pic.5. Linear wearing of the contact surfaces with different thickness of sprayed layer.

For coatings with thickness of 0.7mm indicators of specific work of friction in contact is similar to indicators of established for the friction pairs with a smaller thickness of the coatings. Increasing contact pressure to 200 MPa does not affect the increase in compressive frictional pure rolling conditions and under conditions of rolling with slippage 5% compressive cycles friction increases to 14000 J/mm^2 (pic.4). However, the increase in load does not lead to the intensification of wear, since 80% of the contact area formed the boundary of the film, characterized by strong chemisorption bond with the metal surface and high anti-friction properties (stabilization of the friction coefficient to 0.033 at σ_{max} 200 and 250MPa). With increasing σ_{max} to 250MPa component plastic deformation increases and dominates dispersing mechanism underlying metal layers as surface layers steady micro hardness metal at an operating time of only 10 - 20% higher compared with the same parameter at the minimum thickness of the deposition.

The processes of structural adaptability and lubricating action most effectively take place on the surfaces of a maximum thickness of the sprayed layer. Due to increase in 2.58 times the original micro-hardness of the surface layers of thickness 1,2mm, spraying is characterized by a high resistance to deformation. This is confirmed by the minimum increment of the specific work of friction when accelerating the contact surfaces during start-up in a pure rolling - from 5 to 200 J/mm^2 at 15% of cycles in the slip conditions at σ_{max} 150 and 200MPa fluctuations A_{fr} are 0 - 700 J/mm^2, that is in 2 - 3 times less than the values specified in the study of the contact surfaces with a smaller thickness of the sprayed powder (pic.4). It should be noted that at 250MPa stabilization of specific friction work parameter takes place. For example, In the condition of rolling with slippage, value of this parameter is in average 1500 – 2500 J/mm^2. Low activated ability of sprayed layer at 150MPa increases the period of formatting strength boundary films of lubricated material on the contact surfaces - in 20% of cycles the stall of lubricated layer on the stop takes place (pic.3). However, at the next setting of tribomating elements in the condition of increasing the σ_{max} to 250MPa formed boundary layers are characterized with high anti-frictional and wear resistant properties. Wearing of leading and trailing surfaces is decreased in 6,54 and 4,62 times correspondently in comparison with th analogical parameters of sprayed layer with the thickness of 0,3mm (pic.5). also it is necessary to mark lower state of plasticization surface layers at formation on them boundary lubricated layers - softening of advanced surface is reduced in 2.56 times and in the lagging in 1.55 times compared with the influence of the boundary layer of grease on the sprayed layer with thickness of 0,7mm. We assume that this is due to the uniformity of dissolution in the nickel hardening phases at melting coating, which greatly increases its durability.

Conclusions

1. Increasing thickness of the sprayed covering of self-fluxing powder ПГ-АН9 from 0,3 to 1,2mm rises duration of normal work of tribomating, which is set to the period of the first signs of setting the contact surfaces, in 5.42 times under dynamic loading.

2. High lubricity of transmission oil of TC-type was set – independently on the loading, hydrodynamic mode of lubrication realizes in the contact. By increasing the contact pressure from 150 to 250 MPa and due to change clear rolling to the rolling with slippage short-time decreasing of bearing capacity of lubricant layer for friction pair of thickness of the covering 0,7 and 1,2 mm, which is developed in the implementation of mixed-mode lubricating action.

3. The best anti-frictional properties has self-fluxing coverings with the thickness of 1,2mm, for which moment of friction in the contact is in 1,5 – 2 times lower than analogical set parameters for surfaces with lower thickness of coverings.

4. The highest wear resistance of covering with the thickness of 1.2mm is achieved by the increasing in 2.58 times the initial micro hardness of the surface sprayed layers; reduction of plasticizing surface coating layers on them when forming the boundary layer lubrication, which develops itself in a lower softening of leading and trailing surfaces.

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Tribotechnical and mechanical properties of BT22 alloy after deformation-diffusion surface hardening

The effect of combined treatment on mechanical (level of near- surface hardening, ultimate tensile strength and ductility) and tribotechnical (coefficient friction, wear intensity) characteristics BT22 titanium alloy was shown. Deformation-diffusion (combined) treatment, which includes pre-cold surface plastic deformation (CSPD) and followed thermodiffusion saturation of nitrogen (TDN), combined with standard heat treatment of BT22 alloy was proposed.

High strength BT22 titanium alloy widely used in the aircraft industry for the manufacture of chassis details, in particular hydraulic cylinder of aircraft marks An. In order to ensure reliable transmission of high-pressure hydraulic fluid (150 atm) from fixed to moving aggregates of hydraulic on the chassis, working surface of the hydraulic cylinder protect against wear. For example, in the aircraft An-28 working surface of the hydraulic cylinder is covered by electroplating chrome [1, 2] for protection. However, in practice such treatment is proved to be quite difficult in reproducibility, since the coating due to the small adhesion to the base material flak off during use. Also through looseness and porosity of the chrome cover during exploitation there is possible dribbling of hydraulic liquids across bronze stem seal without obvious signs of wear on the working surfaces. And perhaps the most important problem of application of such coatings is harmfulness of this technology for the health of the working personnel and the problems of waste disposal industries [3]. In that regard, need to replace electroplated coatings on titanium alloys by alternative which should have good anti-friction properties but do not worsen other characteristics. For these purposes promising is deformation-diffusion (CSPD + TDN) surface treatment.

Proceeding from the above the goal of this work – to evaluate the influence of deformation-diffusion (combined) treatment on mechanical and tribotechnical properties of surface hardened BT22 titanium alloy.

Since VT22 titanium alloy has an increased tendency to grasping with most instrumental materials during CSPD, method of diamond ball rolling was selected, through a lower degree of friction sliding and as a consequence less probability for the formation defects [4]. To save the volume hardening which sets the heat treatment and forming surface hardening by thermodiffusion saturation of surface layers nitrogen, previously rolled BT22 alloy treated by the mode, combining heat and chemical-thermal treatments in one technological cycle [5]. Thermal diffusion saturation on the installation which allows playback of technological regulation heat treatment of alloy provided temperature-time and gas-dynamic modes nitriding in one technological cycle. Used gaseous nitrogen technical purity which before submission in reaction space furnace was dried and dismissed from oxygen by passing through silica gel capsule, heated above ~ 50ºC saturation temperature titanium turnings.

The phase composition of the surface layers were determined by X-ray phase analysis on diffractometer DRON-3.0 (in Russia) in a monochromatic Cu K_α-radiation with focusing by Bragg-Brentano scheme. The voltage on the anode X-ray tube was 30 kV and the current through it 20 mA. Diffraction was filmed by a method stepper scanning in the range of angles 2θ - 10 ... 90 °. Step scanning was 0.05 °, the exposure time at the point - 3 ... 5 s.

The quality of the surface, such as roughness, before and after each technological operation was measured on profilometer models 170621 with automatic determination of the arithmetic mean deviation of profile Ra, μm. The microstructure of the near-surface layers was examined for "oblique" sections, using metallographic microscope «Epiquant» (in Russia), equipped camera and computer unit with fixing the image in digital form. The degree of surface hardening and the distribution microhardness of the near-surface layers of a alloy was determined by hardness tester PMT-3M (in Russia) by the load on the indenter 0.49 N. The depth of the nitrided layer evaluated both metallographic and microhardness by a method microhardness. Testing on a temporary breaking strength at uniaxial stretching was conducted on the tensile testing machine P-0.5 (in Russia). The rate tensile – the rate of moving capture was established 4.8 mm/min. The chart tension was built in the coordinates «load – elongation».

Tribological tests were carried out on the machine for metal wear СМЦ-2 (in Russia) scheme pairing "disc - block" on the basis of 1000 m on the specific load 0.6 MPa and sliding speed 0.6 m/s. The intensity wear of friction pairs evaluated for their change in friction mass. Studied of disks BT22 alloy, whose surface is hardened rolling and deformation- diffusion treatment. As counterbody used block with deformable БрАЖН 10-4-4 bronze.

Quality surface finish after rolling of investigated surface increased by 7 classes compared to the original quality. Surface microhardness the rolled surface of alloy increases from 3.25 to 5.02 GPa, compared to the original, and the depth of the hardened layer reaches ≈ 53 μm (Table. 1). This formation of surface hardening occurs due to increase of dislocation density in the surface layer and grinding its surface structure in the process of plastic deformation.

After next thermochemical treatment of the surface being treated samples BT22 alloy was smooth, shiny, light golden. The quality of the surface of sample after nitriding deteriorates in one class, compared with the quality of the surface after rolling. After the thermal diffusion saturation is further (additional) increase the surface hardness of samples (Table. 1). This increased microhardness surface reason is that during HPPD structure of the surface layer of titanium is crushed, thereby increasing the area of grain boundaries, which leads to the intensification of diffusion of nitrogen atoms into the material.

Concerning the mechanical characteristics, the surface plastic deformation increases the performance of strength and ductility of the material. Next thermochemical treatment reduces the tensile strength of the material and approximates it to the original. At the same plasticity increases BT22 alloy is almost three-fold compared with the original (Table. 1).

Table 1 – Roughness and mechanical characteristics of the surface of the alloy VT 22 after deformation-diffusion treatment

Ttreatment	R_a, μm	$H_{0,49}$, GPa	$\sigma_в$, MPa	δ, %	ψ, %
Original	4.00	3,25	1030	7	17
CSPD	0.17	5,02	1311	8	25
CSPD +TDN	0.27	7,73	1052	18	55

After carrying out tribological tests the character changes of the wear intensity tribo-pair was different. For a disc that hardened the HSP, the wear rate is 0.186 g. For a drive that hardened the CSPD, the intensity wear was 0.186 g. Next nitriding reduces intensity wear on 2 order (Table. 2), indicating good anti-friction properties of the surface.

Table 2 – Tribological characteristics of friction pairs hardened BT22 titanium alloy – БрАНЖ 10-4-4 bronze after friction

Pair of friction	Weight loss Δ*m*, g		Coefficient friction, *f*	Temperature *T*, °C
	BT22	БрАЖН 10-4-4		
Hardened CSPD BT22– bronze	0.186	0.391	0.12	42.7
Hardened CSPD + TDN BT22 – bronze	0.003	0.073	0.02	20.3

It should be noted that the intensity wear counterbodies (bronze pads) exceeds the intensity of wear titanium disks. Counterbodies, which work in pairs with a titanium disc hardened of rolling, had large magnitude of wear compared to the counterbody, which worked with the disc, hardened combined treatment (5.4 fold) (Table. 2).

In addition, the frictional interaction the studied tribo-pair fixed change coefficient friction and temperature in the vicinity of the friction zone. The highest coefficient friction had tribo-pair - was disk which hardened CSPD (Table. 2). The next thermal diffusion saturation reduces the coefficient friction on the order of (0.12 vs. 0.02). Concerning the temperature in the vicinity of the friction zone on a stable portion of the wear, it is well correlated with the friction coefficient and the weight loss. So, for a friction pair disk which hardened a rolling temperature in the vicinity of the friction zone is higher compared to friction pair disk which hardened deformation-diffusion treatment (43 vs. 20 °C).

Microstructures friction surfaces of deformation hardened titanium samples typical adhesive wear mechanism. This mechanism describes the interaction of surface friction, accompanied by severe plastic deformation of thin surface layers, for loads that exceed the yield strength materials. During the contact interaction oxide film is destroyed and exposed chemically clean metal surfaces. Plastic deformation of the contact area helps to maximize the convergence of these surfaces and formation of the surface layers of texture with extremely deformed grains arranged in a direction of relative movement of the sample. When friction at atomic distances and seizure order is micro welding contact surfaces with the release of energy. When caught molecular interaction between surfaces is greater than the tensile strength materials, while the body continues to move mutually, it is pulling material from the softer surface. As a result, the contact surface samples with less durable material (bronze) are formed randomly dug, and the samples with greater strength (titanium alloy BT22) - sticking. This analysis confirms micro X-ray analysis rubbing surfaces, fixing on the surface of titanium samples counterbodies material (copper). For tribo-pair, which strengthened the disc deformation-diffusion processing, surface alloy BT22 is almost unchanged. However, on the surface of bronze pads formed grooved terrain typical abrasive wear mechanism.

Conclusions

Deformation-diffusion processing surface hardening of BT22 alloy was performed and slightly reduces the quality of the surface. Mechanical characteristics after ongoing treatment vary ambiguous: ultimate tensile strength is set at the original and performance plasticity increased almost 3.fold

When friction specific load of 0.6 MPa paired with БрАЖН 10-4-4 bronze in hydroliquids АМГ-10 deformation-diffusion treatment of BT22 alloy 7.5 fold the reduces of intensity wear compared to rolling, providing stable during stability wear lower friction coefficient (0.02 vs. 0.12) and the temperature in the friction zone (20 º C vs. 42 °C).

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Working process of bypass gas turbine engines with turbo-fan additional unit

A new approach of module construction of turbo fan engines is represented. The turbo-fan additional module is mounted after universal bypass gas generator module. The turbo-fan additional unit has two-stored blades. Down part of additional unit works as turbine, but top part of additional unit works as fan. In article main parameters of efficiency and economy of double bypass engines are considered.

Turbojet engine with turbo-fan additional unit consists of two modules: module of gas generator and module of turbo-fan unit. Universal gas generator module and turbo-fan additional module combination provied to design a lot of gas turbine engines with minimum cost for different airplans. This factor is very important dyring design the engines for different types of drones because the cost of construction and production engines has big meaning in total airplan live cycle cost. The scheme of gas turbine engine with turbo-fan module is shown on Fig.1.

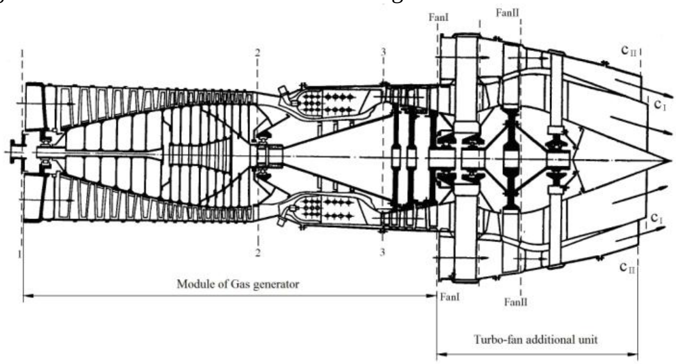

Fig. 1. The scheme of gas turbine engine with turbo-fan module

Usually, turbojet engines are used by construction gas generator module of gas turbine engine with turbo-fan module. For example, modules of gas turbine engines J-79 and J-85 are used in construction engines with turbo-fan additional unit CJ-805 and CF-700. The module of turbo-fan additional unit is mounted after gas generator module.

The turbo-fan additional unit has two-stored blades. Down part of additional unit works as turbine, bat top part of additional unit works as fan.

Relation air flow rate across top part of additional unit to gas flow rate across under part of additional unit is named bypass ratio of turbo-fan additional unit - m_{II}.

The general disadvantage of bypass turbojet engines with turbo-fan additional unit is big temperature gradient along two-stored blades. Down part of two-stored blades have temperature $T_3^* = 800 - 900$K, but top part of two-stored blades has atmospheric air temperature.

Double bypass engines have not this disadvantage, because these engines use bypass gas turbine engines as gas generator. Turbo-fan additional module is mounted after mixing chamber (Fig.2).

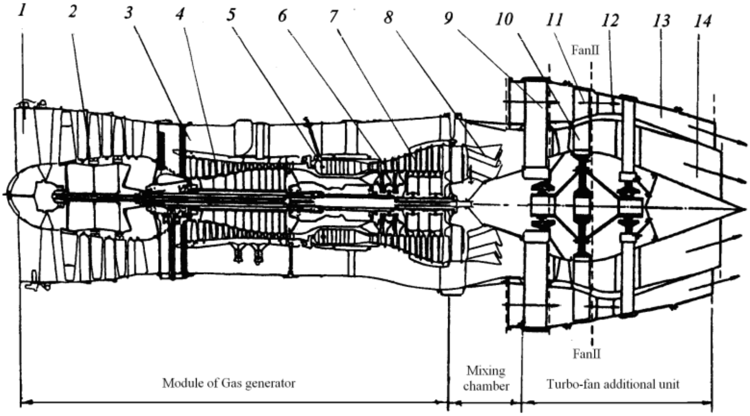

Fig.2 .The scheme of double bypass engine with turbo-fan module

1 – Inlet guide vanes ; *2* – Fan and low pressure compressor of gas generator; *3* – double contour channel of gas generator; *4* – high pressure compressor of gas generator; *5* – combustion chamber ; *6,7* – multistage gas turbine of gas generator; *8* – mixing chamber ; *9* – Inlet guide vanes of third contour; *10* – turbine contour of turbo-fan additional unit; *11* – fan contour (the third contour) of turbo-fan additional unit; *12* – outlet guide vanes of turbo-fan additional unit; *13* – exhaust nozzle of outside contour; *14* – exhaust nozzle of inside contour

Gas flow after low pressure turbine is used by turbine contour of turbo-fan additional unit. Ratio mass flow rate across second contour G_{airII} to mass flow rate across first contour of gas generator G_{airI} is named bypass ratio of bypass gas generator :

$$m_{I} = G_{airII} / G_{airI} .$$

Ratio mass flow rate across outside contour of turbo-fan additional unit G_{airIII} to total mass flow rate across of gas generator (inside contour of turbo-fan additional unit) $G_{airI}(1+m_{I})$ is named bypass ratio of turbo-fan additional unit:

$$m_{II} = G_{airIII} / G_{airI}\,(1 + m_{I}) = m_{III} /(1 + m_{I}).$$

Ratio mass flow rate across outside contour of turbo-fan additional unit G_{airIII} to mass flow rate across first contour of gas generator G_{airI} is named double bypass ratio of double bypass engine $m_{III} = G_{airIII} / G_{airI}$.

Main parameters of working process of double bypass engine are: temperature before high pressure turbine T_3^*; compressor pressure ratio of gas generator $\pi_\Sigma^* = p_2^* / p_\mathrm{I}^*$; fan pressure ratio of turbo-fan additional unit $\pi_\mathrm{fanII}^* = p_\mathrm{fII}^* / p_\mathrm{fI}^*$; temperature T_mix^* and pressure p_mix^* of mixture in outlet cross section of mixing chamber.

Let's consider main parameters of efficiency and economy of double bypass engines. Engine total thrust equals of sum of outlet contour thrust and inlet contour thrust $R = R_\mathrm{I} + R_\mathrm{II}$.

If pressure in outlet cross section of nozzles equals atmospharic pressure, every contour thrust will calculate by equastions:

$$R_\mathrm{I} = (1 + m_\mathrm{I}) G_\mathrm{airI} \left[(1 + g_\mathrm{fuel}) c_\mathrm{cI} - V \right];\ R_\mathrm{II} = m_\mathrm{III} G_\mathrm{airI} (c_{c\mathrm{II}} - V).$$

The specific thrust of every contour:

$$R_\mathrm{GI} = (1 + m_\mathrm{I}) \left[(1 + g_\mathrm{fuel}) c_\mathrm{cI} - V \right]; \quad R_{G\mathrm{II}} = m_\mathrm{III} (c_\mathrm{cII} - V).$$

Velocity of gas after inlet and outlet contour exhaust nozzle c_cI and c_cII.

The thermodynamic processes in gas generator of double bypass engine are similarly the thermodynamic processes in gas generator of bypass engine with mixing chamber. The cycle work of inlet contour is calculated by equastion

$$L_\mathrm{I} = \frac{k}{k-1} R T_\text{н} \frac{e_\mathrm{I} - 1}{\eta_\mathrm{cI}} \left(\frac{\bar{m} \Delta_\mathrm{I} \eta_\mathrm{c\,I} \eta_\mathrm{eI}}{e_\mathrm{I}} - 1 \right).$$

We use basic parameters of gas generator working process (gas tempetature before gas generator turbine T_3^*, total compressor pressure ratio in first contour of gas generator $\pi_\Sigma^* = p_2^* / p_1^*$, compressor pressure ratio in second contour of gas generator $\pi_\mathrm{II}^* = p_{2\mathrm{II}}^* / p_1^*$) for calculation the optimal value of double bypass ratio $m_\mathrm{I} = G_\mathrm{airII} / G_\mathrm{airI}$. Useful cycle work of gas generator during calculation of gas turbine engine with turbo-fan additional unit is regarded as the free energy of exiting gas flow from the mixing chamber. It is determined by the parameters of the working process of the first contour of the gas generator.Part of free energy as external work is transferred to the third (fan) contour of turbo-fan additional unit by turbine part.

At the optimal ratio of the flight speed and gas velocity at the outlet of the nozzle of external contour of turbo-fan additional unit we get. Internal (turbine) part of turbo-fan additional unit is characterized by turbine pressure ratio $\pi^*_\mathrm{t.fan} = p_{mix}^* / p_5^*$. Expantion work of gas in turbine part of turbo-fan additional unit is determined by parameters of gas flow at outlet of mixing chamber. External (fan) part of turbo-fan additional unit is characterized by the fan pressure ratio π_fanII^* and compression work:

Consider the basic equations describing the collaboration of the turbofan gas generator and turbo-fan additional unit.

The energy balance equation of the first contour of turbofan gas generator is

$$G_{\text{air}_I} i_1^* + G_{\text{air}_\text{к}} L_{\text{к}_I} + G_{\text{fuel}} H_\text{u} \eta_0 - G_{\text{air}_I} L_\text{т} = G_{\text{air}_I} i_4^* . \quad (1)$$

The energy balance equation in the combustion chamber of the gas generator:

$$G_{\text{fuel}} H_\text{u} \eta = G_{\text{air}} (i_3^* - i_2^*) = G_{air_\text{I}} c \ (T_3^* - T_2^*) . \quad (2)$$

The power balance equation of the gas generator:

$$G_{\text{air}_\text{I}} L_\text{t} = G_{\text{air}_\text{I}} L_\text{I} + G_{\text{air}_\text{II}} L_\text{II} . \quad (3)$$

Simultaneous solution of equations (1) – (3), we get value of free energy of gas flow after gas generator turbine

$$G_{\text{air}_\text{I}} (i_4^* - i_1^*) = G_{\text{air}_\text{I}} c_0 T_3^* (1 - \frac{T_2^*}{T_3^*}) - G_{\text{air}_\text{II}} L_\text{II} . \quad (4)$$

We denote

$$\frac{T_2^*}{T_3^*} = \frac{T_2^*}{T_3^*} \frac{T_\text{н}^*}{T_\text{н}^*} = \frac{T_2^*}{T_\text{н}^*} \frac{1}{\Delta} = \frac{\pi_\text{I}^{*\frac{k-1}{k}}}{\Delta} = \frac{e_\text{I}}{\Delta}, \text{ where } \Delta = \frac{T_3^*}{T_\text{н}^*} ; e_\text{I} = \pi_\text{I}^{*\frac{k-1}{k}} . \quad (5)$$

Considering (5) the equation (4) takes the form

$$E_\text{I} = G_{\text{air}_\text{I}} L_\text{I} = G_{air_\text{I}} \frac{k_0}{k_0 - 1} R_0 T_3^* (1 - \frac{e_I}{\Delta}) - m_\text{I} G_{air_\text{I}} L_\text{II} . \quad (6)$$

We write the equation (6) in the form

$$L_\text{I} = \frac{k_0}{k_0 - 1} R_0 T_3^* (1 - \frac{e_\text{I}}{\square}) - m_\text{I} \frac{k}{k-1} R T_1^* (e_\text{II} - 1) = \frac{k}{k-1} R T_1^* \left[\alpha \left(1 - \frac{e_\text{I}}{\square} \right) - m_\text{I} (e_\text{II} - 1) \right], \quad (7)$$

The free work of turbo-fan additional unit is calculated by formula

$$L_{\text{free}} = \left[\frac{m_\text{III}}{(1 + m_\text{I})} \eta_\text{III} + 1 \right] \frac{(1 - \eta_\text{III}^2) V^2}{2 \eta_\text{III}^2} . \quad (8)$$

Simultaneous solution of equations (7) and (8) allows to define double bypass ratio of of turbo-fan additional unit m_III .

At full expansion of the gas in the contours specific thrust of gas turbine engine with For calculating flight conditions optimal pressure turbo-fan additional unit is equal to specific thrust each contour

$$R_G = R_{G\text{I}} = R_{G\text{II}} = (c_{\text{cI}} - V) = (c_{\text{cII}} - V) .$$

The double bypass ratio of engine is selected according to condition of minimum specific fuel consumption $C_{R\ \text{min}}$. This choice determines sizes, external resistance of the power plant and mass characteristics of the engine.

For drones with subsonic speed of flight (700…800 km/h) optimal values of double bypass ratio are located in range m_III = 4...8. Higher parameters of working process correspond to higher values of double bypass ratio.

Economic efficiency of gas turbine engine with turbo-fan additional unit is estimated by internal (energy) efficiency coefficient. This efficiency coefficient is characterized by efficiency of heat energy conversion, allocated during the fuel combustion in cycle work (the change of kinetic energy of gas flow.

$$\eta_{\text{dbp}} = \frac{(c_{\text{c}}^2 - V^2)(1 + m_{\text{I}} + m_{\text{III}})}{2\eta_{\text{г}} H_u g_{fuel}}.$$

The combination of universal gas generator and turbo-fan modules with different parameters permits to create different gas turbine engine for various aircraft with the smallest economic investments. This is especially important in creating of engines for various drones when the cost of design and creation of power plant has a large part in the summary cost of the aircraft life cycle. Table 1 presents the data on the efficiency of the turbojet engine, turbofan engine and gas turbine engine with turbo-fan additional unit with the same air mass flow rate through the gas generator contour. Turbofan engine is used as a gas generator in gas turbine engine with turbo-fan additional unit.

Table 1.

Engine parameters

Parameters	Engine type		
	Turbojet engine	Turbofan engine	GTE with turbo-fan additional unit
Temperature T_3^*, K	1600	1600	1600
Pressure ratio π^*_{Σ}	13,5	29,5	29,5
Air mass flow-rate of first contour G_{airI}, kg/sec	0,75	0,75	0,75
Air mass flow-rate $G_{\text{air}\Sigma}$, kg/sec		1,725	5,39
Bypass ratio m	-	1,3	m_{I}=1,3; m_{II}=2,6
Thrust $R_{\max}$, kN (H=0, M=0)	0,586	0,9085	1,596
Specific fuel consumption C_R, kg/(kN·hour)	0,096	0,051	0,034

The data in Table 1 show that gas turbine engine with turbo-fan additional unit has trust-economic characteristics more, than turbojet and turbofan engine. Methods for selection and validation of working process parameters of gas turbine engine with turbo-fan additional unit for drones have certain features in comparison with the calculation of full-sized engines. These features are determined by the higher level of losses in all units of small-size gas turbine engine with turbo-fan additional unit for drone.

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Research of exhaust-screen devices for jet-engine

The article addresses scientific issues of design of exhaust screens as most common and reliable method of protecting aircraft from guided infrared homing head missiles and surface-to-air missile systems. Array of experiments was conducted for different types of jet engines, all of which achieve forward thrust from the principle of jet propulsion: turbojet, turbofan, turboprop and ramjet. Using non-axial flow turbines result in a drop of thrust power. For purposes of reducing energy loss and achieving less field flow fractionation static exhaust blades should be used.

At present the most perspective and commonly used way of planes, helicopter and other air objects protection form target engagement by missiles with infrared homing and also from man-portable air-defense system (MANPADS) is the use of ejectors in exhaust screen devices [1-3].

Using of MANPADS by terrorist groups is extremely exacerbated the problem of civil aircraft and helicopter flight safety and also made this issue on of the most acute and actual in the modern world. Therefore, the new direction of aviation facilities, flight safety is a creation of aircraft protection system from potential destruction.

According to the data [4] decreasing of exhaust gas temperature from engines on 30% leads to decreasing the length of the capture range by opto-electronic systems on 43% and reducing temperature to 50% decrease the length of the capture range on 67%. Consequently, the use of ejectors in GTE exhaust screen devices is appropriate and necessary in many cases.

Theoretical investigation improving of the experimental data those allow to describe with the help of some equations gas flows and gas mixes. By the methods of applied mathematics developed efficient ways to solve these equations on a computer.

Experimental data give an opportunity to define the necessary values of physical and chemical characteristics, which are common to the investigation environment or process. A lot of tasks before scientists, caused by the development of modern technology, currently, can't be solved by calculation-theoretical methods. In these cases there are widely used gas-dynamic experiments, conducted in wind tunnels and special gas dynamic facilities.

During providing gas-dynamic calculations are commonly used simplified theoretical understandings about average gas flow parameters along the cross section of desired object channel using main patterns of the flow that are found by experiment.

During providing calculation of GTE compressors and turbines, nozzles and diffusers, rocket engines, wind tunnels, ejectors, gas pipes and other technical facilities used characteristics obtained from generalization from theoretical and experimental studies.

For the definition of a gas flow feature in present conditions, provide complex of different shapes axial subsonic gas ejectors experimental investigation with flow turning from 0 to 90°. Experimental investigation produced on model facilities, general view gives on fig.1 *a, b*.

a) *b)* *c)*

Fig. 1. Wind tunnel with nozzle part

The installation looks like an open wind tunnel and includes lines of compressed air supply, receiver, transitional section, and knot for installation of different type of nozzles, chamber of mixing and diffusers and instrumentation. Air from environment supply to installation with the help of two consistently connected superchargers (fig. 2 *c*).

Main constructive features of operation parts were taken according to the recommendation [5]. In order to provide a uniform velocity and pressure field in the wind tunnel was designed honeycomb and anti-turbulence netting. Geometrical dimensions of calming chamber correspond to ГОСТ 10921-74.

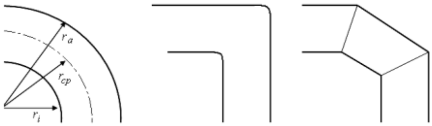
During the research process was obtained capacity characteristics of receiver cross section that narrows the profile of which was close to the Witoszynskyj curve. In this cause exhaust diameter was equal to 105 mm. Along with nozzles have been tested mixing chambers. Diameter of an initial cross section of mixing chamber changes according to ejection coefficient n=0.01; 0.05; 0.1. The length of the mixing chamber was 350 mm. For the cylindrical part of the chamber was mounted tapered expanding section (subsonic diffuser) with half cone -4°.

Nozzle models, mixing chambers and diffusers were installed in compressed air supplying manifold after the transitional cross section of the receiver. One of the variants of experimental model nozzle part of active gas flow and experimental model of axial subsonic ejector present at fig. 3.

Fig. 3. Experimental model nozzle tips and model axial subsonic ejector

In all cases, design of the gas ejector model allows to change the ejection rate by the changing of cross-section area of the passive air ringing type nozzle. Irrespective of the form of the channel cross section turning of a flow provided by a right angle or along the curved channel contour of which consisted of straight segments.

At fig. 4 present three types of turning knees and marked inside radius r_i, external r_a and average r_{av} radiuses of the curve.



a) b) c)

Fig. 4. Type of knees: a - curvilinear; b - rectangular; c - broken

To rebuild the model conditions at the active gas nozzle input were used turning knees with flow turning to 90°.

Research of the gas ejector with mixing chamber and flow turning, which had several stages of passive gas, conducted on the prototype, that is presented on fig. 5.

Fig. 5. Multistage mixing chamber

Visualization of the flow was provided with the help of gluing hair strands on the surface of the mixing chamber, which is reflected in fig. 6.

Complex of research experiments involved studying construction of gas ejectors with the intensification of the mixing process:

- gas ejectors with nozzles of active gas, that divided on to the several flows;
- gas ejectors with nozzles of active gas, with had part of transition cylindrical in to the flat;
- gas ejector with petal active gas nozzle;
- gas ejector with the combined nozzle of active gas and supplying of passive gas into the center of mixing chamber.

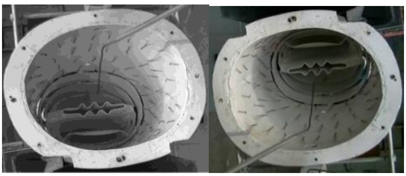


Fig.6. Flow visualization at experimental model of ejector

Results of experimental investigations

In ejectors with petals at the inlet to the mixing chamber (fig. 7) alignment of the velocity field is more intense. At low velocities unevenness of velocity field produce useful effect, that obtained by further aligning at mixing chamber, doesn't compensate the value of hydraulic losses which increased.

Fig.7. Prototype of ejector with petals at the inlet to mixing chamber

Consequently, there is a finite optimal length of mixing chamber. Experimentally this is defined by the presence of a maximum static pressure of the mixture at some finite distance from the inlet to the mixing chamber.

This is caused by the necessity to turn the hot gases behind the mixing chamber up regarding the helicopter to reduce the length of its capture by missile of «ground-to-air» type.

Flow turn leads to additional energy losses and as a result, in reducing of power turbine power.

In order to reduce energy losses and providing uniform velocity field advisable to use profiled or non-profiled plates and guide vanes that installed at the corner [6].

Provide research of experimental prototypes of ejector type exhaust screen devices of the flow turning with guide vanes at the outlet of the mixing chamber (diffuser).

At fig.8 shows an experimental prototype of ejector type exhaust screen devices with guide vanes at the outlet from mixing chamber. Research has approved that the using of guide vanes at the outlet from exhaust screen devices and reduced direct "visibility of hot gases" gas ejector active nozzle. This, in turn, reduces range of helicopter capture by "air-land" missile type with infrared homing heads.

The length of the mixing chamber of exhaust screen devices restricted by permissible dimensions of the helicopter, so the mixing process intensification depends from the length of mixing chamber and become more actual.

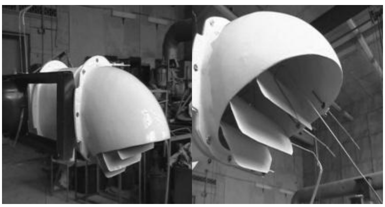


Fig.8. Experimental type of exhaust screen devices with guide vanes

Important direction of intensifying the mixing process is the using flow spin, separation of the active gases into the several jets, applying a petal type of mixers and other.

The analysis of work on the subject of research where the results of experiments and theoretical knowledge leads to the conclusion that the satisfactory results of theoretical researches is available only for the causes of insignificant flow spinning and absence of reverse gas flow. Nowadays, significant characteristics for the subsonic gas ejectors with intensification of the mixing process can be determined only by experiment.

Conclusions

Substantiated a scientific and technical problem of development exhaust screen devices device as one of the most common and effective means of aircraft protection, helicopters and other air objects from destroying with infrared homing heads and portable MANPADS.

In determining the characteristics of gas flow in real conditions performed complex of experimental studies of various forms axial subsonic gas ejectors with flow turning from 0 to 90°. Visualization of the flow in the mixing chamber performed by using a carbon black mixture and horsehair stickers.

Studied the structures of gas ejectors with active gas nozzles that divided into several flows; gas ejector with nozzles of active gas that had transition parts from cylindrical to flat; gas ejector with combined nozzles of active gas and supplying of passive gas inside the mixing chamber.

Revealed that flow turning leads to additional energy losses and thus to reducing of the power turbine. In order to reduce energy loss and providing uniform velocity field appropriate to use profiled of non-profiled plates of guide vanes.

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Application of the genetic algorithms in an aviation gas turbine engines diagnostics

A study of the optimization problem of multivariate regression equation describing the technical condition of a aviation gas turbine engine using a genetic algorithm considered in this paper. The results of the application of genetic algorithm for optimizing of the output parameter of a linear multivariate regression equation is presented

INTRODUCTION

One of the modern approaches used in the diagnosis of aviation gas turbine engines (GTE), is a genetic algorithm (GA) [1,4,5]. GA is used as an effective optimization tool to obtain the parameters of engine components, which are defining a set of dependent predictor parameters by a non-linear model of GTE. As a result of this optimization the best measure is predicted.

The solution of this task is achieved by reaching the minimum valued target function, which is a rate of the difference between the measured and predicted values of GTE parameters. GA is using three typical operations within optimization.

Selection - selection of individuals (diagnostic events) to generate a new generation according to the natural selection criteria.

Crossover - the information exchange among two individuals by exchange of parameters vector parts, in order to reach the adapted diagnostic events

Mutation – input the new or untimely-lost information by random exchange among randomly selected vector components.

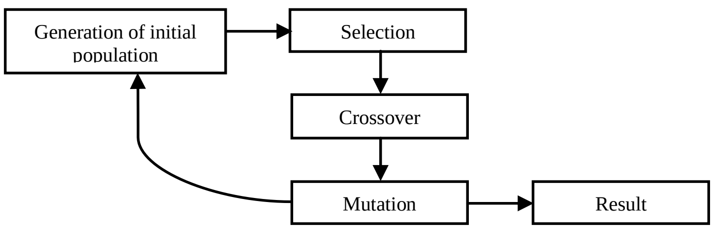

Fig.1 General Scheme of any GA operation

As can be seen, the GA is an effective search tool and optimization. Summarizing the researches in GA application direction, the follow distinctive features may be tagged [5].

- there are no requirements in derivatives, so any grainy function can be optimized;
- the limits can be adjusted by different methods, for instance, by penalty functions or specific operations;
- the global search is used to avoid jamming of the optimization process within a local minimum;
- the probabilistic rules are preferable than deterministic within generation of new individuals ones.

But the complexity of the GA application, is inability without researching whole surface of target function, to answer the question: is the found solution the be global or local minimum? That is certainly impacts on the rapid assessment of the current technical condition of the engine. Despite this fact, the application of GA in the GTE diagnostic are being analyzed below.

For instance, Singhs and Zeddas' researches [4,5] were represented the GTE sensors and units fault diagnosis by GA with noises and displacement measures. There is the GTE technical GA real coding embodied conditions (TC) evaluation via the optimization of the target function. Nevertheless, for noise-measured problems solving and availability of fault sensors and engine assembly maximum numbers are putting forward by statistical assumptions. However, this method is suitable for new generation engines, where a relatively large number of measurements usually available. This methodology has been applied in the diagnosis of three spool engine RB199 [4] and two spool engine with a low bypass ratio EJ200 [5]. That attitude proved high accuracy of the results.

There was demonstrated the following combination of two approaches in the [3,4,5] researches: diagnostic approach with sets of operation points and GA. Here is formed GA method based on the engine multi mathematics mode. This approach is suitable for the diagnosis of GTE, which has a limited part of the monitored parameters, or faulty sensors. It has been applied to the RB199 engine and reached successfully results. A similar approach was applied also for the PW100 engine, where in order to improve the GTE TC assessment, was carried out the gradient method [2]. The research analysis is showing that one of the main tasks in aviation GTE diagnosis is an optimal form of the regression equation, which is forming on the real flight parameters. Therefore, this circumstance makes GA application as an extra tool for building the GTE diagnostics automated systems, which is considered in the next paragraph.

THE MULTIPLE LINEAR REGRESSION OPTIMIZATION OF GTE TC

The optimization task of multivariate regression equation is considerated in this paragraph. The mathematical model GTE TC, based on the regression equation is considered:

$$Y_i = \sum_{j=1}^{n} h_{ij} x_j, \quad i = \overline{1,m}$$

Here Y_i - output parameter of TC GTE model (diagnosed parameter of GTE) x_j - the input parameters of the TC GTE model, h_{ij} - coefficients, identified by regression analysis. The values range of the regression factors are forming at the initial stage of GTE operation in service and $h \in \{h_{\min}, h_{\max}\}$.

Let the given model is an empirical equation as an approximate function of the eleven parameters described the GTE operation.

$$y \approx h_1x_1 + h_2x_2 + h_3x_3 + h_4x_4 + h_5x_5 + h_6x_6 + h_7x_7 + h_8x_8 + h_9x_9 + h_{10}x_{10} + h_{11}x_{11}$$

where $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}$ - the inputs parameters of model from the eventual intervals [$x_{j\min}$, $x_{j\max}$] for the considered GTE operation phase. $h_1, h_2, h_3, h_4, h_5, h_6, h_7, h_8, h_9, h_{10}, h_{11}$ - values of the influence coefficients in the regression model, which are within trust interval [$h_{j\min}$, $h_{j\max}$] for the considered GTE operation phase.

In accordance with the developed method, the analysis of the engine TC (D30KU-154) has been carried out. The condition of engine initially evaluated by the results analysis in the changes of an influence factors in the model.

$$V_{ЗО} = h'_1 \cdot H + h'_2 \cdot M + h'_3 \cdot T^*_H + h'_4 \cdot p^*_H + h'_5 \cdot n_{НД} + h'_6 \cdot T^*_4 + +h'_7 \cdot G_T + h'_8 \cdot p_T + h'_9 \cdot p_M + h'_{10} \cdot T_M + h'_{11} \cdot V_{ПО}$$

where h' - is an appropriate impact factors of the regression equation, H - altitude (m), M - Mach number, T^*_H - ram air temperature at the engine intake station (C), p^*_H - ram air pressure at the engine intake station (kgf/cm^2), $n_{НД}$ - low pressure shaft rotation (%), T^*_4 - gas temperature engine (C), G_T - fuel consumption (kgpm), p_T - fuel pressure (kgf/cm^2), p_M - oil pressure (kgf/cm^2), T_M - oil temperature (C), $V_{ПО}$ - vibration of the front bearing (mm/sec).

However the suggested approach do not allow to determine the maximum expected value of the vibration $V_{ЗО}$ at the considered flight conditions and parameters values of a serviceable engine. That stipulate to solve the task of reaching the maximum and minimum value. There was appear the problem of the optimization task solving. Thereby, the possible maximum of input parameter $V_{ЗО}$ is required to be found, which describes the serviceable condition of a GTE. With this purpose, the influence factors ranges were formed initially.

With the purpose of GA application for the finding of $V_{ЗО}$ maximum value, the lower and upper limits of engine's parameters variation have been identified. (Table 1).

As an example, the research to find the maximum value of the aft bearing vibration parameter based on the GA application, by the Statistic 10 Software (Statsoft) and with the HP ProBook 4720s (İntel Core i3, 2.4GHz, 4 Gb RAM, Windows 7 Ultimate, 64-bit) computer using, was perfomed.

Table 1

The range of the engine's parameters variation in the regression equation

$$V_{ЗО} = h'_1 \cdot H + h'_2 \cdot M + h'_3 \cdot T^*_H + h'_4 \cdot p^*_H + h'_5 \cdot n_{НД} + h'_6 \cdot T^*_4 + h'_7 \cdot G_T + h'_8 \cdot p_T + h'_9 \cdot p_M + h'_{10} \cdot T_M + h'_{11} \cdot V_{ПО}$$

GTE parameters	Basic statistical characteristics of GTE parameters			
	max	**min**	**average**	**st. deviation**
H	10573,33	8300	12100	566,5437
M	0,82	0,75	0,85	0,016
T^*_H	-50,22	-62	-34	5,2371
p^*_H	0,39	0,306	0,51	0,0324
$n_{НД}$	80,17	72	82	1,3399
T^*_4	477,3	410	500	12,8661
G_T	1824,17	1500	2200	140,8845
p_T	40,38	40	42	0,5849
p_M	4,02	3,9	4,2	0,0493
T_M	35,9	22	50	6,9421
$V_{ПО}$	6,88	5	10	1,5414

An optimization of the equation with the $V_{ЗО}$ output parameter, was performed with the maximum, minimum and average values ($h_{j\min}$, $h_{j\max}$ и $h_{j\,сред.}$) of the influence factors. The basic parameters of all optimization cases were applied as: the number of the population - 40; number of generations - 100; Crossover probability - 0.7; mutation probability - 0.09091; number of descendants - 1000. The computation time for all variants was about 0.8 seconds.

The results of the GA application is shown that the maximum expected value of vibration at the considered flight conditions and parameters values of a serviceable engine's operation process does not exceed 15 mm/sec. However, the real value of the engine's vibration is almost or far exceed, or fall short of it, which testifies about presence of faults in systems, including mechanical destruction of the rotor assemblies.

The peculiarity of the GA application for solving this problem is follow. Whereby the start variety is less, the less likely to get satisfy solutions at the stage of a population generating, but the development of the evolutionary process goes longer. On the one hand, there is a danger to pass correct decisions with the initial release to the local maximum. In the case of the successful launch of the initial population, more number of steps will be enable better approach to the correct answer. Accordingly, the option with a large population is less susceptible to the danger of falling into a local maximum, but has fewer opportunities to improve the solutions found. Nevertheless, the option with a large number of populations and generations gives the best results as a combination of the above-mentioned advantages.

Table 2

The results of the GA application for the output parameter $V_{ЗО}$ optimization

GTE parameters	**GTE parameters values, which provide** $V_{ЗОopt}$		
	При $h_{j\,a\,var}$	При $h_{j\min}$	При $h_{j\max}$
H	8300,003	8300	8300,005
M	0,75	0,75	0,75
T_H^*	-50,22	-50,22	-50,22
p_H^*	0,306	0,306	0,306
$n_{НД}$	72,00002	72,00002	72,00001
T_4^*	410	410	410,0001
G_T	1500	1500	1500
p_T	40	40	40,00003
p_M	3,9	3,900001	3,900001
T_M	22,00001	22	22,00002
$V_{ПО}$	5	5	5,000002
$V_{ЗОopt}$	14,24723	13,49157	15,00289

CONCLUSION

The researches show that using GA in the GTE TC diagnostics with the empirical model of condition adapted for the considered flight conditions and a serviceable engine's operating process parameters value is allowed to improve efficiency of acceptance decisions at the further operation.

The using of this approach also allows for the optimal control of GTE operation in terms of getting the most thrust with the possible minimum fuel consumption. In this formulation of the problem, the using of the GA is required to use appropriate mathematical models of GTE, which is provided with a sufficient number of sensors.

The researchers shows that in some cases the calculation of the answer by the exhaustive search would take a longer time, which is not unacceptable for diagnosing processes of GTE. To reduce the time for optimization the amount of recorded data (the number of measurements) should be reduced to a some value m, that is obtained experimentally. But for the m measuring all the conditions of adequate regression equation formation for TC GTD, have to be followed. Therefore, the optimization task for a number of measurements within limit (for example, $m = 12 \div 15$) and observation of global maximum variation is considerated as optimal.

The character of the area or the global maximum point variation is enable to take a final decision related the expected output parameter dynamics of the investigated regression equations.

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Complex of the programs for support of information integrity while displaying the integrated dynamic scenes in automated air traffic control systems

A new approach is proposed to display the integrated dynamic scenes on the basis of programmatic support of information integrity in the automated air traffic control systems. The result of combining the components of different scenes is semantically correct and consistent image of the air situation observed on-screen.

XXI century: mankind has entered the information technology era; data carriers have become cheaper than information, stored on them, a value of which is determined by content. In this regard, any modern information system is faced with problems of information security and data integrity. Especially it concerns the large distributed real-time systems, to the class of which the automated air traffic control systems (AS ATC) belong.

Importantly, a modern form of the information systems are data banks, which include in its structure a computer system, one or more databases (DB), a database management system (DBMS) and a set of application programs. Growth of requirements to characteristics of applications that as part of AS ATC provide the processing of complex data about the current location of the observed aircrafts and geospatial information, correlated with them, and also ensuring the implementation of a number of calculations [1] for generation of the output integrated dynamic scenes, entailed the development of these systems towards the improvement of 2-D scenes' imaging technology to support the informed decisions of ATC controllers.

If initially the primary importance when developing such systems has been an increase in the speed of access to data and a minimization of amount of stored data and service information related to them, then afterwards, with appearance of more rapid element base and with increase of the memory volumes, the requirement of reliability of information storage [2] moved to the fore, that, in turn, led to the need for redundant data storage.

Evolution of the information systems is linked, foremost, with development of relational database technology. One of the fundamental concepts of database technology is the concept of integrity associated with the fact that a database reflects an object or a set of related objects of the real world in the informational form. In the relational model such objects are represented as a set of interconnected relations [3]. By other words, in the theory of databases the integrity implies the accordance of informational domain model, stored in database, to the objects of the real world and their relationships at each time point. Any changes in the domain, which are meaningful to the constructed model, should be reflected in database, with saving the unambiguous interpretation of information model in terms of subject area.

It is known [4] that support of integrity in the relational data model in its classical sense includes three aspects: structural, language and reference.

Support for structural integrity consists in that a system, based on the relational data model, should be allowed the work only with the homogeneous data structures such as "relations". At the same time to ensure integrity of database, the constraints of integrity are imposed in the form of certain conditions to be fulfilled by data stored in base. Examples of such conditions are:

- limitation of the range of possible values of attributes of objects, the information about which is stored in database;
- absence of duplicates of the tuples determined by the rows of relations;
- arising from the previous statement, the mandatory presence of the unique primary key that is one or more columns-attributes, which uniquely identify each record in table, that is allow clearly to distinguish one record from another;
- absence of concept of ordering of tuples.

In addition to the structural integrity it is necessary to consider the issue regarding the uncertain (Null) values. Null-value in a relational database is interpreted as a value, which is unknown at this point. At appearance of additional information at any time this value can be replaced with a certain specific value.

The support of language integrity is treated as an opportunity to ensure description and manipulation of data using SQL language, by eliminating the possibility of the low-level data manipulation tools that do not conform to the SQL standard. That is why access to the information stored in database, and any changes to this information can only be performed using SQL language operators [3, 4].

Support for referential integrity means ensuring one of the principles defining the relations between the instances of tuples of associated relations: the tuples of subordinate relation are destroyed or are modified when removing the tuple of the main relation, associated with it. Thus, in second case, Null-value is placed to the site of the parental relation key.

Referential integrity excludes the errors of links between the primary and secondary key, providing support for a consistent database state during modification of data when performing operations of adding or deleting. Examples of violations of data integrity are the existence of records-orphans (child records that have no connection with parent records) or the existence of identical primary keys.

The above integrity constraints in general do not define semantics of database; therefore other methods are needed to determine the restrictions which are related to database content. These methods are summarized in support for semantic consistency. The semantic support can be provided in two ways: declarative and procedural. The declarative support is executed by means of the SQL language, and procedural one is to use a code implemented in DBMS as stored procedures and triggers.

If the system supports neither declarative mechanisms for integrity constraints nor triggers then the code that monitors the database correctness must be placed in the user application. It substantially hampers the programs design and, most importantly, does not protect against the possibility of the user fulfillment of the operations violating the data integrity, bypassing the restrictions implemented by the application. A situation is particularly complicated in the case where database works with many different applications, rather than alone. Each of such applications must contain the same code, responsible for maintenance of the database integrity and which at necessity of change of character of integrity constraints must be modified in all applications synchronously.

Thus, securing the database integrity is a prerequisite for the successful operating of not only database, but also of application using it, as a whole.

Organization of AS ATC in the form of client-server applications produces the high demands on database performance with considering transmission of data arrays of large volumes over the network [5]. Moreover, the current real-time system should provide not only effective access to the files, but also protection against unauthorized access and the data consistency.

Scheme of the computer flight data processing in modern AS ATC contains the risk of loss of data integrity [6]. According to the intention underlying the functioning of these systems, the solution of general task – maintenance of the integrated technology of work of controllers' staff – is divided into two directions:

1) maintenance of updatable data about the environment in which the ATC process develops – about the state of atmosphere, the bandwidth of the airspace structure elements, the technical condition of the radiometric tools and communications equipment;

2) support of data about the objects of management – aircrafts, accomplishing flights.

Subsequently, both types of data are integrated into the sequence of the displayed dynamic scenes combining the variable layers of cartographic background and the symbols of varying degrees of complexity reflecting a state of controlled mobile objects.

Accordingly, structure of AS ATC software is built on the principles of separation of functions of its elements [7]. So, the testing and management operations of radars, direction finders, data transmission channels are assigned to the complex of the programs (CP) for control of the peripheral information sources. CP for processing of meteorological information summarizes the data about weather in the area of responsibility of the system. Special programs transmit the data about the mode restrictions (into the workplaces of controllers) regulating the order and the access levels for different groups of users to databases, which contain detailed information about the cartographic background of dynamic scenes [8].

As a result of work of the listed programs the geospatially referenced and the stand-alone updated descriptions complemented mutually (about every air field, about every source of measured and planned information, about situation in sectors) are created in an appropriate system database. The resulting descriptions may overlap, for example, coordinates of aerodrome, its name, airstrip code, and may partially differ (state of cloudiness, air temperature, boundaries of sectors of approach and circle).

Similarly, each object of control – aircraft – is accompanied in the separate descriptions of CP for handling of the planned and measured in real-time radar and satellite information. In accordance with the objectives of the two subsystems – planned and actual – each of them uses different mathematical models for computation of trajectory of the same aircraft.

The programs-schedulers work with an accuracy of the scheduled messages, in which time is indicated in hours and minutes, the distances are converted from coordinates and names of air fields, air traffic areas and routes, and a height is set to within a echelon. However, at computations they take into account neither the rotation maneuvers in the inflection points of tracks nor other nuances of the flight path.

In contrast to the algorithms of work of the planned subsystem, in the process of calculation of trajectory, CP for handling of radar data monitors the parameters of the aircraft movement with accuracy of the radar measurements and uses a powerful mathematical formalism of theory of optimal statistical solutions.

Each maneuver of the controlled aircraft that characterizes a change in its speed and direction of motion is displayed in a dynamic scene on the user's screen in a corresponding change in the position and angle of the movable object symbol [9, 10].

In turn, CP for data processing of automatic dependent surveillance (ADS) receives from the on-board equipment of aircraft the results of the radio-navigational measurements together with computations of deviations of actual path from the predetermined. It is necessary to underline that the ADS reports also contain calculations of aircraft maneuvers to correct the mentioned deviations.

As a consequence, the descriptions of each element of the airspace and each aircraft, accompanied by a variety of CP of AS ATC software, are not identical. Over time, the mismatches become all more substantial, and probability of loss of data integrity increases.

A significant role in this trend is assigned to the implementation of data input by users for the purpose of DB correction. Every act of reception and transmission of management, change of callsign signal of the aircraft, as a rule, corresponding to the registration number assigned it, specification of motion parameters, which are sequentially executed by various controllers, are recorded in each copy, both in the address space of computers of workplaces, and in the DB of system server. Fixing points are separated in time and are subject to the discipline set in the local network, of exchange and access. Under such conditions, there are probable differences not only in data of interacting functional CP, but also in their copies on the server and on the workstations.

The ambiguity of copies results in display of an inconsistent information, in errors in computations and other effects, which coincide by nature of manifestations with the results of inadequate debugging of software. In addition, there is a probability of loss of part of information that leads to violation of DB integrity due to insufficient synchronization of CP.

The proposed way for prevention of integrity violations is based on reconfiguration of AS ATC software through inclusion of developed CP, which provides support for information integrity when displaying the integrated dynamic scenes that are built on the basis of attributive information got by selecting from database.

In the context of the integrated dynamic scenes the integrity of information means correctness, accuracy, timeliness and consistency of the data involved in the formation of such scenes, and also includes the integrity of links between these data. The offered CP for support of the designated integrity is based on an ontological description of selected domain objects; it allows to take into account its semantics in the visual presentation of these objects in the dynamic scenes.

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Study of the mesh parameters for results in CFD - calculation of fan stage turbofan

When using numerical calculations for the simulation of physical processes is necessary to consider the impact of a large number of parameters to calculate the results. These settings include the grid type (structured, unstructured), the number of elements of the computational domain, compliance with those elements of the quality parameters, etc. Because at the moment there are no strict dependencies that allowed to take into account the deviation calculation results of the above parameters, prior to numerical modeling for a particular geometry and requires a number of preliminary calculations. As a result of their implementation should be set enough size quality mesh to obtain results with the required accuracy.

Formulation of the problem

The reliability of the calculation of mathematical models is very closely linked with the correct definition of turbulence models, because it depends on them of a gas-dynamic calculation. Model of turbulence, in turn, is connected to the grid model, because the more complex demands for a certain density grid, which will be the minimum necessary to describe the vortex flow in the channel. However, the use of large nets (nets with a very large number of elements) is possible only on a very powerful PC, and the calculation of time with such nets is greatly increased. Therefore there is a need for determining the density of the mesh size to ensure adequate results of calculation of the maximum with a minimum calculating time.

The dependence of the turbulence models on the grid

One of the key moments in the gas-dynamic calculation of turbomachinery is a selection of the most efficient in terms of duration and adequacy of the calculation of the results, the computational grid and turbulence models. Each turbulence model has its own set of tasks for which it is well-proven. In addition, each model of turbulence computational grid requires a certain quality.

When computational studies of turbomachinery using the software package ANSYS is possible to set the following turbulence models: k-ε model, k-ω model, the BSL model, the SST model SAS model, LES model, DES model, the Reynolds stresses and others, including mixed models [1] .

So for two different tasks fit different models of turbulence (for flow simulation in large-diameter pipes, one model fit and streamlined for the calculation of difficult objects, other). The main element in the study of turbomachinery are the boundary conditions on the walls. This wall region of fluid flow characterized by the special nature of turbulence in which the pulsation directed along the normal to the wall are absorbed. The closer to the wall - the greater the viscosity of the forces that are beginning to prevail over the forces of inertia, in consequence of which the flow begins to change the nature of the flow and becomes close to laminar. Therefore, turbulence models are divided into two broad categories: 1) low- Reynolds numbers (LRN); 2) high- Reynolds numbers (HRN) [3].

The first category (LRN) models allows a good description of near-wall flow, but it is very inconvenient for the calculation of the free movements. In addition, the reporting method has low accuracy solutions in the field of free flow. The main representative of this category is the model of k-ω.

The second category (HRN) is widely used for the free flow of (jet mixing layers, etc.). But it is poorly describes the near-wall flow. The fact that the derivation of the basic equations relating to the dissipation rate ε, the assumption used value of large local Reynolds number. Near the wall, this assumption is violated, since here the local Reynolds number tends to zero. A typical model for this category is the k-ε - turbulence model.

When calculating the complex with the passage channels (input channel with a first fan stage) is necessary to consider both components, so in this case, a SAS SST turbulence model. This model is combined and used models in the wall regions and k-ε model in areas that are at a sufficient distance from the wall. This combined method lies in the fact that transformation equations k-ε-model to - k-ω formulation.

Thus, adequate values for the investigation of the fan stage model, it is necessary to set the grid parameters that maximizes the writing up turbulent flows in the flow cavity. However, reducing the grid leads to complication of the problem and as a result of increasing demand for PC and calculating time. The speed of calculation tasks, depending on the density of the computational grid is shown in Table 1.

Table 1

Time of numerical simulation in ANSYS Fluent

number of the computational grid elements	time of calculation
100 000	60 min.
1 000 000	400 min.
2 000 000	1400 min.
7 000 000	7200 min.

In the present study investigates the influence of the density of the computational grid to study the working of the fan stage of the process perspective turbofan using SAS-SST turbulence model on the quality of the results of CFD-calculations.

The aim of this study is to determine the degree of influence of various mesh sizes on the resulting flow pattern and determine the possibility of making the preliminary assessment results, which were obtained in the "weak" PC.

Studies based on the results of the calculation of the mesh parameters was carried out using ANSYS Fluent software package (numerical modeling) to the fan engine model.

To simplify the construction of settlement areas and reduce the total number of grid cells - used model of inter-blade channel with the imposition of the boundary conditions of periodicity (Figure 1.).

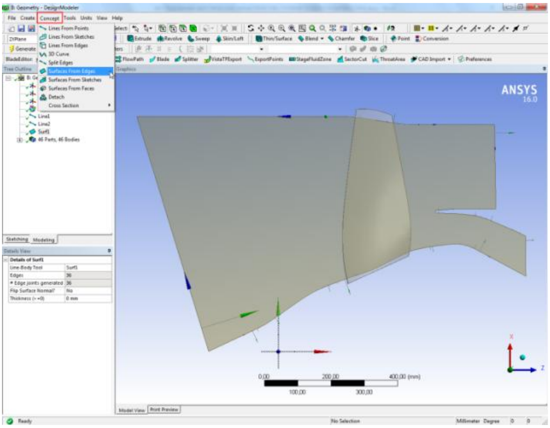

Fig. 1. The meridian section of the computational model

Calculations used a structured hexahedral mesh prismatic sublayer (Fig. 2).

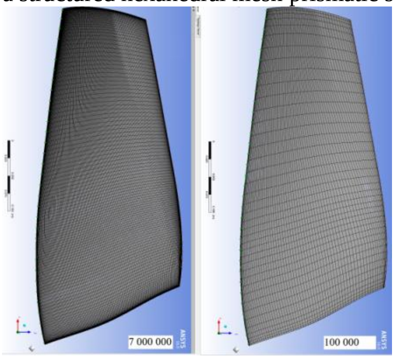

Fig. 2. finite element mesh computational domain on the surface

Numerical simulation was carried out on several grids, different number of elements with the same boundary conditions to determine the required degree of computational domain sampling.

The boundary conditions of the project:

at the entrance - the mass of the working fluid flow rate for one crown, which is equal to 11.02917 kg / s, the total pressure of 101325 Pa, and the temperature of the incoming flow - 288 K;

Output - the total pressure and temperature that are similar to the inlet.

The ideal gas (air) was chosen as the working fluid.

The work was carried out in several stages:

At the first stage it was built coarse mesh: the total number of elements 100 thousand, the amount to the nearest 0.5 mm wall element, dimensionless ratio of the grid y + ≈140. Spend calculation for working lattice characteristics in the mode n = 5306 rpm.

Next it was modeled second screen, which differs from the first only in the size closest to the wall of the element equal to 1 micron, which provided the value y +≈15.

At the third stage a quality grid, the total number of elements which the gain of 2 million into the calculated area was built.

At the last stage of the allocated grid varied parameters and limits of the changes. Selection of the maximum and minimum values of the parameters was carried out on the basis of preservation of the recommended values for the parameters of the grid quality (skewness, growth factor, and others) [4].

The CFD-calculation result of the working process stage fan turbojet several grids of different quality, different characteristics were obtained, some of which are listed below:

distribution of Reynolds numbers on the estimated length of the field (Figure 3).

acoustic power vs. frequency (Fig. 9-12).

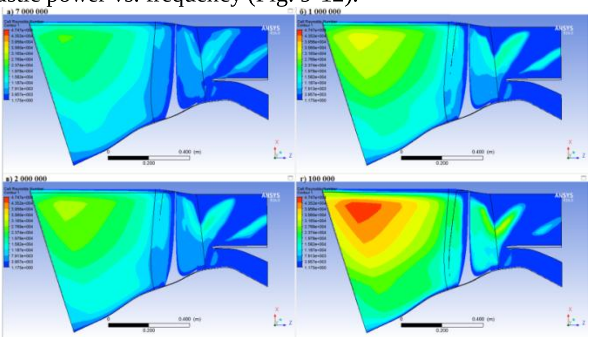

Fig. 3. Distribution of the Reynolds number for the length of the computational domain for grid consisting of a) 7 000 000 cells; b) one million cells; c) 2 000 000 cells; g) 100,000 cells

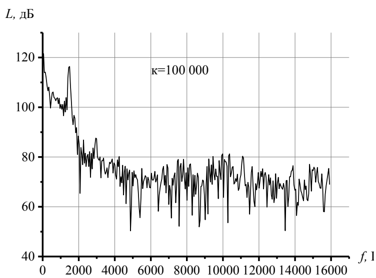

Fig. 9. The acoustic power versus frequency for k = 100000

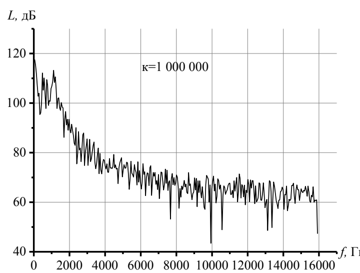

Fig. 10. Dependence of the acoustic output of the frequency for k = 1000000

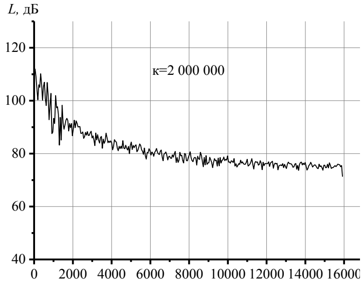

Fig. 11. Dependence of the acoustic power of the frequency at k = 2 000 000

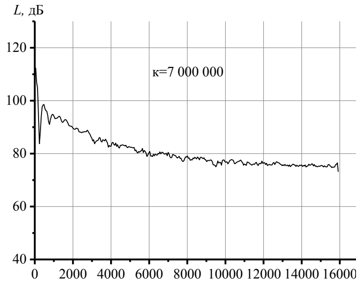

Fig. 12. Dependence of the acoustic power of the frequency at k = 7 000 000

Conclusions

From the analysis of the results we can see that increasing the density of the computational grid with 100 thousand elements to 1 million, the result of the distribution of the Reynolds number for the length of the settlement area is significantly diverge, but a further increase in the number of elements in the computational domain -.. changes are less noticeable. If we compare the readings of the acoustic sensor, you can see clear differences between "light" and "heavy" mesh. However, for the grid model with 7 million cells for models with 2 million -.. The acoustic performance of a similar, so we can talk about a certain similarity of these two models. Thus, for more efficient calculation of rational use grid model with 2 million. Elements.

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Mathematical model of thermocyclic durability estimation of heat-resisting alloys on the basis of experimental diagram of boundary stresses

It is experimentally shown the possibility of estimating thermocyclic durability of the alloys at critical points of components operating in identical conditions of cyclic thermo-mechanical stresses.

Problem

At present time used extensively heat-resistant materials operate at maximum safe temperature. These heat-resistant materials limit durability of gas turbine hot section parts. Advancements made in the field of materials have contributed in a major way in building gas turbine engines with higher power ratings and efficiency levels. Development of powerful engines requires new models and methods of calculation. The correctness of the models and methods of calculation is confirmed by the experimental data of thermocyclic durability available in the literature [1, 2, 3]. This empirical model should more accurately represent effect of extreme value of temperature and thermomechanical stresses and allow determination the influence of thermomechanical stresses cycle asymmetry on the strength of materials and gas turbine engine components reduction [3]. The main problem is to determine the optimal level and parameter of cycle asymmetry. These characteristics must provide the greatest durability of materials and components at critical points of tension.

Analysis of research and publications

The analysis has showed that known thermocyclic durability characteristics are not enough to develop empirical models as for the well- known high-temperature materials so for the latest high-temperature alloy. It is known a lot of theoretical models using three-component approach [4] to calculation of GTE parts, but they are not sufficiently confirmed by experimental characteristics. For example, the model of durability of materials for the most common type of load gas turbine hot section parts is considered in the work [4]. It is model of three-component load.

This model is based on approximation of hypothetical surfaces of boundary stresses by equation of elliptic paraboloid form:

$$\sigma_a = \alpha + \beta\sigma_m + \gamma\sigma_m^2 + \delta\Delta\sigma_{\text{òì}} + \lambda(\Delta\sigma_{\text{òì}})^2, \tag{1}$$

where: σ_a - amplitude of cyclic stress; σ_m -average stress of cycle; $\Delta\sigma_{\text{òì}}$ - thermomechanical stresses range; $\alpha, \beta, \gamma, \delta, \lambda$ - parameters determined by the experimental characteristics of high- temperature materials thermocyclic durability. These parameters were obtained under the following loading conditions (fig. 1): during vibration fatigue loading in terms of symmetric load cycle with an amplitude of stress σ_{-1}; with asymmetric fatigue loading $(\sigma_a + \sigma_m)$; sustained static thermal cyclic loading with the level of stress σ_{CT}; at (vibration) fatigue load imposed on the cyclic thermomechanical stress $(\sigma_a + \sigma_{\text{òì}})$; with a load of thermal fatigue in symmetric load cycle with an amplitude of stress $\Delta\sigma_{\text{T}}$.

Asymmetric vibration stresses were studied by A.N. Vetrov [5]. According his studies and equation [1] boundary curves (asymmetric vibration) of stresses $\sigma_a = f(\sigma_m)$ and $\sigma_a = \varphi(\Delta\sigma_{\text{тм}})$ can be described by the equations of the parabolas with sufficient accuracy. Coefficients α, β, γ can be defined by three experimental points.

It is very important in practice to minimize the absolute value of vibration components. It means $\sigma_a = 0$ and equation (1) becomes an ellipse equation [4]. Positioning of these equations relative to axes $\Delta\sigma_{\text{òì}}$ and σ_m does not depend on the experimental points of curve $\Delta\sigma_{\text{òì}} = \psi(\sigma_m)$. Therefore, it is clear that there can be significant deviations between calculated relation and the experimental one. The purpose of the study is more accurate empirical mathematical model evaluation.

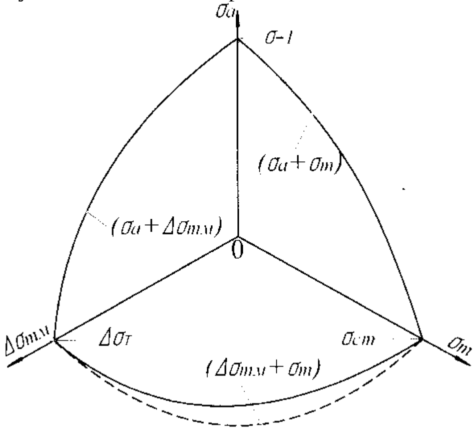

Fig.1. Scheme of surface of boundary stresses under three-component thermomechanical load

In the work [6] to provide accuracy of calculation it was proposed to approximate relation $\Delta\sigma_{\text{òì}} = \psi(\sigma_m)$ by equations of parabola:

$$\Delta\sigma_{\text{òì}} = \alpha_1 + \beta_1\sigma_m + \gamma_1\sigma_m^2, \tag{2}$$

where $\alpha_1, \beta_1, \gamma_1$ - parameters determined from experimental characteristics of thermocyclic durability of materials.

The experimental characteristics were obtained under the following loading conditions (see dashed line in fig.1):

- at long term static loads with the equal levels of stress σ_{CT};
- at thermal fatigue load in symmetric cycle of thermal stresses with divergence of parameter $\Delta\sigma_{\text{T}}$;

- at asymmetric thermomechanical loading scheme (fig. 2), where *T(t)* – thermal cycle temperature; t_{H} - heating time and t_{ox}- cooling time of material.

The formula for calculation thermocyclic durability of materials under asymmetry thermomechanical loading was proposed in the work [6]. Approximating parameters $\alpha_1, \beta_1, \gamma_1$ of equation (2) by linear functions of the logarithm of the number of thermal cycles ***N*** to fracture we get:

$$N = \frac{a_{1T} + a_{2T}\left[\Delta\sigma_{\text{òì}} - \sigma_m\left(\beta_{11} + \gamma_{11}\sigma_m\right)\right]}{1 + \frac{a_{2T}}{\lg N_2}\left[\beta_{12} - \beta_{11} + \left(\gamma_{12} - \gamma_{11}\right)\sigma_m\right]}; \qquad (3)$$

where α_{1T} , α_{2T} , β_{11}, β_{12}, γ_{11}, γ_{12}, lgN_2– approximation constants of α_1, β_1, γ_1.

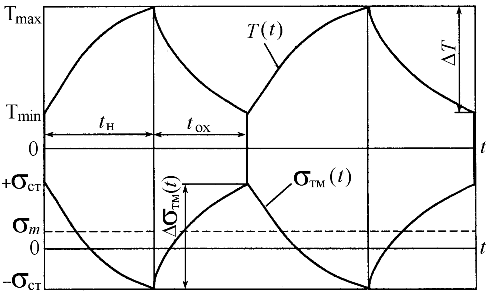

Fig.2. Scheme asymmetric cycle thermomechanical loading

The proposed approach provides a more accurate estimation of thermocyclic durability due to correlation of the relation $\Delta\sigma_{\text{òì}} = \psi(\sigma_m)$. But its implementation requires additional experimental data obtained in asymmetric thermomechanical loading $(\Delta\sigma_{\text{ТМ}} + \sigma_m)$.Therefore it is important to build an empirical model of thermocyclic durability based on a minimum of experimental data, and provide pinpoint accuracy of computational evaluation. It is primary purpose of this study. A new empirical model of thermocyclic durability of materials based on the analysis of the experimental curves of the strains in asymmetric thermomechanical loading is proposed in the article.

Method and program of experimental research

Researches were performed on the experimental facility described in work [7]. Test setup has been improved in order to expand the range of options thermomechanical loading and parameters stabilization. Setup allows to implement scheme (fig.2) of asymmetric cyclic thermomechanical loading in a wide range of changes of cycle mean stress a_m,including their significant negative level that can be given to applying standard static stresses at the beginning of half cycles of heating and cooling which is determined by the ratio $\sigma_m = \sigma_{\text{CT}} \pm 0{,}5\Delta\sigma_{\text{TM}}$.

The experimental facility allows researching of symmetric cycle loading $(\sigma_m = 0, \Delta\sigma_{\text{òì}} = \Delta\sigma_{\text{T}})$ and performs testing in terms of only static stresses and cyclic temperatures $(\Delta\sigma_{\text{ТМ}} = 0; \sigma_m = \sigma_{\text{СТ}})$. Standard cylindrical samples of materials ЖС6К, ЖС6У, ЕІ437Б, ЕП99вд, Х18Н10Т having diameter of 5 mm, working length of 30 mm were studied on the modes listed in table 1. Each mode was tested at least 15 samples in three to five levels of stress.

Methods of statistical processing of experimental data

Statistical analysis of the test results showed that the distribution of the number of cycles to fracture samples N corresponds to lognormal law, which is well illustrated by one of the modes of testing (fig.3). Lognormal density distribution of N can be displayed:

$$\varphi(N) = \frac{\lg e}{N\sqrt{2\pi D_{\lg N}}} \exp\left[-\frac{(\lg N - M_{\lg N})^2}{2D_{\lg N}} \right] \tag{4}$$

The parameters of this distribution: the mathematical expectation M_{lgN} and variance D_{lnN} dependent on the intensity of thermomechanical stresses σ_{TM} and can be described by linear functions of stress σ:

$$M_{\lg N} = a_1 + a_2\sigma; \quad D_{\lg N} = a_3 + a_4\sigma \tag{5}$$

Combining equations (4) and (5) we determine conditional probability density:

$$\varphi(N / \sigma, a_1, \ldots a_4) = \frac{\lg e}{N\sqrt{2\pi(a_3 + a_4\sigma)}} \times \\ \times \exp\left[-\frac{(\lg N - a_1 - a_2\sigma)^2}{2(a_3 + a_4\sigma)} \right]. \tag{6}$$

The most effective method of estimation parameters $a_1, \ldots a_4$ of distribution (6) is the maximum-likelihood method [8], according to which a system of nonlinear equations can be written. The system can be solved by one of the method of successive approximations. For example, in the first approximation, when a_4=0 and $D_{\lg N}=a_3$=const, it is possible get a system of equations for determination parameters a_2, a_1, a_3:

$$a_1 = \frac{1}{n}\left(\sum_{i=1}^{n} \lg N_i - a_2 \sum_{i}^{n} \sigma_i \right),$$

$$a_2 = \frac{n\sum_{i=1}^{n} \sigma_i N_i - \sum_{i=1}^{n} \sigma_i \sum_{i=1}^{n} \lg N_i}{n\sum_{i=1}^{n} \sigma_i^2 - \left(\sum_{i=1}^{n} \sigma_i \right)^2}, \tag{7}$$

$$a_3 = \frac{1}{n}\left(\sum_{i=1}^{n} \lg^2 N_i - a_1 \sum_{i=1}^{n} \lg N_i \right) - a_2 \sum_{i=1}^{n} \sigma_i \lg N_i .$$

Usually dispersion of logarithm of the cycles number before fracture D_{lgN} is considered independent of the stress level σ, i. e. $D_{lgN} = a_3 = const$, but the results of this study show a monotonic decrease D_{lgN} at load reduction (see table 2 and fig.3), this allows to use completely dependences (5) and (6). Computer calculations allowed to define the distribution (6) parameters ($a_1,...,a_4$) for all materials and modes of testing program (table 1) and are listed in table 3. There are number of material samples subjected to a test for the corresponding modes in the table. Data in table 3 indicate that it is indeed $a_4 \approx 0$ especially at purely thermal loading $\Delta\sigma_T$ (when $\sigma_{CT} = \sigma_m = 0$); dispersion D_{tgN} according to a_3 and a_4, does not have large absolute values and changes slowly, the coefficient a_2 has a small negative values, and the most important is the statistical evaluation of mathematical expectation of parameters a_3 and a_2. This allows using expressions (5) to determine the mathematical expectation and variance of the cycles number logarithm to fracture of models, and then use these values for quantile estimation of thermocyclic durability of materials taking into account probability of fracture. This allows take into consideration of failure probability during calculation of real parts of gas turbine hot section. The possibility of such estimation increases practical signification of received results.

The median curves of thermocyclic durability for models of alloy ЖС6К are shown in fig.4. The curves graphed using expression (5) as relations of thermomechanical stresses range $\Delta\sigma_{TM}$ (during thermal cycles $T_{\min} \leftrightarrow T_{\max} = 350 \leftrightarrow 1000^0 C$) and mean loading of cycle σ_m of the cycles number to fracture N. The diagrams of limit stresses under asymmetric cyclic of thermomechanical loading as $\sigma_m = f(\Delta\sigma_{òì})$ were plotted (fig. 5).

Table 1

Regimes of sample testing

Alloy	Temperature range	№ regime	Number of samples	$\sigma_{ст}$, MPa	$\Delta\sigma_{TM}$	σ_T
ЖС6К	150 ÷ 800^{0}C	1	21	var	0	$\sigma_{ст}$
		2	36	0	$\Delta\sigma_T$	0
		3	15	250	var	var
		4	17	3700	var	var
		5	17	470	var	var
	250 ÷ 900^{0}C	6	62	var	0	$\sigma_{ст}$
		7	58	0	$\Delta\sigma_T$	0
		8	15	50	var	var
		9	17	100	var	var
	350 ÷ 1000^{0}C	10	43	var	0	$\sigma_{ст}$
		11	58	0	$\Delta\sigma_T$	0
		12	15	50	var	var
		13	15	100	var	var
		14	17	230	var	var
		15	16	-130	var	var

ЖС6У	350 ÷ 1000^{0}C	16 17 18	28 17 17	var 0 100	0 $\Delta\sigma_т$ var	$\sigma_{ст}$ 0 var
ЕІ437Б	250 ÷ 900^{0}C	19 20 21	28 18 16	var 0 100	0 $\Delta\sigma_т$ var	$\sigma_{ст}$ 0 var
ЕП99вд	250 ÷ 900^{0}C	22 23 24	24 15 17	var 0 100	0 $\Delta\sigma_т$ var	$\sigma_{ст}$ 0 var
Х18Н10Т	100 ÷ 750^{0}C	25 26 27	27 21 15	var 0 50	0 $\Delta\sigma_т$ var	$\sigma_{ст}$ 0 var

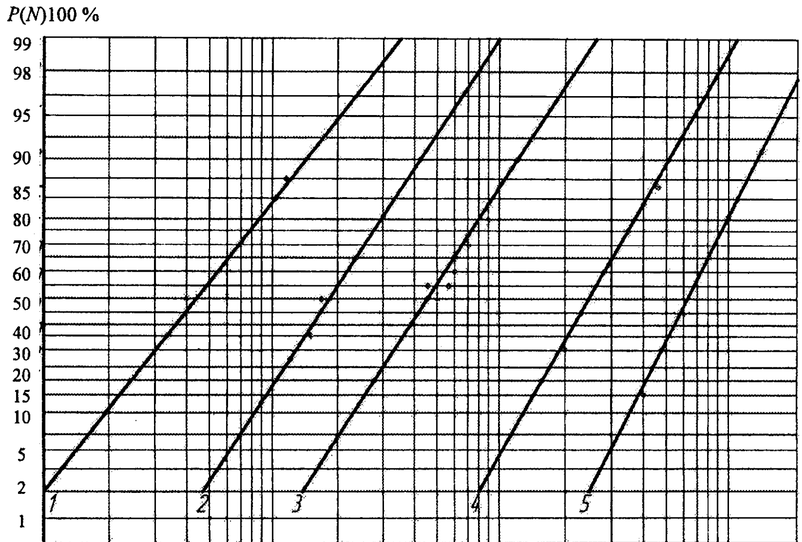

Fig. 3. Distribution of the number of cycles to fracture for alloy ЖС6К samples studied under thermocycling regime $T_{min} \div T_{max}$ = 250÷900°C:

1 – $\sigma_{ñò}$=580MPa; 2 – $\sigma_{ñò}$=500MPa; 3 – $\sigma_{ñò}$=450MPa; 4 – $\sigma_{ñò}$=350MPa; 5 – $\sigma_{ñò}$=310MPa

Table 2

Results of statistical manipulation of experimental thermocyclic durability of alloy ЖС6К samples studied under thermocycling regime $T_{\min} \div T_{\max}$ = 250÷900°C:

$\sigma_{ñò} = 580$ MPa				$\sigma_{ñò} = 500$ MPa				$\sigma_{ñò} = 450$ MPa				$\sigma_{ñò} = 350$ MPa				$\sigma_{ñò} = 310$MPa			
№	N	lgN	P_m,%	№	N	lgN	P_m,%	№	N	lgN	P_m,%	№	N	lgN	P_m,%	№	N	lgN	P_m,%
1.	17	1,23	8,3	1.	74	1,896	7,7	1.	188	2,274	5,3	1.	1261	3,101	8,3	1.	3547	3,55	9,1
2.	25	1,398	16,7	2.	95	1,978	15,4	2.	213	2,328	10,5	2.	1544	3,189	16,7	2.	4875	3,688	18,2
3.	32	1,505	25	3.	117	2,068	23,1	3.	271	2,433	15,8	3.	2010	3,303	25	3.	5080	3,706	27,3
4.	40	1,602	33,4	4.	137	2,137	30,8	4.	316	2,499	21	4.	2496	3,397	33,4	4.	5890	3,77	36,4
5.	41	1,613	41,7	5.	173	2,233	38,5	5.	337	2,528	26,3	5.	2585	3,412	41,7	5.	7070	3,849	45,5
6.	52	1,716	50,1	6.	190	2,279	46,1	6.	400	2,602	31,6	6.	3004	3,478	50,1	6.	7663	3,884	54,5
7.	60	1,778	58,4	7.	200	2,301	53,8	7.	402	2,604	36,8	7.	3213	3,507	58,4	7.	8090	3,908	63,6
8.	71	1,851	66,8	8.	236	2,373	61,5	8.	520	2,716	42,1	8.	3830	3,583	66,8	8.	9258	3,966	72,7
9.	92	1,964	75,1	9.	297	2,473	69,2	9.	548	2,739	47,4	9.	4020	3,604	75,1	9.	11968	4,078	81,8
10.	131	2,117	83,5	10.	310	2,491	76,9	10.	560	2,748	52,6	10.	5321	3,726	83,5	10.	13771	4,139	90,9
11.	160	2,204	91,8	11.	420	2,623	84,6	11.	603	2,780	57,9	11.	6221	3,794	91,8				
				12.	518	2,714	92,3	12.	730	2,863	63,2								
								13.	830	2,919	68,4								
								14.	849	2,929	73,7								
								15.	982	2,992	78,9								
								16.	1026	3,011	84,2								
								17.	1222	3,087	89,5								
								18.	1485	3,172	94,7								
$\overline{\lg N} = 1.725$ $D_{\lg N} = 0.35$				$\overline{\lg N} = 2.295$ $D_{\lg N} = 0.303$				$\overline{\lg N} = 2.735$ $D_{\lg N} = 0.307$				$\overline{\lg N} = 3.463$ $D_{\lg N} = 0.256$				$\overline{\lg N} = 3.854$ $D_{\lg N} = 0.223$			

As seen from the diagrams limit stresses of alloy ЖС6К (see fig.5) relatively low levels of positive mean stresses of cycle σ_m increase range of thermomechanical stresses $\Delta\sigma_{TM}$, it leads to increase thermocyclic durability (*N*). This conclusion is also confirmed by the data of [9].

Table3

Statistical estimates of parameters of thermocyclic durability distribution of samples

Number of samples	a_1	a_2	a_3	a_4
21	8,06059	-0,00839945	0,011597	0,0000689
36	7,28220	-0,0064153	0,007699	0
15	6,53944	-0,0083038	0,025385	0,00000085
17	5,4927	-0,0076307	0,028698	0,00001403
17	4,29553	-0,0064885	0,034016	0,00002911
62	6,24305	-0,0078277	-0,023887	0,00019168
58	6,52317	-0,0056851	0,004257	0
15	6,40896	-0,0065169	0,000663	0,00005931
17	6,13322	-0,0066683	-0,05935	0,00021959
43	5,03457	-0,0082559	0,00519	0,00017839
58	5,85304	-0,0050111	0,009083	0
15	4,76957	-0,0037742	0,03090	0,00000437
15	4,49662	-0,0038763	0,069555	-0,00000723
17	7,55897	-0,0087095	0,106676	-0,0001244
15	6,12944	-0,0049032	0,277858	-0,00038
28	5,26417	-0,0080124	0,024884	0,00005214
17	5,76021	-0,0045648	0,006003	0
17	4,80768	-0,004802	0,063062	-0,00007874
28	4,86561	-0,0105707	0,034710	0,00008322
18	4,81458	-0,0040563	0,009504	0
16	3,78153	-0,0038650	0,039663	0,00004221
24	4,86144	-0,0086278	0,035193	0,00002619
15	5,20993	-0,0041488	0,015956	0
17	4,05533	-0,003783	0,024548	0,00003355
27	5,21174	-0,0148718	0,021481	0,0000761
21	4,47117	-0,0040383	0,009333	0
15	4,43352	-0,0069375	0,015201	0,00005916

The positive influence of cycle asymmetry also considered in [1]. The positive static tensile stresses reduce the absolute value of the negative thermomechanical stresses acting at the highest temperature of the cycle (see fig.2, $T_{\max}$) and thus cause major damage of the material. This effect reaches a maximum [1] at some values of average cycle stresses σ_m, and then further growth of cycle asymmetry leads to significant reduction of durability due to considerable influence of high positive thermomechanical stresses.

Presented in fig.5 experimental points of limit stresses can be approximated by the equation of inclined ellipse, which axes pass through the origin of coordinates and incline at an angle α to axis σ_m and $\Delta\sigma_{\text{тм}}$.

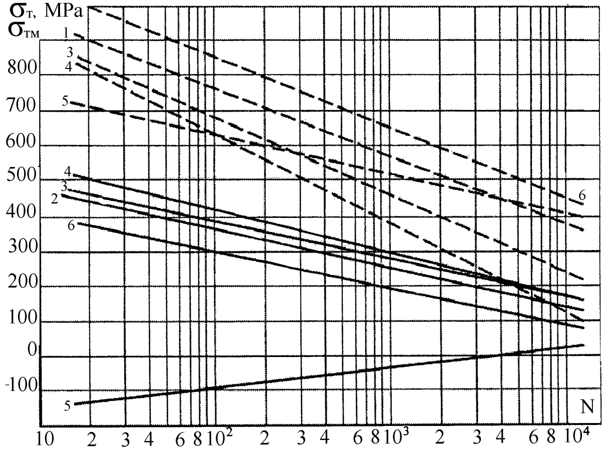

Fig.4. Characteristics of cycle durability of alloy ЖС6К studied for mode $T_{\min} \div T_{\max}$ =350÷10000C;

$\sigma_{\text{ò}} = f(N)$; $\Delta\sigma_{\text{òì}} = f(N)$: 1 – $\sigma_{\text{ñò}} = \sigma_{\text{ò}} = 0$; $\Delta\sigma_{\text{òì}} = \Delta\sigma_{\text{ò}}$; 2 – $\Delta\sigma_{\text{òì}} = 0$, $\sigma_{\text{ñò}} = \sigma_{\text{ò}}$; 3 – $\sigma_{\text{ñò}}$=50 MPa; 4 – $\sigma_{\text{ñò}}$=100 MPa; 5 – $\sigma_{\text{ñò}}$=230 MPa; 6 – $\sigma_{\text{ñò}}$=–130 MPa

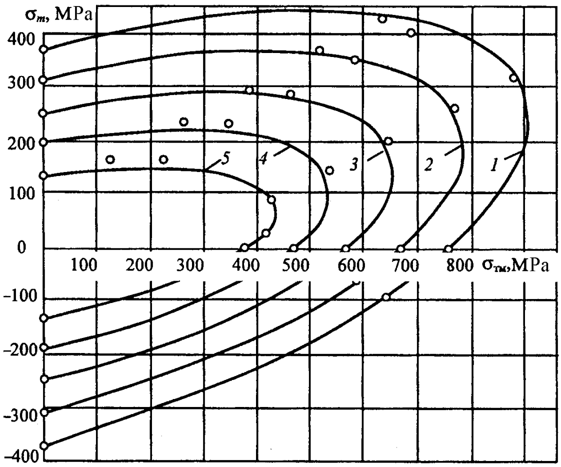

Fig.5. Curves of limit stresses of alloy ЖС6К at asymmetric cyclic thermomechanical loading under thermocycling regime $T_{\min} \div T_{\max}$ = 350÷1000^{0}C:

1. N=10^2; 2. N=3*10^2; 3. N=10^3; 4. N=3*10^3; 5. N=10^4

After simple geometric and trigonometric transformations equation of ellipse will take the following form:

$$\frac{\sigma_m^2}{\sigma_{\text{ñò}}^2}+\frac{\Delta\sigma_{\text{òì}}^2}{\Delta\sigma_{\text{ò}}^2}\left(\frac{1}{\sigma_{\text{ñò}}^2}-\frac{1}{\Delta\sigma_{\text{ò}}^2}\right)tg2\alpha\cdot\sigma_m\Delta\sigma_{\text{òì}}=1, \tag{8}$$

where σ_{CT} - limit of prolonged static durability of the material at a thermocycling; $\Delta\sigma_{\text{T}}$ - range of thermocyclic stresses in symmetric cycle.

Values σ_{CT} and $\Delta\sigma_{\text{T}}$ are the boundary points. The estimated ellipse of limit stresses for specified values of thermocyclic durability can be constructed using these points and equation (8). According to equation (5), these values are linear functions of the durability logarithm in cycles N, which can be written as:

$$\sigma_{\text{CT}}=\frac{1}{a_{2\text{CT}}}\left(\lg N-a_{1\text{CT}}\right), \tag{9}$$

$$\Delta\sigma_{\text{T}}=\frac{1}{a_{2\text{T}}}\left(\lg N-a_{1\text{T}}\right), \tag{10}$$

where $a_{1\text{ÑÒ}}, a_{2\text{CT}}, a_{1\text{T}}, a_{2\text{T}}$ - coefficients given in table 3 for modes 1, 6, 10, 16, 19, 22 ,25, and 2, 7, 11, 17, 20, 23, 26

Analysis diagram of limit stresses determined that the angle α varies from 10 to 18°, while higher values α correspond to lower durability. It was also found that the angle α dependence on the durability can be approximated by the equation:

$$tg2\alpha=A+B\lg N, \tag{11}$$

where A, B – coefficients which for the given diagram equal A=1,04; B= - 0,17 (see fig.5).

Combining expressions (8) - (11) it is possible to get an ellipse equation written for stress and durability (lgN):

$$\begin{gathered}\frac{\sigma_{2CT}^2\cdot\sigma_m^2}{(\lg N-a_{1CT})^2}+\frac{a_{2T}^2\cdot\Delta\sigma_{TM}^2}{(\lg N-a_{1T})^2}+(A+B\lg N)\times\\ \times\left[\frac{a_{2CT}^2}{(\lg N-a_{1CT})^2}-\frac{a_{2T}^2}{(\lg N-a_{1T})^2}\right]\cdot\sigma_m\Delta\sigma_{TM}=1\end{gathered} \tag{12}$$

The derived equation is the equation of the fourth power of lgN (durability):

$$\lg^4 N+c_3\lg^3 N+c_2\lg^2 N+c_1\lg N+c_0=0 \tag{13}$$

where c_0, c_1, c_2, c_3- coefficients which are equal:

$$c_0=\left[\begin{array}{l}a_{1CT}^2\sigma_{1T}^2-a_{1CT}^2a_{2T}^2\cdot\Delta\sigma_{TM}\cdot\\ \cdot(\Delta\sigma_{TM}-\sigma_m tg2\alpha)-a_{1T}^2a_{2CT}^2\sigma_m+\\ +\Delta\sigma_{TM}tg2\alpha\end{array}\right], \tag{14}$$

$$c_1 = 2\begin{bmatrix} a_{1CT}\sigma_{2T}^2\Delta\sigma_{TM}(\Delta\sigma_{TM} - \sigma_m tg2\alpha) + \\ + a_{1T}a_{2CT}^2\sigma_m(\sigma_m + \Delta\sigma_{TM}tg2\alpha) - \\ - a_{1CT}\cdot a_{1T}(a_{1CT} + a_{1T}) \end{bmatrix}, \tag{15}$$

$$c_2 = \begin{bmatrix} a_{1CT}^2 + a_{1T}^2 + 4a_{CT}a_{1T} - a_{2CT}^2\sigma_m \times \\ \times(\sigma_m + \Delta\sigma_{TM}tg(2\alpha)) - a_{2T}^2\sigma_{TM} \times \\ \times(\Delta\sigma_{TM} - \sigma_m tg(2\alpha)) \end{bmatrix}, \tag{16}$$

$$c_3 = -2(a_{1CT} + a_{1T}) \tag{17}$$

Under these assumptions [10] solution of equation (13) is:

$$\lg N_{1,2,3,4} = \begin{bmatrix} -\frac{c_3 + z_{1,2}}{2} \pm \\ \pm\sqrt{\frac{(c_3 + z_{1,2})^2}{8} - \left(y + \frac{c_3 y - c_1}{z_{1,2}}\right)} \end{bmatrix}, \tag{18}$$

where $z_{1,2} = \pm\sqrt{8y + c_3^2 + 4c_2}$; y – real root of the cubic equation:

$8y^3 - 4c_2y^2 + 2(c_1c_3 - 4c_0)y + c_0(4c_2 - c_3^2) - c_1^2 = 0$, Solution of the equation by Kardan method is:

$$y_1 = u_1 + u_2 + \frac{c_2}{6};\ y_2 = \varepsilon_1 u_1 + \varepsilon_2 u_2 + \frac{c_2}{6};$$

$$y_3 = \varepsilon_2 u_1 + \varepsilon_1 u_2 + \frac{c_2}{6};\ u_{1,2} = \sqrt[3]{-q \pm \sqrt{q_2^2 + p^3}};$$

$$\varepsilon_{1,2} = -\frac{1}{2} \pm \frac{\sqrt{3}}{2};\quad p = \frac{3(c_1c_3 + 8c_0) - c_2^2}{36};$$

$$q = \frac{c_0(4c_2 - c_3^2) - c_1^2}{16} + \frac{c_2(c_1c_3 - 4c_0)}{48} - \frac{c_2^3}{216}.$$

The equation (8) under the conditions (9) and (10) can be solution with any numerical method.

To check the empirical model and the calculation method the experimental studies of thermocyclic durability of high- temperature alloys were carried out for modes listed in table 1.

This method was used to calculate the median durability according to the same data of asymmetric thermomechanical loadings σ_m, $\Delta\sigma_{òì}$. The calculations (table 4) showed slight difference between calculated and experimental data. This difference is within the limits of accuracy of the experiment.

Table 4

Calculated and experimental data of thermocyclic durability

№ regime	$\Delta\sigma_{\text{тм}}$, MPa	σ_m, MPa	$\overline{N}_{\text{р}}$, cycles	$\overline{N}_{\text{експ}}$, cycles	Δ, %
3	420	460	1324	1132	16,9
	350	425	4433	4259	4,1
	280	390	13912	16454	-15,4
4	450	595	87	114	-23,7
	300	520	1569	1608	-2,4
	220	480	5417	6488	-16,5
5	320	630	171	170	0,6
	250	595	571	462	23,6
8	440	270	3474	3445	0,8
	400	250	6396	6199	3,2
	370	235	10018	9860	1,6
9	450	325	1518	1333	13,9
	400	300	3251	3028	7,4
	350	275	6736	6190	8,8
12	550	325	407	511	-20,3
	470	285	748	929	-19,5
	380	240	1720	2230	-22,9
13	580	390	144	178	-19,1
	480	340	387	425	-8,9
	410	305	647	816	-20,7
14	540	-40	826	735	12,4
	500	-20	1703	1514	12,5
	470	-5	2938	3015	-2,6
15	600	170	1187	1535	-22,7
	560	150	1033	2440	-20,8
	530	135	2831	3378	-16,2
18	380	290	1227	1278	-4
	320	260	2240	2354	-4,8
	240	220	4809	5413	-11,2
21	400	300	155	171	-9,4
	250	225	584	665	-12,2
	150	175	1568	1575	-0,4
24	420	310	273	296	-7,8
	300	250	893	815	9,6
	200	200	2235	2012	11,1
27	260	180	518	424	22,2
	120	110	4418	4000	10,5

Conclusions:

1. Model of boundary stresses for the family of cyclic durability characteristics of high- temperature alloys ЖС6К can be approximated by the equation of an inclined ellipse with range of thermomechanical stresses $\Delta\sigma_{òì}$ and mean cycle stresses σ_m and described by the equation of 4-th power in durability logarithm lg*N*.

2. Relatively low levels of positive mean stresses of cycle σ_m increase limit value of thermomechanical stresses range $\Delta\sigma_{òì}$ and consequently lead to an increase of thermomechanical durability [1, 5, 9] for thermocyclic and complex thermomechanical loading.

3. The positive effect of asymmetry cycle thermomechanical loading [1, 9] can be explained by static stress σ_{CT} decreases negative thermomechanical stresses (absolute value) $\sigma_{òì}$ at the maximum temperature of the cycle.

4. The calculations by the proposed method and the additional experimental test showed good convergence of calculated and experimental thermocyclic durability with maximum accuracy Δ up to 25%, this is within the limit of the experiment accuracy.

Experience shows that it makes sense to develop similar models and calculation methods, carry out experimental testing for all high - temperature alloys including the latest and give recommendation for practical using of alloys and materials of "hot parts" GTE components and other components operating in a cyclic asymmetric thermomechanical loading

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Analysis change of gas-dynamic stability of gas turbine engine compressors at operation on transient modes

Considered method of determination change the limit of stable operation of gas turbine engine due to the nonstationarity and operation factors

1. Introduction

Influence of variety of factors connected with outboard parameters which characterize atmosphere conditions and parameters which characterize peculiarities of application of power plant in the aircraft are constantly change characteristics of aircraft engines during their operation. The value of this change depends on peculiarities of acting factors and increase with engine operation time. All acting factors can be divided into two groups: caused by the changing technical state of the engine and operational factors. To the factors of technical state we can refer: roughness and cracks of rotor blades and stator vanes, carbonization of fuel nozzles and variation of engine flow path cross-section area. Parameters of air are referred to operational parameters: pressure, temperature, humidity, and also flow parameters such as irregularity and unsteadiness of temperature and pressure fields, turbulence caused by the flight conditions.

2. Problem formulation

Under action of mentioned above factors the limit of compressor stable operation is changed, and as a result the flight safety level decreases. That's why the problem of determination of compressor gas-dynamic stability in operation and without application of additional experiments and facility is serious, especially in time of transition to the technical state mode of aircraft maintenance strategy. The method of determination of limit of compressor gas-dynamic stability in operation must give the possibility of its determination with taking into account the operational factors and changing of technical state of the engine, especially its flow path at everyday operation of the engine.

3. Analysis of investigations and publications.

Most of familiar methods of gas-dynamic stability determination are experimental and demand preparations and installation of additional systems. Method [2] requires minimal amount of additional units, according to which fuel system of the engine are equipped with regulated drain. Rapid closing of fuel drainage leads to short increasing fuel consumption and correspondingly to increasing gas temperature before turbine at almost constant rotor rotation speed. Increasing fuel consumption during next attempts leads to unstable operation of the compressor which allows determination of gas-dynamic stability limit position on compressor characteristics.

Necessity of engine preparation makes it impossible to use the experimental methods in operation, that's why calculation methods are applied.

Calculation method given in source [3] includes the determination of real position of line of operational modes and limit of gas-dynamical stability by measured rotor rotational speed and thermo-dynamical parameters. There is also method according to which the position of operational modes line and gas-dynamical modes are determined by the parameters which are measured by installed tools, using engine mathematical model.

4. Method of determination of change of gas-dynamic stability margin

Familiar methods [1-4] allows to estimate only general value of gas-dynamic stability margin, which depends on technical state of the engine, outboard conditions and operation mode of GTE (steady or transient). During the operation with the increasing of operation time the technical state of the engine is worsened and the gas-dynamic stability limit decrease. For providing of high level of flight safety it is necessary that gas-dynamic stability must be not less than minimal acceptable. That's why for prevention of surge cases it is necessary to estimate the change of real margin of gas-dynamic stability with taking into account operation time and influence of operational factors (humidity of air, temperature and pressure of the air at the inlet of compressor, unsteadiness of flow at engine transient operational modes). All mentioned above tells us about relevance of development of method of determination of change of gas-dynamic stability in the process of operation.

Here method for determination of change in margin of gas-dynamic stability in the process of engine operation is proposed. The essence of proposed method is in following. During the engine diagnostic operation mode following parameters are registered: rotor rotational speed, air temperature and pressure at the engine inlet, total pressure at the compressor outlet, temperature after turbine or after turbine stage, and momentum fuel consumption.

Mentioned parameters are used as input data for mathematical model of the engine, for example mentioned in source [5], with the help of which the relative flow density is calculated $q(\lambda)_{\text{op}}$, and degree of pressure increasing at line of operational modes $\pi^{*}_{\text{ñ.o}}$ for each of compressor stages, by the way [3] the position of limit of gas-dynamic stability and correspondingly the value of $\pi^{*}_{\text{c.lim}}$ are found. The value of margin of gas-dynamic stability $\Delta\tilde{N}_{\text{s}}$ of compressor stage which corresponds to some operational time of gas-turbine engine at the time of registration of parameters is calculated by the formula:

$$\Delta C_{\text{st}} = \left[\frac{\pi^{*}_{\text{c.lim}} / q(\lambda)_{\text{lim}}}{\left(\pi^{*}_{\text{c.lim}} / q(\lambda)\right)_{\text{op}}} - 1 \right] 100\%$$

Change of margin of gas-dynamic stability which is connected with worsening of technical state of the engine at increasing of its operational time is determined by the formula:

$$\delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{st}} = \left(\Delta C_{\mathrm{st}}\right)_0 - \left(\Delta C_{\mathrm{st}} + \delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{oc}}\right)$$

Where: $\left(\Delta C_{\mathrm{s}}\right)_0$ - value of margin of gas-dynamic stability at the start of engine operation;

ΔC_{st} - Value of margin of gas-dynamic stability determined by the proposed method, at some operational time;

$\delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{oc}}$ - change of margin of gas-dynamic stability which is caused by the change of outboard conditions (humidity of atmospheric air, altitude and speed of flight, field of gas-dynamical parameters at the compressor inlet) and unsteadiness of flow at engine transient operational modes.

Value of margin of gas dynamic stability of compressor stages at the start of its operation $\left(\Delta C_{\mathrm{st}}\right)_0$ is determined by the way of statistical data processing of first twenty flights for each of which the value of ΔC_{st} was determined by the proposed method.

Change of gas-dynamic stability margin caused by the change of external conditions is considered as the sum of changes caused by the set of operational factors.

$$\delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{oc}} = \delta\left(\Delta C_{\mathrm{st}}\right)_d + \delta\left(\Delta C_{ó}\right)_{\mathrm{Re}} + \delta\left(\Delta C_{ó}\right)_{\mathrm{unev}} + \delta\left(\Delta C_{ó}\right)_{\mathrm{unst}} \quad (3)$$

Where $\delta\left(\Delta C_{ó}\right)_d$, $\delta\left(\Delta C_{ó}\right)_{\mathrm{Re}}$, $\delta\left(\Delta C_{ó}\right)_{\mathrm{unev}}$, $\delta\left(\Delta C_{ó}\right)_{\mathrm{unst}}$ – correspondingly the changes of margin of gas-dynamic stability which are caused by the changes of humidity of atmospheric air, altitude and speed of flight (Reynolds number), unevenness of gas-dynamic parameters field at the inlet to compressor and imperfection of flow at engine transient operational modes.

For operational range of change of value of relative humidity the change of margin of gas-dynamic stability is found by the formula:

$$\delta\left(\Delta C_{\mathrm{st}}\right)_d = -1{,}36\,\delta d\left(\Delta C_{\mathrm{st}}\right). \quad (4)$$

The value $\delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{Re}}$ is determined by the following way:

$$\delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{Re}} = \left\{ \frac{1}{2 - C_{\pi_{ê}}}\left[b\,\delta\eta_{\mathrm{c}}^{*} + \delta\eta_{\mathrm{a}} + C_{\pi_{ê}}\,\delta G_{â} + \delta\eta_{\mathrm{t}}^{*}\right] + \delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{Re}\,air} + \delta\left(\Delta C_{\mathrm{st}}\right)_{\mathrm{Re\,g}} \right\} \Delta C_{\mathrm{st}} \quad (5)$$

Where $C_{\pi_{ê}} = \dfrac{\dfrac{k-1}{k}\pi_{\mathrm{c}}^{*\,\frac{k-1}{k}}}{\pi_{\mathrm{c}}^{*\,\frac{k-1}{k}} - 1}$; $b = 1 + \dfrac{C_{\pi_{ò}}}{\dfrac{2}{C_{\tau_{ò}}} - C_{\pi_{ò}}}$; $C_{\pi_{ò}} = \dfrac{\dfrac{k_{ã}-1}{k_{ã}}\pi_{ò}^{*\,\frac{k_{ã}-1}{k_{ã}}}}{1 - \pi_{ò}^{*\,\frac{k_{ã}-1}{k_{ã}}}}$;

$C_{g_{ò}} = \dfrac{Ò_{\mathrm{g}}^{*} - Ò_{\mathrm{t}}^{*}}{Ò_{\mathrm{g}}^{*}}$;

k , k_{g} – correspondingly, adiabatic exponents for air and gas;

T_{t}^{*} , T_{g}^{*} – gas temperature before and after turbine;

$\delta\eta_{\text{t}}^{*} = f[Re_{\text{t}}]$ – change of turbine efficiency coefficient;

$\delta\eta_{\text{m}}$ – Change of part of mechanical losses which depends on value of total air pressure at the engine inlet;

$\delta(\Delta C_{ó})_{\text{Re air}}$, $\delta(\Delta C_{ó})_{\text{Re g}}$ – correspondingly, changes in $\Delta K_{ó}$ by the displacement of limit of gas-dynamic stability which are determined by the characteristic of compressor of concrete engine.

Value of change of margin of gas-dynamic stability which is caused by unsteadiness of flow at the compressor inlet is calculated by the formula

$$\delta(\Delta C_{ó})_{\text{unev}} = \frac{\delta ð_{\text{a min}}^{*}(1 - Ï_{\text{c}})}{Ï_{\text{c}} + C_{\pi}(Ï_{\text{c}} - 1)} \ , \tag{6}$$

Where $C_{\pi} = \frac{2k}{k + 1\delta G_{â}}\left(\frac{\lambda_{\text{c}}^{2}}{1 - \lambda_{\text{c}}^{2}}\right)$;

$\delta p_{\text{a min}}^{*}$ – relative change of minimal total pressure at the compressor inlet;

λ_{c} – reduced pressure at the compressor outlet;

$Ï_{\text{c}} = \frac{\delta\pi_{\text{c}}^{*}}{\delta G_{\text{air}}}$ – slope of pressurized line compressor characteristics.

Value of change at transient mode under influence under action of unsteadiness factors, for low pressure compressor (fan) double spool gas turbine engine is described by the equation

$$\delta(\Delta C_{ó})_{\text{uns}} = \left(\frac{1}{m\nu + 1} Ï_{\text{air}} - \frac{1}{m + 1}\right)\left(q_{ê}\delta S + \frac{\delta C_{\text{u.unl}}}{Ï_{\text{c}} - 1}\right)\Delta C_{ó} \ , \tag{7}$$

Where $\nu = \frac{\pi_{\text{â çîâ}}^{*}}{\pi_{\text{â âí}}^{*}}$, m – by-pass ratio;

$\pi_{\text{air out}}^{*}$, $\pi_{\text{air inb}}^{*}$ – correspondingly, degree of pressure increasing in the fan inner and outer contour;

$Ï_{\text{a in}} = \frac{\delta\pi_{\text{a in}}^{*}}{\delta G_{\text{air}}}$ – slope of pressurized line fan characteristics;

$Ï_{\text{a lin}}$ – density of pressurized lines of the high pressure compressor;

$n_{\text{c.red}}$ – reduced high pressure compressor rotor rotational speed;

δS – Change of rotor sliding;

$\delta C_{\text{st.c.trans}} = \left(\sqrt{\frac{T_{\text{g.uns}}^{*}}{T_{\text{g.op}}^{*}}} - 1\right)$;

$T^*_{\text{g.uns}}$ – gas temperature before turbine at engine transient mode of operation;

$T^*_{\text{g.op}}$ – gas temperature before turbine at corresponding state mode.

After determination of change of margin of gas-dynamic stability which is caused by the changes of external conditions, with application of formulas (3–7), by the formula (2) the value of change of margin of gas-dynamical stability of compressor with operational time.

Conclusions

Proposed method allows estimating value of change of margin of gas-dynamic stability of GTE compressor stages which is caused by worsening of its technical state at increasing of operational time.

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The quasi-perpetual electricity generating device based on ceramic fuel cell for closed systems

The features of ceramic fuel cells developed in Ukraine are discussed and their application for production of hydrogen and oxygen as well as for energy devices operating in closed systems is analyzed.

Ceramic fuel cell (CFC) is proposing the highest amount of electric energy released at reactions between chemical elements. As the most impressive are zirconia ones those may generate electric energy using hydrogen as a fuel and oxygen from air at ~95 % efficiency. They may operate at 600 ^{o}C and for above 70 000 hours [1]. To produce electricity they need in pure gaseous hydrogen and oxygen only. Their by-products are heat, that originally may consist of 1/3rd of all the energy released, and pure water. 1 kg of water is produced at generation of ~4.5 kWh of electric power.

Fuel cell is principally able to operate in reverse manner. Being as electrolyzer, reversible ceramic fuel cell (RCFC) may efficiently produce gaseous hydrogen and oxygen being supplied by water and electricity [2].

Currently, electrical efficiency of CFCs is ~65 % of the released energy. The concomitant heat power may be converted into electrical one by mechanical or thermoelectric converters. As result, general efficiency of CFC system is ~95 %.

CFCs are now in the process of their structural optimization, the goal of which is to achieve the named figures at mass production [1]. For the last few years, we have witnessed major technological advances and competition of major energy companies within the evolving fuel cell market. General Electric, which was one of the fuel cell pioneers supplying energy for the first space missions, is planning now to enter a fuel cell market with their CFC system. GE has claimed a recent fuel cell breakthrough with an unprecedented electrical efficiency of 65 % and an overall efficiency of up to 95 % when the system is configured to capture heat produced by the fuel cell process that allowed GE to claim that "the resulting technology could soon start producing electricity around the world" [3].

The goal of the paper is to discuss the opportunity of RCFC to be based on available developments and scientifical principles to be put in their basement.

In Ukraine, the data accumulated in Laboratory for Ceramic Fuel Cells at Frantcevych Institute for Problems of Materials Science indicate undoubtedly that the structure of CFC might be optimized for purposes of both maximal efficiency and prolonged use. The main achievements, which led the authors to understanding that CFC structural optimization would be realized are as follows [1]:

The ionic conductivity of bulk and film electrolytes made of Ukrainian 1Ce10ScSZ powder is 0.035 $S\cdot cm^{-1}$ at 700 ^oC instead of the 0.010 $S\cdot cm^{-1}$ obtained with the best powders available at international scale. Electrolytes made of our powder has the highest strength (450 MPa), fracture toughness – 1.2 – 1.7 $MPa\cdot m^{1/2}$. The Ukrainian electrolyte is much less inclined to recrystallization.

The ionic conductivity of electron beam – physical vapor deposition (EB-PVD) electrolyte films deposited onto a porous $NiO\text{-}ZrO_2$ anode substrate is higher (half an order of magnitude) than of layers deposited, e.g., by typical screen printing.

CFC made with EB-PVD electrolytes were the first to pass the severe Juelich Research Center, Germany, standard for He leakage rate below 10^{-4} $mbar\cdot l\cdot cm^{-2}\cdot s^{-1}$, and has demonstrated an area specific resistance (ASR) of ~0.6 $ohm\cdot cm^2$ at 600 ^oC.

The laboratory fuel cells made of gadolinia doped ceria electrolyte have demonstrated ~0.04 W/cm^2 being fueled by model gas – 5-vol. % with Ar at 650 ^oC. I.e., with right designed electrodes, which could ensure the linear dependence of electric current on non-diluted hydrogen fuel, such the fuel cell may provide ~0.80 W/cm^2 with 100 % hydrogen. The available literature data shows ~ 0.82 W/cm^2 as a typical power but at 750 ^oC.

The structural optimization might be easily realized, if all the steps of a long CFC creation process could be united under one research project acting under the "from powder to power" concept, i.e., it begins from powder synthesis and completes by CFC testing via comprehensive structural characterization of powders and their transfer into CFCs, behavior characterization of their electrical and mechanical properties in different gas environment and at different mechanical and electrical loadings, catalytic activity both electrodes and their new concepts, integration into technically relevant cells and stacks, and long-term tests.

Finally, at the last stage of the study, the stage of the "positive degradation", using data obtained for powders and CFC, materials will be modified and optimized in order to get a positive effect on the CFCs long-term performance at their usage in energy systems. The CFC, which has no any delaminating cracks along contacts between its structural parts that is very important for any electrotechnical device, might be elaborated (Fig. 1). The laboratory fuel cells made of gadolinia doped ceria electrolyte have demonstrated ~0.04 W/cm^2 being fueled by model gas – 5-vol. % with Ar at 650 ^oC. I.e., with right designed electrodes, which could ensure the linear dependence of electric current on non-diluted hydrogen fuel, such the fuel cell may provide ~0.80 W/cm^2 with 100 % hydrogen. The available literature data shows ~ 0.82 W/cm^2 as a typical power but at 750 ^oC.

Regarding the use of hot outcoming water steam, it is known that the efficiency of the electrolyzer is increasing with temperature reaching 100 % at around 900 ^oC [4]. It means that both 600 ^oC CFCs and their electrolyzers might be efficiently used in electricity generating devices in order to supply any closed system.

An imagination is painting some quasi-perpetual energy system for any aircraft, which could be launched with energy produced by CFC from some initial amount of hydrogen and oxygen. The CFC by-product, water steam, is decomposed for H_2 and O_2 with the CFC electrolyzer to be supplied by electricity produced by solar or thermoelectric cells. H_2 and O_2 gases will be stored and further re-used for production of electricity with no any water losses in the closed system. In such a

way, the accumulation and the storage of electric power will be solved via gaseous way. Energy losses would be compensated by Sun, which might gift the required energy and would do the CFC energy system as quasi-perpetual one (Fig. 2).

Figure 1. SEM picture of fracture cross-section of the well-designed CFC.

The cell voltage, E_q, relevant to the thermal effect is $E_q = \Delta H / \eta \cdot F$, where ΔH is the thermal effect of water decomposition, η – number of electrons, F – Faraday’s constant, at a hypothetic isobaric isothermal reversible process with no any heat and mass exchange between the cell and environment, and all energy required for the decomposition process is electrical one. ΔH is weakly depending on temperature, $E_q \cong$ const, but for water $E_{qw} \cong 1.48$ V and for water steam $E_{qs} \cong 1.25$ V. Obviously, the high-temperature electrolysis is favorable thermodynamically and requires lower voltage. The data available indicate that in order to produce H_2 1 m^3, around 3 kWh of electrical energy is required [3,4].

Conclusions

The quasi-perpetual energy system based on reversible ceramic fuel cells for closed systems like space planes or unmanned aerial and navy vehicles looks as possible both thermodynamically and technically thanks to the suitable R&D

achievements in zirconia CFC.

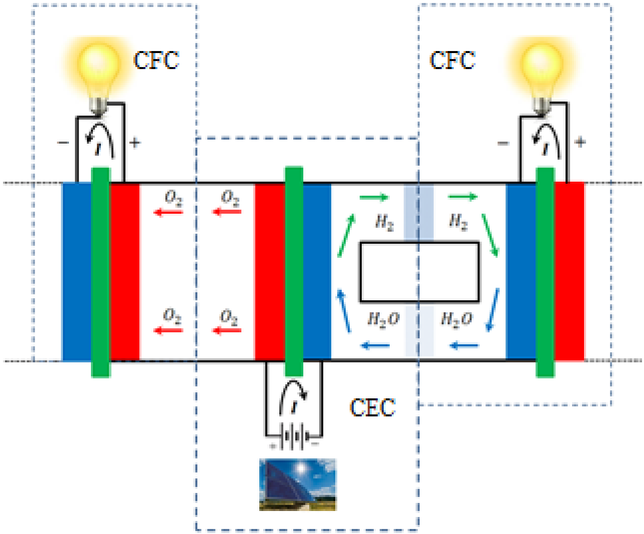

Figure 2. The schematic presentation of quasi-perpetual RCFC energy system. CEC – ceramic electrolyzer cell, CFC – ceramic fuel cell.

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Acoustic emission amplitude-energy parameter at change of composite properties for its thermo-activative destruction

The analysis of acoustic emission amplitude-energy parameter regularity change is conducted at composite material machining for thermoactivative model destruction depending on its surface layer properties. Are determined the regularity of percentage decreasing acoustic emission amplitude-energy parameters at ascending parameter describing of composite material properties. Is showed, that informative parameter is the dispersion of acoustic emission resultant signal average level amplitude.

Assignment formulation. The controls, diagnostic and monitoring of machining composite materials (CM) are directed on obtaining the items given quality. For researches of technological processes the different methods will be used. One of them is the method of acoustic emission (AE). Distinctive feature of AE method is its high sensitivity to materials deformation and destruction processes. Thus AE method allows receiving considerable amounts of information about processes, which flowing past in the structure of the materials.

Experimental researches of AE at CM machining [1, 2] demonstrate that the registered signals are continuous signals. Thus the AE signals parameters are influenced by technological factors, which, in the issue, are connected to produce items quality. Such factors are: cutting speed, feed rate, cutting depth. On AE also influences the condition of cutting tool or its wearing. The experimental researches of AE are directed on optimization of CM machining technological parameters and also monitoring of cutting tool condition. However obtained regularity influencing machining technological parameters on AE parameters have composite and discordant nature change. It is resulted in individual and restricted AE usage for mining methods of control, diagnostic and monitoring CM machining.

For the solution of the indicated problems value have the models and acoustic radiation simulation at CM machining with allowance the prevailing surface layer destruction mechanism and operating the different factors. In sources [3, 4] influencing the CM physical-mechanical characteristics for thermoactivative model its surface layer destruction on AE signals amplitude-energy parameters are reviewed. The simulation of AE signals amplitude and energy parameters change in time is conducted. Is showed, that the increase of parameter, which describing CM property results in decreasing AE resultant signals amplitude and energy parameters. At the same time, the concern introduces of informative AE amplitude-energy parameter analysis to change the CM properties for thermoactivative destruction its surface layer.

Research tasks. To conduct simulation data processing with definition of AE amplitude and energy parameters percentage change at change of CM properties. To conduct estimations of AE amplitude and energy parameters percentage change with definition of their sensitivity to change of CM properties.

Researches results. For analysis of AE resultant signals amplitude-energy parameter informative to treated CM properties change for thermoactivative model of its surface layer destruction we shall use the simulation data, which are obtained in articles [3, 4]. In table 1 and table 2 are adduced the values of AE resultant signals amplitude and energy parameters at change of parameter $\tilde{\tau}_0$, describing CM properties.

Table 1

Statistical amplitude characteristics of AE resultant signals at ascending $\tilde{\tau}_0$

$\tilde{\tau}_0$	$\tilde{\tilde{U}}$	s_U	s_U^2
$1{,}0 \cdot 10^{-7}$	$2{,}68721 \cdot 10^{-5}$	$9{,}29958 \cdot 10^{-6}$	$8{,}64822 \cdot 10^{-11}$
$1{,}5 \cdot 10^{-7}$	$1{,}34372 \cdot 10^{-5}$	$6{,}05029 \cdot 10^{-6}$	$3{,}6606 \cdot 10^{-11}$
$2{,}0 \cdot 10^{-7}$	$9{,}97565 \cdot 10^{-6}$	$4{,}4951 \cdot 10^{-6}$	$2{,}02059 \cdot 10^{-11}$
$2{,}5 \cdot 10^{-7}$	$7{,}93723 \cdot 10^{-6}$	$3{,}51846 \cdot 10^{-6}$	$1{,}23796 \cdot 10^{-11}$
$3{,}0 \cdot 10^{-7}$	$6{,}45269 \cdot 10^{-6}$	$2{,}89879 \cdot 10^{-6}$	$8{,}40301 \cdot 10^{-12}$

Table 2

Statistical energy characteristics of AE resultant signals at ascending $\tilde{\tau}_0$

$\tilde{\tau}_0$	$\tilde{\tilde{E}}$	s_E	s_E^2
$1{,}0 \cdot 10^{-7}$	$8{,}08568 \cdot 10^{-14}$	$5{,}27677 \cdot 10^{-14}$	$2{,}78443 \cdot 10^{-26}$
$1{,}5 \cdot 10^{-7}$	$1{,}49524 \cdot 10^{-13}$	$1{,}02916 \cdot 10^{-13}$	$1{,}05918 \cdot 10^{-26}$
$2{,}0 \cdot 10^{-7}$	$2{,}23871 \cdot 10^{-13}$	$1{,}69706 \cdot 10^{-13}$	$2{,}88001 \cdot 10^{-26}$
$2{,}5 \cdot 10^{-7}$	$3{,}21097 \cdot 10^{-13}$	$2{,}59533 \cdot 10^{-13}$	$6{,}73573 \cdot 10^{-26}$
$3{,}0 \cdot 10^{-7}$	$4{,}1238 \cdot 10^{-13}$	$3{,}33727 \cdot 10^{-13}$	$1{,}11374 \cdot 10^{-25}$

In table 1 and table 2 the following notations are adopted: $\tilde{\tau}_0$ - parameter describing CM properties; $\tilde{\tilde{U}}$, $\tilde{\tilde{E}}$ - AE resultant signal amplitude and energy average level; s_U . s_E - AE resultant signal amplitude and energy average level standard deviation; s_U^2 , s_E^2 - AE resultant signal amplitude and energy average level dispersion.

The simulation data (table 1, table 2) demonstrate that the ascending parameter value $\tilde{\tau}_0$ results in decreasing of AE resultant signals all statistical amplitude and energy parameters. For definition sensitivity and informative AE parameters to change $\tilde{\tau}_0$ we shall conduct data processing with definition of percentage decreasing of AE resultant signals amplitude-energy parameter in relation to their values at initial value parameter $\tilde{\tau}_0 = 1{,}0 \cdot 10^{-7}$. The outcomes of the conducted calculations are showed in Figure 1. In Figure 1 notation ΔZ - parsed AE resultant signals amplitude or energy parameter.

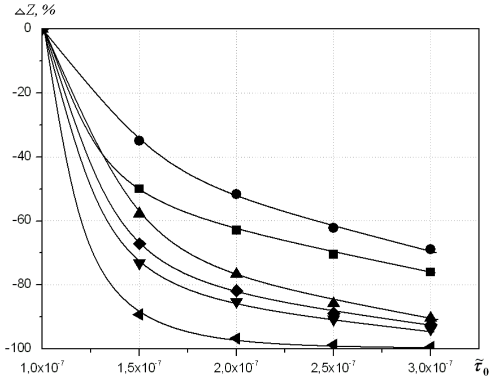

Fig. 1. Graph of percentage decreasing AE resultant signal amplitude average level $\tilde{\bar{U}}$ (■), its standard deviation s_U (●) and dispersion s_U^2 (▲), AE resultant signal energy average level $\tilde{\bar{E}}$ (◆), its standard deviation s_E (▼) and dispersion s_E^2 (◀) at CM machining for thermoactivative model surface layer destruction depending on parameter $\tilde{\tau}_0$, describing CM property

The conducted researches have shown following (Fig. 1). The ascending value of parameter $\tilde{\tau}_0$, which is determined by CM properties, results to not linear percentage decreasing of AE resultant signal statistical amplitude and energy parameters. However change of AE resultant signal statistical amplitude and energy parameters speeds differ among themselves. Decreasing of AE resultant signal statistical energy parameters are advances decreasing of AE resultant signal statistical amplitude parameters. Really, ascending $\tilde{\tau}_0$ in 2 times (from $\tilde{\tau}_0 = 1{,}0 \cdot 10^{-7}$ up to $\tilde{\tau}_0 = 2{,}0 \cdot 10^{-7}$) results in decreasing AE resultant signal statistical amplitude parameters $\tilde{\bar{U}}$, s_U and s_U^2, accordingly, on 62,88 %, on 51,66 % and on 76,64 %. Thus the AE resultant signal statistical energy parameters ($\tilde{\bar{E}}$, s_E and s_E^2)

decrease, accordingly, on 85,19 %, on 81,77 % and on 96,68%. Ascending $\tilde{\tau}_0$ in 3 times (from $\tilde{\tau}_0 = 1,0 \cdot 10^{-7}$ up to $\tilde{\tau}_0$ $\tilde{\tau}_0$ $= 3,0 \cdot 10^{-7}$) results in decreasing AE resultant signal statistical amplitude parameters $\tilde{\tilde{U}}$, s_U and s_U^2, accordingly, on 75,99 %, on 68,83 % and on 90,28 %. Thus the AE resultant signal statistical energy parameters ($\tilde{\tilde{E}}$, s_E and s_E^2) decrease, accordingly, on 93,81 %, on 92,32 % and on 99,41%. The outcomes processing data demonstrate, that at ascending value $\tilde{\tau}_0$ decreasing AE resultant signal energy average level dispersion advances decreasing their remaining amplitude and energy parameters.

Resume

The data processing of AE resultant signals amplitude and energy parameters simulation at change of treated CM properties is conducted. The AE resultant signals amplitude and energy parameters percentage changes at change of treated CM properties in relation to their initial values are determined. Is showed, that about ascending parameter, which is determined by treated CM properties, informative AE parameter (having the greatest sensitivity) is the AE resultant signal energy average level dispersion.

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The statistical approach for diagnosis and prediction operator's psychophysiological states

The article presents statistical approach for estimation of information-energy field parameters of the human cerebral cortex which based on processing of transition biopotentials considering psychological characteristics of the operators of extreme activities. Presented approach includes the use of robust methods of data analysis and simulation Monte Carlo.

Foreword.

In today's world, there is a need of high-quality and fast evaluation of psychophysiological health state (PPHS) for operators of extreme activities (OEA), such as pilots, polar explorers, athletes, drivers and others. The countries of the world spent considerable effort and money for quality professional recruiting of OEA [1], which is based on evaluation of PPHS of operator's organism.

To understand the interaction of psyche and physiology analyzed the information-energy fields (IEF) of human, main aspects of which are as follows. The human brain is a complex 6-layered structure that controls the human body via informative saturated biosignals. The limbic system of the human brain via nerve pathways implements the collection, processing and management of information about psychophysiological state of human homeostasis, moreover, the main element in the present process of the limbic system is a "supercomputer" - epiphysis. Thus, the limbic system synthesizes IEF which parameters fully describe the psychophysiological state of homeostasis human body.

Considering the functional biomedical communications modules of the brain, including the cerebral cortex (CC), found that one of the main parameters of limbic system's IEF are shown in biorhythms of CC (energy field) using ascending nerve pathways, and in the vestibular system (information field) using histamine-energy pathways. It possible to evaluate changes in IEF by using modern tools kephalograph and electroencephalograph with application software. As an additional method of identifying human condition of IEF state used the parameters of human blood.

This article presents a statistical approach to evaluating parameters of IEF based on processing of biopotentials of the CC considering psychological characteristics of the operators. The present approach is a computerized expert system that provides medical-specialist analyze quantitative parameters of stationary signal recording and transition electroencephalogram, which allows to asses and predict PPHS.

Main part.

Modern medicine is focused on the implementation noninvasive diagnostic tools and prediction of human body dysfunction. Analysis of the literature showed that 80% of aviation accidents [2], 70% accidents in nuclear power and 64% accidents to the Navy [3] occurred because of erroneous actions of professionals, that is the human factor. Almost 95% of Antarctic expeditions have been violations of psychophysiological state of the body due to extreme long-term factors of external environment [4].

The issue psychophysiological recruiting and development of information technology of professional recruiting extreme activity operator's exploring by our scientist [1, 4, 5] and foreign scientists [6].

Recent studies show the effectiveness of quantitative characteristics of biosignals for the diagnosis of CC and body as a whole [7]. In foreign studies electroencephalograph stands out as one of the effective means of evaluating the psychophysiological state of the body in the recruiting of the operators of extreme activities [5] and it effectiveness with experimental psychological examination for diagnosing and predicting proficiency of pilots [1].

Analysis of modern computerized electroencephalographic facilities showed that software products focused on the following form electroencephalograms research: the study of the spectral component of the electroencephalographic signal, automate the allocation of artifacts in the electroencephalogram, evoked potentials study. Research spectral component electroencephalographic signals provide information about PPHS CC, but current studies using this method focused, first, on the assessed CC of human or attempts assessment of human organs [7] and not integral evaluated PPHS of the human body; Secondly, the evaluation of PPHS of CC based on identifying deviations in frequency spectral signal peaks [8], instead of assessing the spectral like the integral part of CC biorhythms.

The latest results of foreign studies show, firstly, the effectiveness of the transition process for evaluating psychophysiological state of the human brain [9]; Secondly, the effectivity of methods for processing electroencephalographic (EEG) spectral density signal for the evaluation of psychophysiological state of the human brain [10].

Recent studies [11-14], which are implemented at the Department of Aerospace Medicine and Biocybernetics in National Aviation University show the effectiveness of the evaluation psychophysiological state body of OEA using modern system – kephalograph and electroencephalograph.

For the purpose of effective experimental studies OEA classified by type of temperament to approach their individual psychological and physiological characteristics of the organism. This approach based on special developed software for psychological testing, by which operators can be grouped in 36 categories of temperament. Methods of psychological testing is done once and has a duration of about 30 minutes. The above method is provided by three well-known psychological test and two anthropometric parameters such as:

- Test "Eysenck" (EPQ);
- Test "Tomsk questionnaire rigidity Zalyevskoho" (TQRZ)
- Test "State activity mood" (SAM)
- Ketele index;
- Trohanter index.

By using special developed algorithm of EEG signal processing available next coefficient: energy density coefficient (Q_{eeg}) and kephalograph coefficient (K_{kef}). This coefficient and blood parameters are stored in specially developed data base, but to implement PPHS for certain OEA with a specific type of temperament should be normalized value of mentioned above coefficient.

That's why developed software calculated interval estimate (v) at a known standard deviation and at the chosen significance level α = 0,05:

$$P\left(\bar{x} - t_{\alpha,n-1} \cdot \frac{S}{\sqrt{n-1}} < v < \bar{x} + t_{\alpha,n-1} \cdot \frac{S}{\sqrt{n-1}}\right) = 1 - \alpha, \quad (1)$$

where n - number of samples, $t_{\alpha,n\text{-}1}$ - Student coefficient, $\bar{x}$ - the arithmetic mean of the sample, S - standard deviation.

Whereas, for the formula (1) of the sample distribution to be normal should check it on the normality. Because the sample data at the start of the selection may be small, folded criteria used to test the normality of the distribution that is suitable for a sample size of 11 <n <50:

$$d = \frac{\sum_{i=1}^{n}|X_i - \bar{X}|}{\sqrt{n\sum_{i=1}^{n}(X_i - \bar{X})^2}}. \quad (2)$$

If the hypothesis of normality of the sample distribution hasn't confirmed software used the criterion of error named Hrabbs on the sample. Then again used folded criteria to verify the normality of the distribution.

If the hypothesis of normality of the sample hasn't confirmed again provided robust method to calculate statistical estimates [11] that are close to the normal distribution law, then apply iterative modeling with normal distribution named Monte Carlo. Due to the modeled sample can apply the formula (1) to determine the normalized interval estimate that is used to identify the PPHS for OEA.

Whereas the above calculated interval estimates of Q_{eeg} coefficient for Antarctic explorers before and after polar expedition (Table 1).

Table 1.

Results of calculated interval estimate of Q_{eeg} coefficient

Group of operators	Interval estimate of Q_{eeg} coefficient before polar expedition	Interval estimate of Q_{eeg} coefficient after polar expedition
31 subgroup without iterative modeling	$0{,}644 \le Q_{eeg} \le 0{,}850$	$0{,}540 \le Q_{eeg} \le 0{,}975$
31 subgroup with iterative modeling	$0{,}741 \le Q_{eeg} \le 0{,}752$	$0{,}882 \le Q_{eeg} \le 0{,}896$
35 subgroup without iterative modeling	$0{,}612 \le Q_{eeg} \le 0{,}846$	$0{,}724 \le Q_{eeg} \le 0{,}953$
35 subgroup with iterative modeling	$0{,}835 \le Q_{eeg} \le 0{,}843$	$0{,}864 \le Q_{eeg} \le 0{,}878$

Standardized coefficient K_{kef} for Antarctic explorers made: $0{,}48 < K_{kef} < 2{,}53$. For comparison presented normalized values of K_{kef} for ordinary operators: $2{,}11 < K_{kef} < 3{,}12$. Considering the above, method of kephalography proved to be sensitive in evaluating of PPHS for OEA, which confirmed with the results of electroencephalographic studies and blood parameters.

To provide predictive function of PPHS for OEA used regression modeling in three-dimensional between the energy density coefficient (Q_{eeg}), kephalography coefficient (K_{kef}) and time (t) based on polynomial 7th degree of statistical calculation tolerances. The adequacy of the models tested by two methods: the average of guest models (t-statistics); deviation in dispersion models and response system (Fisher criterion). Due to calculated analytical dependences are able to control the PPHS in the performance of professional duties in extreme envelopment conditions or in the process of rehabilitation OEA. Below shows a graphical model of three-dimensional statistical dependence with tolerances for 31th (Fig. 1 a) and 35th (Fig. 1 b) subgroup of operators.

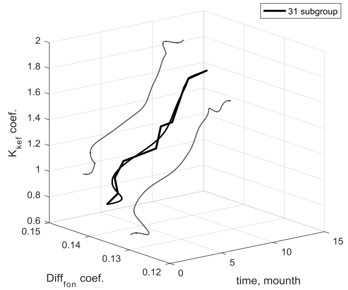

Fig. 1 a

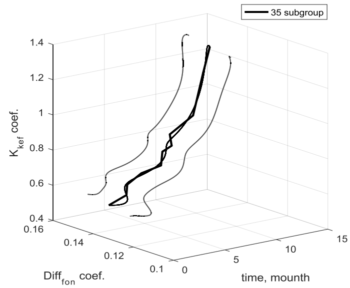

Fig. 1 b

Substituting the experimental values of K_{kef} and Q_{eeg} at t=0 can be implemented PPHS for OEA depth evaluation and monitoring this coefficient specified in the performance of professional duties in extreme environmental conditions (t>0) can implement control and rehabilitation of PPHS OEA.

Conclusions

1. Was analyzed process of information-energy field appearance, thus making the conceptual model, the main element of which is the limbic system of the human brain, which analyzed and synthesizes information and making homeostasis' regulation of the human body.

2. Was computerized algorithm and calculating electroencephalogram integral criterion, named the energy density coefficient (Q_{eeg}), which allows with transition biosignals of cerebral cortex to make diagnostics and prediction of the psychophysiological health state of operators' organism.

3. Was computerized algorithm of statistical processing of data to calculate the normalized values of power density coefficient (Q_{eeg}), kephalograph coefficient (K_{kef}) and blood parameters, which allows to automate the evaluation of psycho-physiological health state of operators' organism.

4. Was built graphical and analytical model three-dimensional relationship between the energy density coefficient (Q_{eeg}), kephalograph coefficient (K_{kef}) and time (t), thus improving the quality of assessment and prediction of psychophysiological health state of operators' organism.

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Information support of computer measuring experiments in evaluating of the noise processes characteristics

The constructive model of non-stationary and stationary noise processes was considered. The algorithms of computer simulation of realizations noise processes using a histogram analysis and autoregression model were developed.

Introduction. The noise process refers to known information processes in various subject areas. Such processes distribute in different physical environments and create a total intensity, power, energy, motion of fluid particles, gases, etc.

The two main directions of noise processes research can be identified conditionally [1, 2]: noise processes that are interfering in combination with other information processes, which relate to useful; noise processes carry useful information about the operation of objects, systems, and thus become a useful process, ie, research objects.

Currently, most of the measurement tasks of the characteristics of the noise processes are solved within the correlation and spectral theory. This is due to the fact that is common to use a Gaussian stationary process as a noise process. This model confirms in practice in some cases. However, analysis of the results of many publications, including [3, 4] confirms that some of the noise signals are non-Gaussian stochastic processes. These signals are the result of superposition of a large number of elementary pulses with random parameters. And random parameters occur at random times. Signals have a nonstationary character in some cases.

Non-Gaussian noise processes cause the research not only in the correlation and spectral theory, but also in view of the higher moments. At the same time, we can construct the equivalent Gaussian stochastic process for any non-Gaussian process of the correlation and spectral theory. The first two moment functions will be equal to the studied non-Gaussian and its equivalent - Gaussian process.

Formulation of the problem. Information support of a wide range of computer simulation of the realizations of noise processes should be justified. The basis of modeling noise processes need to use their experimental measurements.

The main results. The model of noise process has to be described before describing the algorithm of computer simulation of the noise processes.

The structural model of the noise processes. Gaussian and non-Gaussian processes can be described by the following structural model [6]:

$$\xi(\omega,t)=\sum_{i=1}^{n}\eta_i(\omega,t)I(t,\Delta T_i)+\sum_{j=1}^{m}\zeta_j(\omega,t)I(t,\Delta T_j),\ \omega\in\Omega,\ t\in[0,T], \qquad (1)$$

where $\{\eta_i(\omega,t),\ i=\overline{1,n}\}$ - a sequence of homogeneous non-stationary (stationary) stochastic processes; $\{\zeta_j(\omega,t),\ j=\overline{1,m}\}$ - sequence of homogeneous random periodic processes; indicator function is given by:

$$I(t,\Delta T_j)=\begin{cases}1, & t\in\Delta T_j\\ 0, & t\notin\Delta T_j.\end{cases}$$

and it is formed by sentries instant change-point homogeneity of the test component in practice. In other words - the uniformity intervals $[0,\Delta T_1)\cup[\Delta T_1,\Delta T_2)\cup...\cup[\Delta T_{n-1},\Delta T_n]=[0,T]$ studying component (1).

For example, the model (1) becomes constructively in practice when as a component of the model was used Gaussian linear random processes [5].

In modeling tasks Gaussian linear random process can be represented as a structural model [6]:

$$\eta(\omega,t)=\int_0^t\varphi(t,\tau)x(\omega,\tau)d\tau\ , \tag{2}$$

where $\varphi(t,\tau)$ - impulse response function of a linear shaping filter, $x(\omega,\tau)$ - Gaussian white noise as a generalized derivative of a process with independent increments. For a stationary random process the expression (2) takes the form:

$$\eta(\omega,t)=\int_0^\infty\varphi(t-\tau)x(\omega,\tau)d\tau\ .$$

Gaussian linear random process $\zeta(\omega,t)$ is called periodic (T_0-periodic) if there exists a number $T_0>0$, in which the finite vectors $(\zeta(\omega,t_1),\zeta(\omega,t_2),...,\zeta(\omega,t_n))$ and $(\zeta(\omega,t_1+T_0),\zeta(\omega,t_2+T_0),...,\zeta(\omega,t_n+T_0))$ for all integers $n>1$ are stochastically equivalent

Classes of linear processes are selected depending on the formulation of the research problem. For example, a stochastic periodicity is accounted for in technical diagnostics of objects, systems and mechanisms.

Computer simulation. Two methods of computer simulation was suggested: using a histogram analysis; using autoregression model.

Computer simulations using a histogram analysis. Let $\xi_t, t\in\mathrm{Z}$ - a sequence of independent identically distributed random variables, and $(\xi_1,\xi_2,...,\xi_n)$ - repeated sample of observations (measurements) of the random sequence $\{\xi_t\}$. On the basis of the sample $\{x_i, i=\overline{1,n}\}$ as the implementation of $\{\xi_i, i=\overline{1,n}\}$ was needed to construct a histogram (the implementation of the empirical density distribution) by a known method [7].

In fact, the histogram can be viewed as an estimate piecewise constant approximation of the unknown density distribution. Therefore, the simulation algorithm for each element of the test sequence will be as follows:

- generates a pseudo-random number $\alpha^{(1)}$ by one of the known methods;

- generates the implementation of a discrete random variable η with the distribution obtained on the basis of the histogram;
- generates a pseudo-random number $\alpha^{(2)}$;
- generates the realization of a random variable $\xi = h\alpha^{(2)} + x_{\eta-1}$, which will have uniform distribution in the range $[x_{\eta-1}, x_\eta)$, where x_η - the point of interval partitioning $\left[\min\limits_{k=\overline{1,n}} \xi_k, \max\limits_{k=\overline{1,n}} \xi_k\right]$.

The proposed algorithm is based on method of piecewise approximation used for the simulation of random variables with known (given) density distribution. However, in this case, the estimation of the piecewise approximation of the unknown density distribution is found from the empirical data as a histogram, and the evaluation of the probability of the simulated values falling in the corresponding subinterval Δ_j is $\frac{\mu_j}{n}$, where μ_j - the number of sample points falling within j -th subinterval, $j = \overline{1, m}$.

To verify the simulation model can be used two-sample nonparametric uniformity criteria: the criterion of the Kolmogorov-Smirnov, criterion ω^2, criterion χ^2 etc.

Computer simulation using autoregression model. Let $\xi_t, t \in \mathrm{Z}$ - stationary random sequence (random process with discrete time), $m = \mathbf{M}\xi_t$ - mean and $R_\tau, \tau \in \mathrm{Z}$ - correlation function of the sequence ξ_t.

In the first stage of modeling is necessary to obtain statistical estimates of the mean and the correlation function of the process studied. Namely:

$$\hat{m} = \frac{1}{n} \sum_{k=1}^{n} \xi_k ,$$

$$\hat{R}_\tau = \frac{1}{n-\tau} \sum_{k=1}^{n-\tau} (\xi_k - \hat{m})(\xi_{k+\tau} - \hat{m}), \ \tau = 0, 1, 2, ..., n_1 << n .$$

Without loss of generality, we will continue to assume $m = 0$.

Autoregression sequence has the form:

$$\xi_t = -\sum_{k=1}^{p} a_k \xi_{t-k} + \zeta_t, \quad t \in \mathrm{Z}, \tag{3}$$

where $a_k, k = \overline{1, p}$ - real parameters; ζ_t - centered stationary white noise with variance $\mathbf{D}\zeta_t = \sigma^2$; p - order of autoregression model.

So to build a regression model of the studying process is necessary to evaluate parameters $a_k, k = \overline{1, p}$, σ^2, and the order p.

To obtain estimates of the parameters $a_k, k=\overline{1,p}$, it is necessary to substitute the assessments $\hat{R}_\tau, \tau=\overline{0,p}$ in the Yule-Walker equations and solve it for the unknown $a_k, k=\overline{1,p}$, σ^2. As a rule, the Yule-Walker system of equations is solved using a fast algorithm of the Levinson-Durbin. The required solutions will be consistent estimators of the parameters of the AR-model. Note that the estimates of the parameters of AR-model by the above method are always lead to the construction of sustainable AR-models, that have very important tasks in the use of these models for computer simulation.

The order p of AR-model is also unknown in practice. It is possible to use a set of criteria for its assessment [8].

Akaike criterion, called "the final prediction error" consists of statistics analysis

$$K_1(p)=\hat{\sigma}^2(p)\frac{(n+(p+1))}{(n-(p+1))},$$

where $\hat{\sigma}^2(p)$ - white noise variance estimate of AR-model by order p.

Statistic $K_1(p)$ is calculated for the values $p=1,2,3,...$ to select the order of the AR model with the specified criterion. The order of value is selected such that the value $K_1(p)$ is minimized.

A technique of using other criterion is a similar. Akaike Information Criterion has the form:

$$K_2(p)=n\ln(\hat{\sigma}^2(p))+2p.$$

The criterion of "minimum description length":

$$K_3(p)=n\ln(\hat{\sigma}^2(p))+p\ln(n).$$

Criterion Parzen, called "transfer function regression criterion" has the form:

$$K_4(p)=\frac{1}{n}\sum_{j=1}^{p}\frac{n-j}{n\hat{\sigma}^2(j)}-\frac{n-p}{n\hat{\sigma}^2(p)}.$$

Differences of using these criteria by the real processes were analyzed in [10]. It should be noted that for the simulated AR-processes all four criteria give the same results.

Computer simulation algorithm will be as follows [8]:

- parameters $a_k, k=\overline{1,p}$, σ^2 of the simulated AR-process, which correspond to estimates obtained previously are set;
- sequence for centered stationary white noise $\zeta_t, t=-p,-p+1,-p+2,...,-1,0,1,2,...$ with a given distribution and variance σ^2 is generated;
- AR-sequence is generated by the formula (3) for $t=0,1,2,...$, assuming $\xi_t=0$ for $t=-p,-p+1,-p+2,...,-1$ (zero initial conditions).

The damped transitional process takes place by choosing the zero initial conditions $\xi_t = 0, t = \overline{-p,-1}$ in the simulated sequence. Therefore, samples ξ_t of the desired stationary AR-sequence will be obtained only for $t = t_1, t_1 + 1, t_1 + 2, ...$ where $t_1 >> p$.

The evaluation of the correlation functions the studied process (simulated process) and it generated AR model can be compared to verify the resulting computer simulation model.

Conclusions. Information support of computer measuring experiment in the evaluation of noise processes characteristics is given. Structural model of the noise signal based on a linear random process was considered. Algorithms of a computer simulation of the noise processes using histogram analysis and autoregression model were proposed. The simulation was performed on the basis of real (experimental) data noise processes measurement.

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Main stages of the life cycle of virtual systems to measure characteristics of the stochastic noise processes

The main stages of the life cycle of virtual measurement systems of stochastic noise processes performance are set out. Each stage of the life cycle iss described in detail. Distinctive features of the life cycle of virtual IMS are presented in comparison with real hardware and software systems.

Introduction. The widespread use of computer technology, modern information technology was provided an evolutionary and revolutionary development of potential hardware and software systems and research of stochastic noise processes. The last one began to be the actual subject of research. This is due to the fact that the noise processes are used in many fields of science and technology.

Physically noise process formulated as a result of a plurality sources of vibration, waves, pulses, displacements, cracking of materials, vibrations in various mechanical objects and technical systems.

The two main directions of noise processes research can be identified conditionally [1]:

- noise processes that are interfering in combination with other information processes, which relate to useful;
- noise processes carry useful information about the operation of objects, systems, and thus become a useful process, ie, research objects.

The second area can be conditionally divided into the following groups:

- noise as a broadband random process;
- noise as a narrowband random process with simultaneous amplitude and angular modulations;
- noise as the test signals;
- noise as a sounding processes in the study of macroscopic phenomena;
- noise as an analytical tool of physical processes.

At present, a discrepancy in a sense was created between the capabilities of hardware and software and developed models and methods of determining the characteristics of stochastic noise processes. In this paper, we propose one of the possible solutions of such contradictions. This option is to create a virtual information-measuring system (VIIS) for measuring the characteristics of stochastic noise processes.

Formulation of the problem. The main content of creating a virtual measurement system of noise processes performance is substantiated at key stages of its life cycle.

The main results. The use of modern information technologies has significantly increased the potential for effective practical solutions to problems of measurement noise processes characteristics, and the use of scientific and technical bases is contributed to the creation of modern measurement systems. Modern measuring systems are the hardware and software and can be implemented as:

- the real hardware and software systems;
- virtual systems with the use of modern information and measurement technology simulation of different types of systems and signals.

It is known [2, 3], that the virtual measuring instruments have advantages compared to the real. These include a significant range of research of various options structures, modes of operation, noise modeling processes, algorithmic and software support, etc. At the same time a significant reduction temporal and manufacturing costs and resources takes place, and intelligent amount of research is increasing.

As with any real system, the virtual measuring system has its own life cycle, which consists of several stages [3]. In the report proposed to use the following stages of the life cycle of VIMS:

- order, development and coordination of technical specifications for VIMS;
- VIMS development;
- testing, certification and transfer of exploitation;
- exploitation;
- modernization and further exploitation.

To justify the maintenance of a virtual system, it is necessary to describe in detail each stage of life cycle of virtual measuring system of noise processes characteristics.

1. Step VIMS order begins with the identification of needs in the virtual system. Customer must describe the concept or the need for order, development or improvement of the system. Scope of application and purpose, feasibility and specific requirements, and the development stage and terms must be given.

Attention must be given during developing a system that the virtual measurement system must have speed and measurement accuracy which is necessary. The simplest way to achieve this goal is to increase the productivity of the computer in accordance with the empirical law of Moore [4]. Today, the tendency of realization intensive tasks was formed by the use of parallel computing, even within a single computer. In modern computer graphics and computing productivity exceeds the productivity of the CPU, so the parallelization task is performed on the basis of graphics processors. The main disadvantages of this approach are the high cost of hardware and the need for special software application from developers.

At the same time the problem of parallel processing can be performed by combining multiple computers in a local network. Distributed computing allows computers to use free resources, which are connected to the network. Such a method is the best for the introduction of computer simulations in the implementation of a virtual system. However, it also has a number of disadvantages. Firstly, to commercial software on each computer in the network must purchase a license. Secondly, it is impossible to predict what computing resources must be used at a certain time. Distributed computing is useful when carrying out fast computing.

The most promising technology for the realization of virtual computer system of measurement is the use of "cloud computing". The system, which is implemented in this way will allow to implement a flexible system with real-time access to relevant information almost from anywhere in the world.

2. VIMS development stage includes analysis of system requirements, design, coding, integration, testing, and other associated with software products.

A distinctive feature of the development stage of virtual measuring system of noise processes characteristics is the fact that during this stage must do the following:

- to develop technical task on the virtual system;
- to develop information support for virtual measurement system (model and the characteristics of the noise processes, measurement methods of noise processes characteristics, methods of evaluation of measurement results);
- to conduct preliminary measuring computer experiments.

Furthermore, according to [5], the following documents for software must be developed and described:

- technical task;
- explanatory memorandum (a flowchart and description of the functioning of virtual measuring system of the noise processes characteristics; description and characteristics of precision implemented algorithms; description of the method of identification; description of data protection implemented methods);
- description of the software of virtual measuring system of noise processes characteristics (information about the logical structure and operation of the software; description of the functions that are performed when working with this software);
- software text of virtual system (output code entry with necessary comments).

3. Stage of testing, validation and transfer commissioning is to determine VIMS procedures and resources as are necessary for control and support of virtual systems. The supplier shall establish and documented management plan for system, which consists of the stages described in [6].

In this case it is necessary to note that if the customer chose to develop a system with the use of "cloud computing", the supplier can offer several models of working with virtual system [4]:

- model "Software as a Service" - software of virtual systems where the supplier develops, hosts and manages software. The customer uses the software via the Internet;
- model "Platform as a Service" - service model of virtual systems in which the customer is given the opportunity to use based on "cloud infrastructure" of the various programs that are created using programming languages, libraries, and services. This model can be used not only a mathematical model of measuring instruments, but also the information that comes from real sensors;
- model "Infrastructure as a Service" - service model of virtual systems in which the customer is given the opportunity to manage the resources of processing and data storage, communication networks and other fundamental measurement resources.

4. Operation phase consists of the activities and tasks by user of virtual system. In this case it is necessary to note that if the customer chose the model "platform as a service" or "infrastructure as a service", then in addition to user settings, during the operational stage is also developing a system administrator install.

Setting the user includes information on operating software of virtual systems, description of the user interface and the system's hardware specifications.

In turn, the system administrator installation consists of the information to verify and ensure the functioning of the software under specific conditions of use of virtual systems.

5. Stage of modernization and further support is triggered when a virtual system must be modified with changes to software. In more detail this step is described in [6]. It should be noted that this stage is fundamentally different from the last stage for real IMS. For virtual IMS is not necessary to carry out recycling system, the software can only be upgrade or replace some of its components.

Conclusions. The main stages of life cycle of virtual systems for measuring stochastic noise processes characteristics are set out. The main features of the life cycle of virtual measurement systems of noise processes characteristics are presented in comparison with the real IMS.

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Assessment of the quality of the titanium surface after mechanical and chemical thermal treatments

It analyses methods of assessment of the quality of the surface, advantages and disadvantages. The influence of thermal diffusion saturation by nitrogen and boron on microgeometrical parameters of the quality of the surfaces obtained from two - and three-dimensional methods previously grinded and polished titanium samples. It was found that after thermal diffusion saturation by boron microgeometrical parameters of the quality of the surface titanium alloy Grade 2 decreases compared to the initial grinding.

Today it is impossible to imagine the industry without titanium. Due to the high specific strength, corrosion resistance at high temperatures, low cold brittleness threshold of the main part of the, Titan is used in aviation and space technology. However, the negative feature of titanium and its alloys are low tribotechnical properties that are most effectively to improve methods of surface chemicothermal treatment, namely thermodiffusion saturation of surface layers oxygen, nitrogen, carbon, and boron.

In the production of various machine parts and mechanisms mainly as finish processing, the use grinding or polishing of the surface. This treatment forms a physic-chemical status of the surface layer which largely determines the basic performance properties of parts and assemblies, namely, their wear resistance, resistance to fatigue fracture, the reliability of the landings, contact stiffness, corrosion resistance, tightness of connections, etc. So the problem of the surface quality control is relevant [1].

The real surface has a complex profile and is characterized by micro - and macrogeometry disabilities. Microgeometrical deviations are determined by the surface roughness and macrogeometrical – waviness and deviation from the correct geometric shape. Today there are more than 30 different roughness parameters, which quantitatively evaluate the surface topography. The roughness depends on many technological factors: modes of processing material (processing speed) and surface quality of the tool, mechanical properties, chemical composition and structure of the workpiece material [2]. The most widespread and common roughness parameter, which is included in most international and national standards, is the arithmetic mean deviation of profile i.e. R_a. Improve surface quality and a reduction in roughness lead to an increase in resource details.

Measurement of parameters of surface roughness produced by various methods that are generally accepted in Metrology, but the question of accuracy of its estimation has not been studied. Definition of standard and non-standard criteria of roughness is time-consuming and therefore not always can be used to solve many problems in a production environment. The establishment of reliable roughness parameters that best describe her, as well as the development of devices and methods, is an urgent task that will automate the process of determining these parameters. This will contribute to improving the quality of products and production development in General.

Most of the systems of control of surface roughness are built on the following two methods: direct (qualitative) assessment and quantification of the roughness.

Comparative contactless method (qualitative assessment) based on comparing the real surface with roughness standards, which are standard parameters of R_a. The roughness of the workpiece surface is compared visually (naked eye, magnifying glass or special microscope) with the surface of the etalon, which is made of the same material and processed with the same mode as the detail. It provides a reliable estimate of the surface roughness in the range R_a= 0.63...5 microns. This method is intended to provide an overview of the surface and finds application in single manufacturing details [3].

Methods quantification based on the analysis of the surface profile. The evaluation of the surface profile can be realized without contact of the device with the target surface (optical methods) or by scanning with a special probe – diamond needle.

The mechanical contact method involves the measurement of roughness parameters using probe devices – profilometer and profilograph. The numerical value of the roughness parameters are determined or the scale of the instrument (profilometer), or enlarged several times, the profile or the recorded profilograms (profilograph). Analysis of surface profile and measurement of its parameters provides a diamond needle in a straight line with a length of 1.5 – 6 mm (two-dimensional measurement). But the surface is three-dimensional, any two-dimensional estimate gives an incomplete description. Probe three-dimensional systems like two-dimensional and inherited almost all of their drawbacks: large size of the probe, a significant radius of diamond needle (5 – 10 μm), the wear of the probe in the process of operation, the mechanical effect on the probe chips of metal, have to configure the probe for each workpiece, the measurement error due to vibration, and shocks of the workpiece, slippage of the probe during testing, the low resolution in the vertical direction (~ 0.1 μm), and others [4].

These deficiencies deprived optical methods of investigation of the surface topography (interference, focus), and electronic (scanning, transmission) and sounding (tunneling, atomic force) microscopes.

Methods optical of analysis of surface topography has been widely applied due to its high speed and non-contact, and in connection with the rapid development of optical electronics and computers. At present time, optical methods are widely used in three-dimensional analysis of surface topography and can more accurately assess the real surface characteristics, such as [5]:

– give the possibility to determine the real values of the extrema of the roughness, because with the traditional method of determining the profile runs along the slopes of the peaks and troughs, not intersected by vertices with them, and it distorts the profile bearing curve;

– Increase the information value of the results due to the increased number of new independent researched parameters;

– Can visualize the surface using a computer that is present in detail the topography of the surface;

– These methods are sufficiently precise and allow the analysis of the surface in tenths and even hundredths of a micrometer.

Interferometric techniques successfully and widely used for the study of the geometric parameters of the surface quality. The technique is based on the phenomenon of interference of two coherent light waves reflected from the test and mirror surfaces respectively. Digital camera fix results (light and dark stripes), which through different algorithms and modern computing are processed and the resulting calculated roughness [6]. The use of optical methods to control the roughness of surfaces does not require especially knowledgeable staff and easy to operate.

The aim of this work is to analyze the parameters of the surface topography of titanium alloy Grade 2 after various temperature regimes of thermal diffusion saturation by nitrogen and boron, obtained by two-dimensional (probe method) and three-dimensional (method of phase-shifting interferometry) methods of analysis of the quality of the surface.

The study was carried out on samples of titanium Grade 2 (similar to BT1-0). The surfaces of samples were pre-grinded and polished. As a chemicothermal treatment selected gas thermal diffusion saturation by nitrogen and contactless thermal diffusion saturation by boron at temperatures of 750 and 900 °C, and saturated for 5 hours. Analysis of surface topography was performed using the profilometer model 170621 (the baseline length l= 3 mm) and the interferometer of Twyman–Green method phase-shifting interferometry using the algorithm of reconstruction of surface topography (the study area is 3.2 mm^2) [7].

The surface roughness of the samples (parameter R_a), which were obtained using two-dimensional and three-dimensional techniques given in the table. Data analysis the table shows that the measurement results using two- and three-dimensional methods do not differ and are within the same class of the quality surface. Significant variation in the data to observe the polished surface, which may explain the lack of precision probe method due to the large radius top of the needle its lack of resolution in the vertical direction, and that after passing through the diamond needles remain on the smooth surface scratches. This makes it impossible to adequately assess the surface roughness which is less than $R_a \leq 0.1$ microns.

Microrelief surface after grinding is a large number of parallel spaced furrows that were formed as a result of mechanical interaction of the material with the grain abrasive. Polished surface is perfect micro and characterized by a lower roughness compared to grinded. This reduction in roughness achieved by cutting high peaks, formed in grinding and forming relief to low, relatively smooth peaks and deep cavity.

The influence of thermodiffusion saturation with nitrogen and boron at a temperature of 750 °C for roughness grinded and polished surfaces are different (see table).

Table – Roughness of the surface of the alloy Grade 2 after different modes of processing

Chemical thermal treatment	R_a, µm			
	Grinding		Polishing	
	2 D	3 D	2 D	3 D
Original	0.216	0.213	0.092	0.051
Nitriding by 750 °C	0.244	0.239	0.141	0.135
Boriding by 750 °C	0.167	0.179	0.092	0.087
Nitriding by 900 °C	0.674	0.656	0.491	0.465
Boriding by 900 °C	0.681	0.632	0.559	0.533

After saturation of the grinded surface with nitrogen roughness it's almost constant, and the saturation with boron reduces it because in the process of formation of the boride film filled in depressions of microrelief, then there is the healing of the surface. The saturation of the polished surface of nitrogen and boron increases the roughness, because the newly formed nitrides or borides films create a new high of the surface roughness, which dramatically increase the surface roughness. Less influence on the polished surface observed after boriding (table).

The increase in temperature chemicothermal treatment up to 900 °C, regardless of prior mechanical surface treatment (grinding, polishing) leads to a significant increase of surface roughness due to the intensification in the formation and growth of surface nitrides and borides films. The cleanliness of such surfaces is at the level of 8-th classes.

Conclusions

The results of the measurement of surface roughness titanium Grade 2 by two- (profilometer) and three-dimensional (shifting interferometry) methods do not differ and are within one class surface finish.

Regardless the method of chemical processing (nitriding, boriding) at 750 °C roughness polished samples increases. As for the polished sample, the nitriding and boriding, effects are different on this characteristic, nitriding practically does not change it, and boriding – reduces. For higher temperatures of chemicothermal treatment grade grinding and polished surfaces deteriorates.

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A method of inspection to control airframe design elements

The paper offers to use a method of infrared pulse-echo inspection to control airframe design elements, made of polymeric composite materials under operators` conditions. The following is described: skeleton operation diagram of the given method, device structure and results of the preliminary researches confirming operation capacity of the method offered.

Polymeric composite materials (PCM), fiberglass and carbon fiber reinforced plastic in particular, have wide application for reason of relative low price, the ease of fabrication and processing. So, for example, nowadays airframe design of some aircraft is made of fiberglass and fiber reinforced plastic more than for 80% [1, 2].

Thus, the defining of actual technical conditions of PCM structural element and forecasting of such a state change is a relevant objective.

Methods of acoustic, thermal and optical NDT are widely used to perform operational control of airframe structural elements, made of fiberglass. Despite wide application of the abovementioned methods all of them have advantages and disadvantages, complicating their usage in operation [3 - 8].

However, if we are speaking about light aviation and operators, having mini park of light and ultra light aircraft there is no optimal solution to the problem of PCM state diagnostics by virtue of economic and technology factors.

The dominant position among all defects of airframe structural elements, made of PCM belongs to delaminating and separation (statistically up to 45% of all structural damages) [4, 5]. Also it is necessary to note the insufficient diagnozability of items, made of polymeric composite materials in the result of dispersion of their physical characteristics.

Due to set forth above, it is proposed to apply infrared pulse-echo inspection method in the process of fiberglass nondestructive testing.

This method belongs to the class of optic inspection. The principle of optic infrared radiation (IR) range interaction with materiel of monitored object is taken as a base.

Registration of spatiotemporal IR radiation amplitude distribution in the result of its interaction with the monitored object is used to receive inspection information [3, 6, 8]. It is obvious that the presence of mechanical defects (as surface so hidden ones), nonhomogenity of materials and also foreign inclusions influences on optical properties of monitored object. Transmitted radiation intensity, passed through the monitored object of study, which is used to infer about the defects of material, is and information-bearing parameter.

The peculiarity of the proposed method is the principle of IR radiation usage and the way of its supply to the monitored object.

The given method combines advantages of optic, acoustic and thermal methods, in particular:

- it is analogous with optic methods by the principle of IR radiation usage (the laws of optics are used in the process of IR radiation interaction with the monitored object);

- it is analogous with acoustic pulse-echo method by the principle of operation (the only difference is that the proposed method is based on usage of IR radiation, but not acoustic vibrations);

- usage of IR radiation as the monitoring tool gives the possibility to detect surface defects of material and also to monitor the hidden cavities (composite materials, which are not opaque to visible light, are optical transparent medium for infra-red emission).

- pulse regime of IR radiation supply insures the high level of diagnostics system interference protection from background illumination (solar and/or artificial light) of monitored object.

Critical difference of the method proposed from thermography and IR imagery [3, 6] lies in the supply regime of IR radiation and its subsequent registration. Thus, passive regime (receiving of IR radiation, produced by the monitored object), chronic irradiation of monitored object regime, or single-pulsing radiation regime (so called flash-thermography) are applied in the above given methods. The principle of multiple passing of high frequency radiation impulses is used in the method proposed.

Consequently, it is necessary to compare IR radiation characteristics qualitatively and quantitatively after its interaction with damage-free or defective area of the design.

In our case, diagnostic system, applying IR radiation consists of the following elements (Fig. 1.):

— master oscillator;

— pulse former;

— outlet power stage;

— infrared radiator;

— infrared detector;

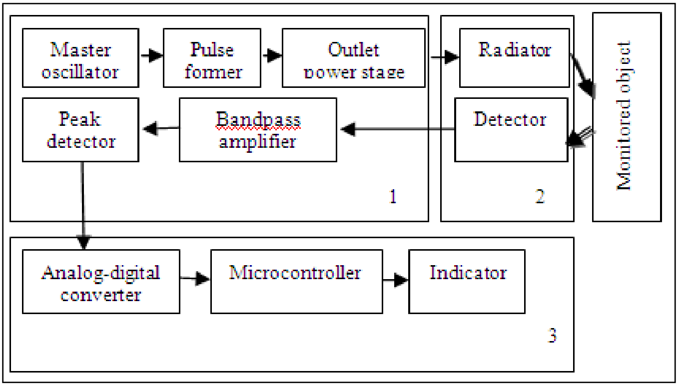
— bandpass amplifier;

— peak detector;

— analogue-digital converter;

— microcontroller;

— indicator.



1 – analog line; 2 – probe head; 3 – digital line

Fig. 1. Functional diagram of IR nondestructive testing instrument.

Master oscillator controls the operation of infrared radiator, insuring supply of IR radiation impulses of the definite amplitude. Radiation impulse, produced by radiator, is supplied to the monitored object, where on the base of reflection, refraction and radiation absorption laws and it is subjected to the change, which is proportional to material structure characteristics.

There is closely-fitting screen between radiator and detector, used for registration of radiation, passing through the monitored object and reflected by its surface.

The radiation impulse, passed through the monitored object material is registered by infrared detector. In order to remove the chronic components of the signal (background illumination of the monitored object by the natural IR radiation sources) and low frequency components (background illumination of the monitored object by the artificial IR radiation sources) evolution of effective impulse signal with the help of bandpass amplifier, adjusted for high frequency of the radiator, is used. By this way, only IR radiation impulses, produced by device radiator, are supplied for further processing.

High pulse-recurrence rate of radiation also insures high level of interference protection and compensates operator`s possible mistakes in the process of inspection.

Evolved impulse of radiation in converted into the voltage value, which is proportional to it, supplied to the analogue-digital converter and further processed with the help of microcontroller. Monitoring results are displayed in the convenient form (in the form of the graph or annunciator).

Diagnostic parameter is not the absolute value of outlet signal but its change over the damage-free and defective areas of the monitored object.

Due to set forth above, experimental device of infrared pulse-echo inspection testing and laboratory bench to study the possibility to perform nondestructive testing of fiberglass by the given method were established .

The list of experimental works (as for the assessment of infrared medium signal intensity change in the result of passing through structural fiberglass models was hold to prove working capacity of the device. The following boundary conditions were assessed:

1. Change of diagnostic parameter if there is a defect of “delamination” class in the model.

2. Change of diagnostic parameter depending on the paint coat over the monitored object surface.

While studying of fiberglass model, dimensions of which are 185x38x3 mm, with artificially embedded defect of “delamination” class, dimensions of which are 50x38 mm for possibility to detect surface defects with the help of radiation intensity, passing through damage-free and defective area it has been found out that the change of diagnostic parameter is 27%. This value is out of background noise (Fig. 2.). Background noise equals not more than 5% of diagnostic signal.

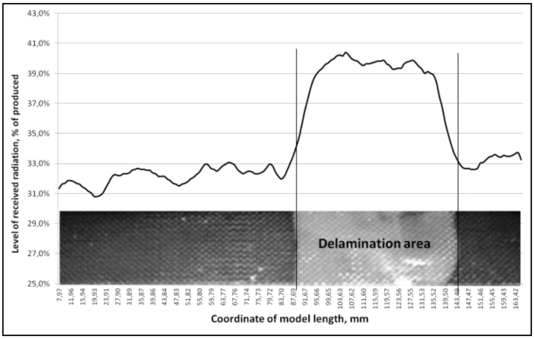


Fig. 2. Monitoring results represented by the graph.

While measuring of diagnostic signal at painted model it is found out that the total decreasing of diagnostic parameter value is by 10% lower comparatively with unpainted model. The proportion of signal level is kept as in the damage-free area and defective area. This proves the possibility of testing over the painted surface.

Conclusions

The principal possibility to apply the infrared pulse-echo inspection to control airframe elements, made of polymeric composite materials, is shown. The proposed device offers the possibility not only to detect the defect but also to determine the boundaries of defective area. The held background researches show that it is possible to apply the given method to detect PCM defects regardless of paint coat presence over the surface.

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UDC 621.314; 621.391

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Diagnosing of designs elements of the aircraft

Elements of methodology of technical diagnosing of mechanical systems. Technical diagnosis is a basis for ensuring safety of the aircraft.

The basic purpose of technical diagnosing consists of reliability increase of the aircraft at a stage of its operation, and also in prevention of decrease in indicators of quality at a fabrication stage of the plane and its components. Safety is ensured by improvement of such indicators, as an availability quotient, coefficient of technical use, maintenance time, and also a resource and a time between failures or time between failures for reservation of objects with restoration.

Problems of diagnosing are establishment of technical condition, working capacity both necessary functioning the aircraft and elements making it, and also search of defects which influence these characteristics. Definition of technical condition of mechanical systems is carried out by different means – hardware or program; the person operator, the controler, can act as diagnostic devices. Means and object of diagnosing which interact among themselves, form diagnosing system. Distinguish systems of test and functional diagnosing. Respectively these systems are necessary for definition of indicators of quality, and also for search of defects which influence them.

Study of the physical properties of objects and possible defects in them are very specific and not amenable to generalization through some big difference between classes of objects of the aircraft. As a result, a certain set list of defects that are to be identified or the search in terms of production and operation, as well as determine the signs identifying these defects. In forming the list reflect the experience of production and operation of the aircraft, the statistics of defects, etc.

Construction of algorithms for functional diagnosis is to determine the operating conditions means that implement these algorithms. Means for functional diagnosis is usually mounted to the object and are often called diagnosing unit built control means, and during normal operation of the object for its intended purpose it provides a constant and change the signal values at their inappropriate normal operation.

Efficiency of the processes of diagnosis is determined not only by the quality of algorithms, but also the quality of diagnostics tools. They can be hardware or software, or the built in external, manual, automated or automatic, specialized or universal.

Due to the lack of regular and economic methods for improving controllability of objects are widely used in practice, informal recommendations that facilitate the diagnosis objects.

Determine the technical state of the aircraft is engaged in three ways.

First - defining the technical conditions in which the object is currently time.

Second - foresight technical condition, in which the object could be some time (weather).

Third - the establishment of a technical condition, which has been located in the past.

Features diagnosis associated with features of composite aircraft. Customary to distinguish two classes of components: digital and analog. To account for the first class tests, compilation of test is to find such a collection or sequence of input actions that serve the object of diagnosis. Answers to these actions, which are obtained in the specified control points allow to conclude the technical condition. For the second class up logic models and graphics causality. These models are useful in cases when the diagnosis is possible to organize the principles of tolerance control parameters object. Organization of functional diagnosis for discrete and analog components depends on the characteristics of the aircraft.

Sensors of communication lines are a part of onboard systems, the processing device and the analysis of size of measured (controlled) parameters. Besides, special devices which visualize diagnostic information, and means of indication of general purpose of the aircraft concern them.

Diagnostic parameters which measure, choose from a set of basic and possible parameters of some limited quantity for research of informational content of the signs created on them. The nomenclature of diagnostic parameters is regulated by standard documentation on the AIRCRAFT.

The basis of logical procedure of the diagnosis is made by a set of physical parameters: geometrical, thermal, acoustic, electric, magnetic, mechanical, thermal, optical, electromagnetic, ionizing radiation, structure, structure, and as complex effects and universal physical constants, etc. The number of physical parameters doesn't exceed 200. The greatest practical interest is represented by parameters of making elements which influence the AIRCRAFT safety and which are in functional dependence on measured physical quantities.

Measurement of physical parameters is the basis for different methods and means of technical diagnosing of mechanical aircraft systems. They include:

- Methods and means of inspection;
- Electron microscopy;
- Separators solid particles;
- Measuring devices stabilizer concentration cooler;
- Satellite telemetry;
- Meters fatigue failure;
- Toxic gas detectors and the installation control of the fuel gas mixtures;
- Diffuse adsorption sensors;
- Detectors outflows;
- Fhysico-chemical analysis of lubricants;
- Detectors and instruments shock pulses;
- Spectrum analyzers, vibration and noise;
- The methods of monitoring and diagnosing the wear;
- Cyclonic separators solids

In this more detail study in the basic physical methods of nondestructive testing are to detect defects such as discontinuity, heterogeneity, the stress-strain state and properties of materials, products aircraft.

Features of determining the technical state of flaw detection methods

The best foreign and domestic practices show that for ensuring reliability of aviation designs of work on defectoscopy begin at a design stage. Thus:

- define the nomenclature of details and knots which are subject to defectoscopy;
- define frequency of testing in operation;
- provide a controleprigodnost of details;
- establish criteria of rejection of details at operation and repair;
- choose and recommend testing methods of details for service conditions and repair;
- develop (in need of) system of complex testing of the most loaded and responsible details.

The experience shows that the majority of details and knots which positively passed tests, can collapse under operating conditions. For them carry out an expert assessment of reliability of formation of cracks and destruction. During an assessment reveal the details which destruction can lead to emergency or catastrophic consequences. On the basis of these data make lists of details and knots which demand testing: one - for service conditions, others - for repair. During operation both lists specify taking into account statistical data on defects. Such order is optimum, nevertheless it often isn't applied due to the lack of regulating documents.

Method of testing chosen for each detail. The selection is made in two stages. At the first stage into account the type and nature of the expected defects, material items, and other factors are taken into account. In the second step - determine the most effective method. According to the results of the control method of choice in some cases need to finalize designs for testability, to avoid mistakes in choosing the method of control used by various programs.

Successful solutions to complex problems in the control conditions are possible by using modern information systems during maintenance. Modern maintenance systems are based on programs that are developed for each type of aircraft. This program consists of two groups of work: planned and unplanned. Planned work is performed at specified intervals. Taking into account unplanned set of fault messages should analyze information about the performance of the machine, site, or system;

Programs are developed by stepwise method of logical analysis and guided by rational work (including holding testing).

Modern programs include damage detection period, which corresponds to the length of time during which the fatigue crack grows to maximum (critical) size. Meet modern requirements and zonal inspection program. Zonal inspection intervals, where possible, should coincide with the interval form of routine maintenance.

Aviation requirements define the main tasks of NDT methods for maintenance and repair. The level and quality testing are determined in accordance with the certification requirements for quality testing in the process of aircraft maintenance, which provide a uniform procedure for the use of methods and means of testing.

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Inverter solar panel control by the criterion of maximum generated power

This research is devoted to the definition of extreme control approaches of single-stage solar panel inverter. Principles of the automatic control theory, converter technology, alternative energy are used in this research. Control approach, which provides the maximum power output from the solar battery at a different light levels is defined.

In recent years, the share of electricity generated by solar panels is growing. This is due primarily to a decrease in production cost of one kilowatt of solar power. According to experts in 2020 the cost of electricity production using solar modules will be equal to the cost of electricity production using traditional techniques.

Currently more and more popularity gaining the use of local low-power solar panels that provide electric power supply of household appliances, battery charging and energy return to the network. Such systems do not require significant maintenance costs and specially allocated land for the installation [1].

To solve the problem of effective use of such solar panels converters with maximum power selection function are used [2]. These devices convert the direct current of the solar panel into alternating current coinciding in shape and phase with the network voltage. Such converters typically have a two-stage structure which includes: DC-DC-converter and a DC-AC-converter (Fig 1). The control unit provides selection of the maximum power from the solar panel and the generated current synchronization with the network voltage [2,3].

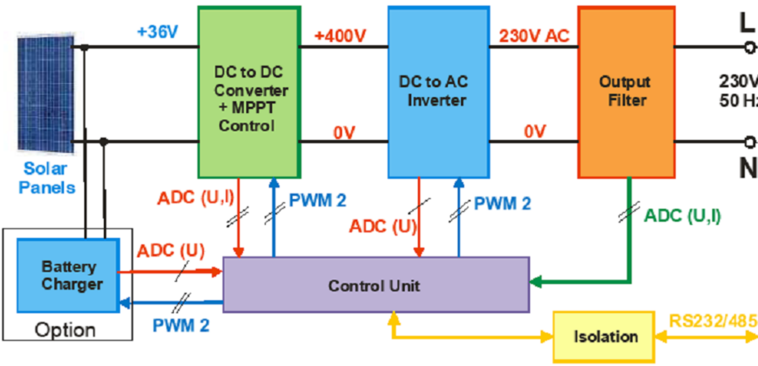

Fig. 1. The structure of the two-stage converter for solar battery

However, these systems have a number of disadvantages, among which should be highlighted: the presence of high voltage sections, decrease in efficiency due to the two-stage construction and relatively high cost. In connection with this perspective solution is a single stage circuit, which is a low voltage tracking transistor inverter with high-frequency pulse modulation and forced output current formation [4] (fig.2).

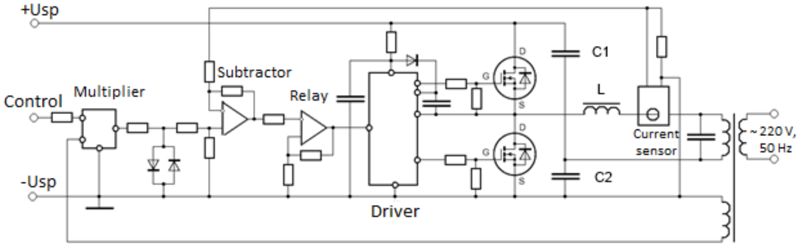

Fig. 2. The structure of the jne-stage converter for solar battery

Formation of the output current is carried out using a switching method – when the inductance current actual value deviates from the required value by a predetermined value, it is corrected by switching of one or other transistor. The reference signal shape and phase coincides with the network voltage and its amplitude determines the power level of electric energy given by the solar panel to the network. The formation of this signal is performed by an analog multiplier, one input of which a signal proportional to the network voltage and the second input - a signal from the control device.

When controlling such a system it should be taken into account that the dependence of the power generated from the solar panel voltage is non-linear and has a definite extreme. Furthermore, depending from the brightness level this curve changes (fig. 3).

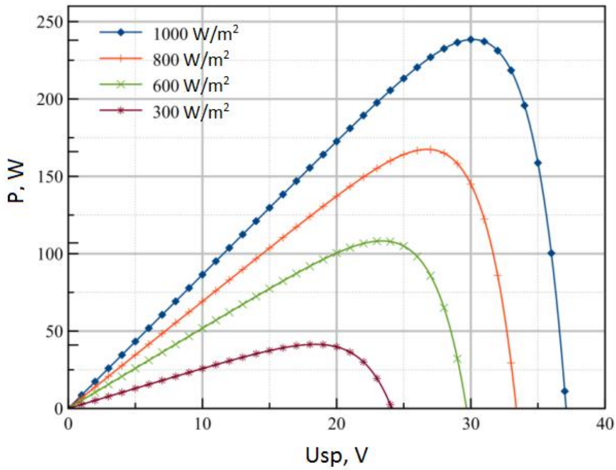

Fig. 3. Dependence of the generated power from the voltage and brightness

Given that the change in light level may occur at any time, in this system it is expedient to use search algorithms [5]. The essence of these algorithms is the incremental change in the control signal and monitoring of the controlled variable, in this case - power. Given the nature of the construction of the considered inverter control process should be carried discretely in a strictly defined points in time. The implementation of the relay method for controlling the output current of the inverter allows to choose the operating point at the solar battery IV characteristic by changing the inverter current reference signal. This control principle is shown in Figure 4.

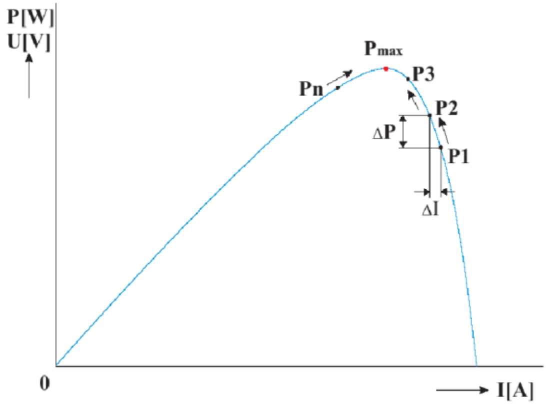

Fig. 4. The search algorithm for operation point of the solar cell

To implement this approach to management it is necessary to choose the search step. Selecting too small step will lead to a long-term transients in finding extremum point and too big step would lead to unstable operation of the system in steady state. Given that the system should work with a wide range of current changes, it is advisable to change the search step from a large value to a small while approaching to the extremum point. Moreover it should be considered not only increment of power, but also the increment of the solar battery current and voltage changes. Taking into account all of these factors the expression for control of the search step will be:

$$\Delta U_{I\,control} = \frac{\Delta P}{|\Delta I_{SP}|} \cdot (-sign(\Delta U_{SP})) \cdot k$$

With such a control step value will be greatest when moving to the maximum power point, and will be minimum in the vicinity of this point. Calculation of the changes in the generated power output of the system at steady state at different light levels is shown in fig. 5.

As shown, the generated power increases to a value almost equal to the maximum and then maintained at this level. At the same time power oscillations are present in the vicinity of the maximum power point. The magnitude of these oscillations can be reduced by reducing the maximum value of the control signal increment, but this will increase the duration of the transient. The maximum deviation of the power generated from the highest possible value in the quasi-steady mode does not exceed 2.1%.

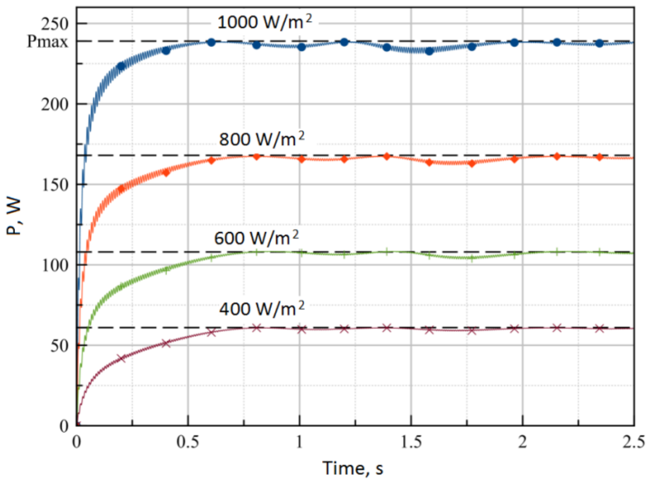

Fig. 5. Graph of generated power changes

It should be noted that the nature of the transition process is identical for all light levels. This indicates the correctness of the used approach to control.

Conclusion: As a result of studies, it was found that for the solar battery inverter control by the criterion of maximum generated power it is reasonable to use search algorithms. Search step of these algorithms should decrease as it approaches the maximum generated power, and at the same time it should be taken into account solar battery current and voltage changes.

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Noise method of temperature measuring with correlation processing of noise signal

Construction of noise thermometer has been improved that allowed to increase the accuracy of temperature measurement by implementing the correlation processing of noise signal.

In the noise thermometers the thermal noise generated by the resistive element has quite low intensity so it requires amplification to the level that is necessary to measure such noise. In order to reduce the influence of amplifiers own noise on the measurement results the correlation methods are widely used to select the useful (informational) noise from the interference. In this case two independent amplifiers are used. Output signals from the amplifiers are multiplied and averaged. The averaging of product of two independent random signals which are the own noises of amplifiers allows to reduce them to zero [1]. But because of disidentity of amplifiers parameters and presence of correlated noise it is impossible to reduce the influence of amplifiers own noise completely. That is the reason why the noise thermometers continue to improve.

Existing noise correlation thermometers [2, 3] has errors caused by the influence of amplifiers own noise and zero drift of multiplier on the measurement results. According to this it is necessary to improve the existing noise thermometers.

Adding to the noise correlation thermometer [4] some new elements, such as resonance circuit that consists of successively connected capacitor and inductor provides the selection of thermal noise in desired bandwidth. Automatic switch allows to change polarity of one of multiplied voltages that makes the output voltage obtained from multiplying of correlated thermal noise voltages alternate. Successively connected low frequency selective amplifier, phase-sensitive rectifier and secondary low frequency filter provides the selection of alternate voltage at the output of the first amplifier that allows to divide the interference from the informative signal, proportional to the product of thermal noise voltages multiplying. Low frequency generator provides the periodic work of automatic switch and synchronous work of phase-sensitive rectifier that allows to increase the measurement accuracy and interference resistance of proposed thermometer.

The electrical functional scheme of noise correlation thermometer is shown in figure 1.

Resistive element 1 is placed in the area of measured temperature. Successively connected capacitor 2 and inductor 3 forms the successive resonance circuit connected to the leads of resistive element. The leads of resonance circuit are connected through the separating capacitors4 and 5 and automatic switch 6, controlled by the low frequency generator 7, to the input leads of selective amplifiers 8 and 9. Low potential input leads of amplifiers are connected to the common ground 10.Output leads of amplifiers are connected to the multiplier 11 with the output lead connected to the low frequency filter. The output lead of the low frequency filter is successively connected with the low frequency selective amplifier 13, phase-sensitive rectifier 14, secondary low frequency filter 15 and voltage to current converter 16. Symmetric outputs of voltage to current converter a connected to the leads of resistive element 1 and voltmeter 17.Low frequency generator 7 is connected to the control lead of automatic switch 6 and phase-sensitive amplifier 14.

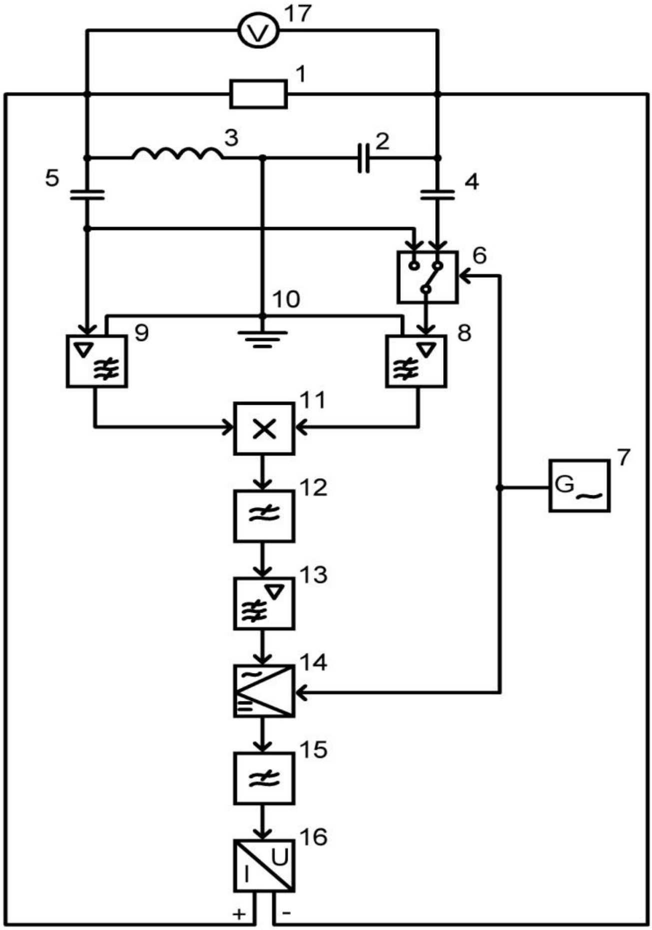

Fig. 1. Electrical functional scheme of noise correlation thermometer.

Resistive element, heated to the measured temperature T_x, because of electric charge carriers (electrons, ions, holes) fluctuation generates the thermal noise.

Selection of thermal noise from the non-thermal and interference noise in the determined bandwidth performed by the resonance circuit.

Resonance frequency is chosen in the 50-100 kHz range with the 10-15 kHz bandwidth because the flicker-noise is absent in such frequency range and the electromagnetic interference level is low.

Voltage drops from thermal noise current will be the voltages with different polarity.

These voltage drops are narrow bandwidth anti-phase random signals with central frequencyf_0. These voltages are amplified in turns by the selective amplifier 8 with the help of automatic switch 6.First voltage also constantly amplified by the selective amplifier 9 with the same central frequency. Low potential inputs of selective amplifiers 8 and 9 are connected to the common ground 10 in order to provide the separate amplification of noise signals.

In the position of automatic switch 6 that shown in fig. 1, voltages, amplified by the selective amplifiers 8 and 9 have different polarity and are mutually correlated. At the same time own noises of selective amplifiers 8 and 9 are also amplified. These noises are significantly correlated due to the narrow bandwidth. As the result of multiplying of correlated voltages with different polarity and averaging it by the low frequencies filter 12 the negative polarity DC voltage is formed.

Except from the useful signal there is an interference in the form of constant component from the multiplying of correlated own noise of selective amplifiers 8 and 9 and from the zero displacement of multiplier 11. Considering the voltage drops before the amplification and multiplying the resulting voltage at the output of low frequencies filter 12 can be represented as the sum of DC voltages.

In the opposite position of automatic switch 6 on the inputs of the multiplier 11 there is the same amplified voltage drop. As the result of multiplying and averaging the positive polarity DC voltage with the same interference is firmed.

With the periodic work of automatic switch 6, controlled by the low frequency voltage from generator 7, polarity of informative component of voltage periodically changes and the polarity of interference from correlated own noises of selective amplifiers 8 and 9 ant the interference from zero displacement of multiplier 11 remains constant. It allows to select the AC component from output voltage of low frequency filter 12 with the low frequency selective amplifier 13 set to the frequency of generator 7.The operating frequency of automatic switch 6 is 30 – 40 Hz.

Amplified AC voltage is the sine voltage with low frequency.

AC voltage is rectified by the phase-sensitive rectifier 14 and smoothed by the secondary low frequency filter 15. DC voltage from the secondary low frequency filter 15 comes to the converter 16 and transforms into the DC current.

In order to reduce the influence of resistance R instability of sensitive element 1 on the result of temperature measurement T_x the DC current is passed through the resistive element 1 and the voltage drop on it is measured.

Voltage drop on the resistive element 1 is measured by the voltmeter 17 that is proportional to the measured temperature T_x, and does not depend on the resistance of the resistive element 1, the own noises of selective amplifiers 8 and 9 and zero displacement of multiplier 11.

Graduation of noise correlation thermometer that have the linear conversion function can be done by single known temperature value during the calibration process.

Conclusions

Removing the influence of interference and and non-informative noise allows to increase the accuracy of temperature measurement especially for low temperatures when thermal noise of resistive element is commensurate with the own noise of selective amplifiers.

Removing the influence of resistance instability of resistive element on the temperature measurement results allows to increase accuracy of measuring high temperatures either when the resistive element degrades (oxidation, evaporation, structural changes), and in accordance its resistance changes uncontrollably.

Connection of serial resonance circuit to the resistive element allows to select the thermal noise current without the low impedance electronic current to voltage converters which have significant own noises. It allows to increase the accuracy of measurement of medium temperatures where the comparably low impedance resistive elements are used.

Instead of resistive element can be used any conductive part of equipment located in the area of measured temperature and connected to the resonance circuit.

Described advantages of proposed noise correlation thermometer allows to reduce the measurement error up to 0,1 Kin wide temperature range.

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Neural network model of evaluating the timeliness of desicion-making during simulator training

The prototype of neural network evaluating the timeliness and correctness of the decision-making by air traffic services specialist during the pre-simulator training has been developed.

Problem statement. Statistics data [1, 2] show us, that causality of aviation accidents didn't change over the past decade: 70-80% of accidents and disasters happened due human factor, and only 15-20% – through constructive and productive deficiencies of the aircraft. Quality training of aviation experts, including specialists in air traffic services (ATS), occupied important part in reducing influence of the human factor. Simulator training is an important part of training of air traffic controllers. The aim of training is to improve air traffic controller's (ATC) work and refinement practical skills of ATS in standard situations, potentially conflict situations (PCS), in the special conditions and in the special cases in flight. According to the recommendations of Eurocontrol and to optimize effectiveness of simulator training, theoretical and practical training combine from the beginning of the training process preparation using the system pre-simulator training. The process of learning starts with getting skills by cadet's / listeners (SA – skill acquisition), then practice the performance of particular tasks (PTP – part-task practice) and continue simulator training [2].

The correctness is the main criterion for evaluating the quality of the exercises [3, 4]. The timeliness is another important criterion for evaluating the quality of the exercises. Take into account as correctness as timeliness can be done with the help of artificial neural networks (ANN). Automation of process verification exercise can reduce the time for its preparation (saving up to 80% of the time).

Hybrid neural-expert system is a perspective direction of development of a neuron-information technologies [5]. ANN have many advantages compared to traditions and knowledge-based of diagnostic systems. It can be trained on examples, work in real-time, secure and tolerant to errors. With the help of ANN diagnoses state of the patient, performs the prediction on the stock market, makes decision on granting the loan, diagnoses condition of equipment, guided operation of the engine, etc [5].

The purpose of the publication is to development of neural network model for evaluation the timeliness and correctness of decision-making (DM) by ATC during performance of exercises in the simulator training through pre-training studying.

Main part. To automate the evaluation of pre-training stage of initial training of air traffic controllers at the stage of learning pre-training studying had been done multilayer perceptron networks (MPN), which has four layers, two of which are hidden. Each neuron characterized by the input value (dendrite) and output value (axon), weight coefficients (synapses), threshold function. The network has additional inputs, called the Bias (offset) that takes into account additional restrictions on calculating parameters:

$$\sum_{i=1}^{n} w_i x_i - \theta \geq 0 ,$$

where w_i – weight coefficients;

x_i – neural network inputs;

$\bar{\theta}$ – Bias (shift).

General view of the ANN shown in fig. 1:

$$\bar{Y} = f(\overline{net} - \bar{\theta}) ,$$

where f – non-linear function (active function);

$\overline{net}$ – weighted sum of inputs.

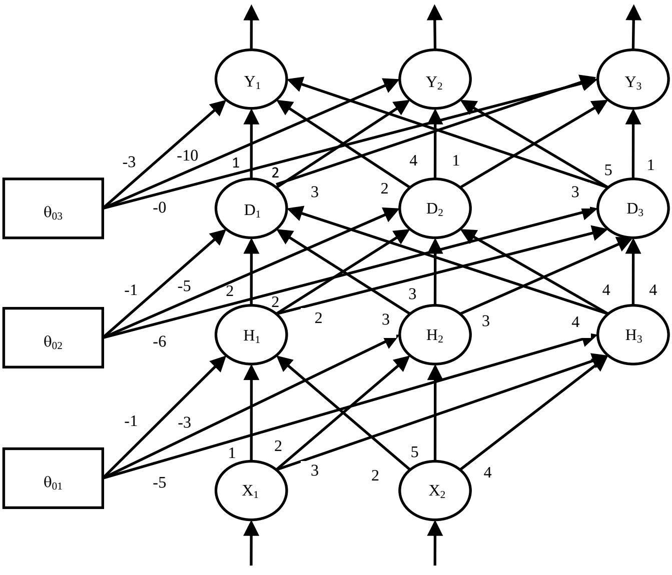

Fig. 1. Example of ANN when three cadets / listeners perform two tasks

Characteristics of ANN's layers: 1 layer (input) – exercises that perform cadets / listeners to solve PCS ($\bar{X}$); 2 layer (hidden) – defines the physiological characteristics of cadets / listeners ($\bar{H}$); 3 layer (hidden) – the complexity of the exercise, which is determined by the number of PCS ($\bar{D}$); 4 layer (output) – assessment of cadets / listeners during performance of exercises ($\bar{Y}$).

Consider in more detail the topology of the neural network as an example, if three cadets / listeners (Y_1, Y_2, Y_3) perform two tasks (X_1 and X_2). 1 layer (input) – inputs x_1, x_2, ..., x_n – meet the objectives that perform by cadets / listeners to solve PCS ($\overline{X}$); 2 layer (hidden) – defines the physiological characteristics of cadet / listener ($\overline{H}$) using additional input Bias, which specifies limits on individual solving exercises (T_{01}). The output vector layer:

$$\overline{H} = f(\overline{W}_1, \overline{X}) = f(\overline{net}_1 - \overline{\theta}_{01}),$$

where $\overline{net}_1 = \overline{W}_1 \overline{X}$;

$\overline{W}_1$ – weight coefficients, for example for studying situation when two exercises doing by three cadet's / listener's:

$$\overline{W}_1 = \begin{pmatrix} w_{01} & w_{11} & w_{21} \\ w_{02} & w_{12} & w_{22} \\ w_{03} & w_{13} & w_{23} \end{pmatrix};$$

$\overline{\theta}_{01}$ – time to solve individual training exercises.

3 layer (hidden) – the complexity of the exercise, which is determined by the number of PCS ($\overline{D}$) and characterized by dynamic air situation. Auxiliary input Bias indicates the total limit time for resolving PCS (T_{02}).

The output vector layer: $\overline{D} = f(\overline{W}_2, \overline{H}) = f(\overline{net}_2 - \overline{\theta}_{02})$,

where $\overline{net}_2 = \overline{W}_2 \overline{H}$;

$\overline{W}_2$ – weight coefficients, which taking into account the complexity of dynamic air situation (fig. 1):

$$\overline{W}_2 = \begin{pmatrix} d_{01} & d_{11} & d_{21} \\ d_{02} & d_{12} & d_{22} \\ d_{03} & d_{13} & d_{23} \end{pmatrix};$$

$\overline{\theta}_{02}$ – time to solve training exercise that takes into account the complexity of the dynamic air situation.

4 layer (output) – directly assessment of cadet / listener during performance of exercises ($\overline{Y}$). Auxiliary input Bias limits the number of attempts for solving the PCS (T_{03}). The output vector layer:

$$\overline{Y} = f(\overline{W}_3, \overline{D}) = f(\overline{net}_3 - \overline{\theta}_{03}),$$

where $\overline{net}_3 = \overline{W}_3 \overline{D}$;

$\overline{W}_3$ – weight coefficients, taking into account the quality of the exercise by the timeliness:

$$\overline{W}_3 = \begin{pmatrix} y_{01} & y_{11} & y_{21} \\ y_{02} & y_{12} & y_{22} \\ y_{03} & y_{13} & y_{23} \end{pmatrix};$$

$\bar{\theta}_{03}$ – attempts to solve exercises.

Provides the following outputs vectors layers of neurons $\overline{H}$, $\overline{D}$, $\overline{Y}$:

$$H_i D_k Y_m = \begin{cases} 1; f(x) > 0 \\ 0; f(x) \le 0 \end{cases},$$

where f – non-linear function of activation.

Consider the following set of values of weight coefficients ($\overline{W} = \overline{W}_1, \overline{W}_2, \overline{W}_3$), that take into account the performance of individual training exercises by cadet / listener depending on the physiological characteristics, complexity dynamic air situation, the quality of the exercise according to the timeliness:

$$\begin{cases} H_1 = f(1x_1 + 2x_2 - 1) \\ H_2 = f(2x_1 + 5x_2 - 3) \\ H_3 = f(3x_1 + 4x_2 - 5) \\ D_1 = f(2d_1 + 2d_2 + 2d_3 - 1) \\ D_2 = f(3d_1 + 3d_2 + 3d_3 - 5) \\ D_3 = f(4d_1 + 4d_2 + 4d_3 - 6) \\ Y_1 = f(1y_1 + 3y_2 + 2y_3 - 3) \\ Y_2 = f(2y_1 + 4y_2 + 1y_3 - 10) \\ Y_3 = f(3y_1 + 5y_2 + 1y_3 - 0) \end{cases}$$

Present an example in vector form:

$$\begin{cases} \begin{pmatrix} 1 \\ H_1 \\ H_2 \\ H_3 \end{pmatrix} = f\left[\begin{pmatrix} 1 & 0 & 0 \\ 1 & 2 & -1 \\ 2 & 5 & -3 \\ 3 & 4 & -5 \end{pmatrix} * \begin{pmatrix} 1 \\ X_1 \\ X_2 \end{pmatrix}\right] \\ \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \end{pmatrix} = f\left[\begin{pmatrix} 1 & 0 & 0 & 0 \\ 1 & 3 & 2 & -3 \\ 2 & 4 & 1 & -10 \\ 3 & 5 & 1 & 0 \end{pmatrix} * \begin{pmatrix} 1 \\ D_1 \\ D_2 \\ D_3 \end{pmatrix}\right] \\ \begin{pmatrix} 1 \\ D_1 \\ D_2 \\ D_3 \end{pmatrix} = f\left[\begin{pmatrix} 1 & 0 & 0 & 0 \\ 2 & 2 & 2 & -1 \\ 3 & 3 & 3 & -5 \\ 4 & 4 & 4 & -6 \end{pmatrix} * \begin{pmatrix} 1 \\ H_1 \\ H_2 \\ H_3 \end{pmatrix}\right] \end{cases}$$

The result of the functioning with different initial data (X = (0;0), (0;1), (1;0), (1;1)), taking into account the coefficients and conditions of performed exercises (time, attempts, characteristics of cadet / listener), are as follows (table 1).

Table 1

Results of functioning ANN

X_1	X_2	H_1	H_2	H_3	D_1	D_2	D_3	Y_1	Y_2	Y_3
0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	1	0	0	0	1	1
1	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	0	1

In general, ANN can be represented as follows: $\overline{H} = f(\overline{W}_1, \overline{X})$; $\overline{D} = f(\overline{W}_2, \overline{H})$; $\overline{Y} = f(\overline{W}_3, \overline{D})$. From the equations, we've get definition of 4-leyer ANN: $\overline{Y} = f(W_1 f(W_2 f(W_3(\overline{X}))))$,

where $\overline{X}$ – network input vector (exercises);

$\overline{W}$ – coefficient of individual cadet's/listener's characteristics. For example, for vector $\overline{H}$, which determines the physiological characteristics of cadet / listener, we have: H_1 №1 – w_{11}, w_{21} – coefficient, which characterized by ability of cadet / listener №1; H_2 №2 – w_{12}, w_{22} – coefficient, which characterized by ability of cadet / listener №2; H_3 №3 – w_{13}, w_{23} – coefficient, which characterized by ability of cadet / listener №3.

The table 1 shown, that during performance of exercise №2 ($X_2 = 1$) cadet / listener №2 and №3 completed the task on time (№1 – not complied). During resolving of exercise №1 – nobody completed the task. During simultaneously performing of 2 tasks ($X_1 = 1$, $X_2 = 1$) completed the task cadets / listeners №1 and №3, and №2 – not coped with the task.

Conclusion

The correctness and timeliness are the main criterions for evaluating the quality of performance simulator exercises. With the help of using artificial neural networks it take into account. For building ANN according to the provisions of the basic concepts of control factors of threats and errors, classified stages of the developing conflict situation and defined quantitative indicators of the complexity level at each stage using fuzzy logic. Developed neural network models of assessment the timeliness and correctness of the decision-making by specialist of ATS in the simulator training and defined its parameters.

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Method of selecting the corrective devices of automatic control systems

The algorithms for calculating the logarithmic frequency characteristics of serial and parallel corrective devices of automatic control systems are received.

The generalized structural scheme of the automatic control system (ACS) is shown at the Fig.1.

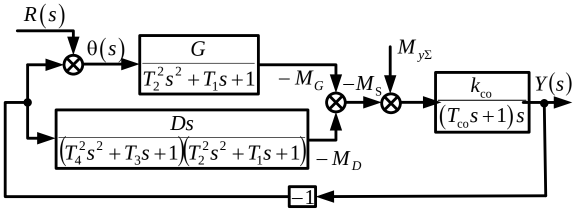

Fig. 1. The structural scheme of the stabilization system

The following designations are accepted in structural scheme: $W_{co}(s) = \frac{k_{co}}{(T_{co}s+1)}$ is the transfer function of a control object; $G = k_{ds}k_{reg}$ is the stiffness of a system which is considered by the gain coefficient of the deflection sensor k_{ds} and the regulator k_{reg}; $D = k_{sds}k_{reg}$ is the damping of a system which is considered by the gain coefficient of the speed deflection sensor k_{sds} and regulator k_{reg}; $M_{y\Sigma}(s)$ is the total disturbing moment which impacts on the control object; M_s is the moment of stabilization; $R(s)$ is the control signal.

The illustrated structural scheme does not always allow to obtain the required quality of the control processes at the selected design parameters of elements. Besides feedback by the absolute angular velocity of the control object into the structure of the regulator of the ACS are usually introduced an additional parallel and serial corrective devices to ensure a given quality.

The main difficulty when choosing the corrective devices for automatic control systems consists in determining their frequency characteristics.

Parallel corrective devices are implemented as rigid and flexible feedbacks covering an element, a chain of elements or the entire system. Hard negative feedbacks are used relatively rarely for the correction of quality. This is because that the introduction of negative rigid feedback, providing speed increasing and expansion of the linearity zone, at the same time reduces the transfer coefficient of the covered element or the chain of elements. As a result - increasing of the control errors. The most widely for the purposes of quality correction are applied the flexible feedbacks - feedbacks from the derived output value of the element (a chain of elements) or system. Since the flexible feedbacks are acting only during the transients, their introduction allows to correct the quality of governance without changing the static properties of the system.

In general, the inverse transfer function of the open-loop system, adjusted by the ideal differentiating feedbacks, has the form:

$$E_{\text{ol}}^{(\text{c})}(s) = E_{\text{ol}}(s) + k_1 s + k_2 s^2 + k_3 s^3 + \ldots, \quad (1)$$

where $E_{\text{ol}}(s)$ is the inverse transfer function of the system, that is not corrected; $k_1, k_2, k_3, \ldots$ are coefficients of flexible feedback of the corresponding order by dimension second.

Inverse amplitude and phase frequency characteristic (APFC) of the corrected system according to equation (1) will be:

$$E_{\text{ol}}^{(\text{c})}(j\omega) = U_E^{(\text{c})}(\omega) + jV_E^{(\text{c})}(\omega),$$

where

$$U_E^{(\text{c})}(\omega) = U_E(\omega) - k_2\omega^2 + k_4\omega^4 - \ldots;$$

$$V_E^{(\text{c})}(\omega) = V_E(\omega) + k_{1\partial}\omega - k_3\omega^3 + \ldots .$$

Therefore, the coordinates of each point of the original characteristic $E_{\text{ol}}(j\omega)$ with the introduction of flexible feedbacks acquire an increments

$$\Delta U_E(\omega) = -k_2\omega^2 + k_4\omega^4 - \ldots ,$$

$$\Delta V_E(\omega) = k_1\omega - k_3\omega^3 + \ldots ,$$

and the whole characteristic is shifted on the plane $U_E(\omega) \to jV_E(\omega)$.

Fig. 2 shows the feedback APFC deformation of the open loop system when introduced the four first derivatives of control value.

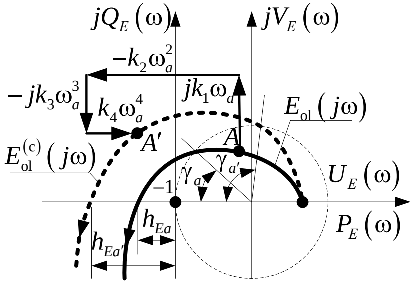

Fig. 2. The offset of the point of inverse APFC of the open-loop system $E_{\text{ol}}(j\omega)$, when flexible feedbacks are introduced

Effect of flexible feedbacks by the first and third derivatives so as the effect of the feedbacks by the second and fourth derivatives are mutually opposite. Feedbacks by the third and fourth derivatives have a little effect on the initial (low frequency) part of the characteristic and significantly distort its high-frequency part.

In the ACS of inertial control objects, operating on a movable base, the forced oscillations have a low frequency spectrum, depending on the perturbation and control signals. Therefore, for correction the quality generally are used the feedbacks by the first two derivatives - by speed and by acceleration of the control object.

Application of the feedback by the first derivative (by the velocity) increases the stability margins in modulus $h_{Ea'} > h_{Ea}$ and phase $\gamma_{a'} > \gamma_a$, shifting up (Fig, 2) the characteristic $E_{\text{ol}}(j\omega)$. It is necessary to mean that in this case the tracking error is increases.

Application of the feedback by the second derivative (by the acceleration) increases the stability margin in modulus, but reduces the stability margin in phase, since the characteristic $E_{\text{ol}}(j\omega)$ is shifting to the left due to the component $-k_2\omega^2$. In this case the stability region is expanding, but at the same time increases the transient recovery time. This demonstrate, in particular, a decreasing of the frequency ω_{p} of the positiveness of characteristic $P(\omega)$, with which the transient recovery time related by the ratio $t_{\text{tr}} > \pi/\omega_{\text{p}}$.

What was said above should be considered when selecting the type of flexible correcting feedback in ACS.

Serial corrective devices are usually realized in the form of differentiating or integro-differentiating passive DC circuits. The differentiating circuits along with the expansion of the area of stability of the system improve its action in time, providing the forcing of transients.

Fig. 3 shows the effect from the sequential correction circuit (SCC) on the region of stability of the stabilization system. SCC moves to the right the low-frequency stability border, thus enabling to regulate the system on a larger stiffness. In the same figure is compared the ideal and the real differentiating circuits. Comparison demonstrates that the non-ideality of the differentiating circuit reduces its impact on the effectiveness of the system.

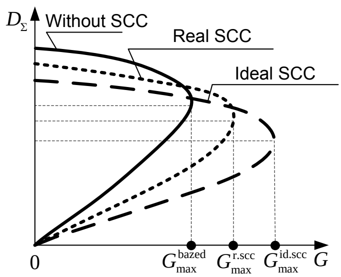

Fig. 3. Impact of SCC on the stability region

Raising the margin of stability of the system while simultaneously forcing of the transients - important advantage of the successive differentiating contours. The widespread use of these contours for the correction the quality of system is also caused by the simplicity of their constructive realization.

The main disadvantages of the successive differentiating contours include:

• significant (by 10 times or more) reduction of the amplification coefficient of stabilization system, requiring a corresponding increase in the transfer coefficients of other units or the introduction of special amplifiers;

• high sensitivity to interference (noises);

• the difficulty of implementing of contours for AC control signals and therefore the necessity to have in the system the phase-sensitive amplifiers.

Much less often differentiating circuits apply the integrating SCC. Application of the integrating circuit (ideal) allows to increase an order of magnitude system astatism, but leads to deterioration of its stability.

In order to choose one or the other type of corrective device and determine its parameters, you must compare the original (uncorrected) system with the desired system. Comparisons are usually conducted on logarithmic amplitude and phase frequency characteristics.

When correction is serial transfer function of the desired (corrected) open-loop system will be equal to:

$$W_{\text{ol.des}}(s) = W_{\text{ol}}(s) W_{\text{c}}(s), \tag{2}$$

where $W_{\text{ol}}(s)$ is the transfer function of the original (uncorrected) system; $W_{\text{c}}(s)$ is the transfer function of SCC.

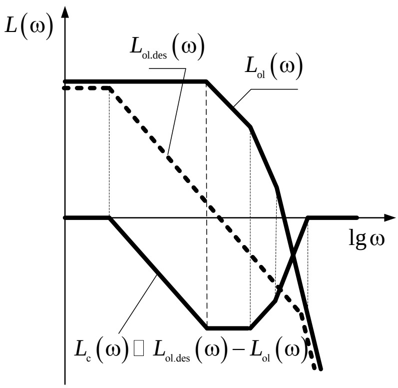

Fig. 4. LAFC determination of the correcting device

Hence the amplitude phase frequency characteristic of the correcting device can be determined from the from the relation:

$$W_{\text{c}}(j\omega) = \frac{W_{\text{ol.des}}(j\omega)}{W_{\text{ol}}(j\omega)}.$$

Proceeding to logarithmic and phase frequency characteristics, we have:

$$\left.\begin{aligned} L_{\text{c}}(\omega) &= L_{\text{ol.des}}(\omega) - L_{\text{ol}}(\omega); \\ \varphi_{\text{c}}(\omega) &= \varphi_{\text{ol.des}}(\omega) - \varphi_{\text{ol}}(\omega). \end{aligned}\right\} \tag{3}$$

Thus, the logarithmic and phase frequency characteristics of the serial correcting device determines as the difference between the desired and original characteristics. Typically, determination of $L_{\mathrm{c}}(\omega)$ is made graphically (Fig. 4).

In case of parallel correction, transfer function of desired (corrected) open-loop system will be

$$W_{\mathrm{ol.des}}(s)=\frac{W_{\mathrm{ol}}(s)}{1+W_{\mathrm{cov}}(s)W_{\mathrm{fbc}}(s)}, \tag{4}$$

where $W_{\mathrm{cov}}(s)$ is the transfer function of the elements, that are covered by the feedback correction; $W_{\mathrm{fbc}}(s)$ is the transfer function of the feedback correction.

Taking into account that by any method of correction must be obtained the same desirable characteristic, will equate (2) and (4), substituting $s=j\omega$:

$$W_{\mathrm{c}}(j\omega)=\frac{1}{1+W_{\mathrm{cov}}(j\omega)W_{\mathrm{fbc}}(j\omega)}. \tag{5}$$

For the frequency range in which

$$W_{\mathrm{cov}}(j\omega)W_{\mathrm{fbc}}(j\omega) \ll 1$$

correction is not required, since $W_{\mathrm{c}}(j\omega)\cong 1$.

For the frequency range when

$$W_{\mathrm{cov}}(j\omega)W_{\mathrm{fbc}}(j\omega) \gg 1$$

will have:

$$L_{\mathrm{c}}(\omega)=-\left[L_{\mathrm{cov}}(\omega)+L_{\mathrm{fbc}}(\omega)\right]. \tag{6}$$

Having defined by equation (3) the characteristic $L_{\mathrm{c}}(\omega)$ and knowing the characteristic $L_{\mathrm{cov}}(\omega)$, we can find:

$$L_{\mathrm{fbc}}(\omega)=-\left[L_{\mathrm{cov}}(\omega)+L_{\mathrm{c}}(\omega)\right]. \tag{7}$$

Using special tables, by known characteristics $L_{\mathrm{c}}(\omega)$ or $L_{\mathrm{fbc}}(\omega)$, it is possible to select the scheme and find the parameters of the serial or parallel correcting device

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Analysis of the potentiation digital-to-analog converter with accounting of imperfection of integrator

Potentiation digital-to-analog converter with iterative additive correction of errors is described. Analysis of errors of this converter with accounting of imperfection of integrator was produced. Basic expressions for the calculation of these errors are listed. The obtained equations conversion and carried out error analysis allow to create high-precision potentiation digital-to-analog converter.

Introduction. As is well known accurate measurement is essential in many fields, and all measurements are necessarily approximations, a great deal of effort must be taken to make measurements as accurate as possible. Accuracy in various information systems largely depends on the accuracy of measuring converters. Reduction of level of measuring converters error often plays a decisive role in solving the problem of creation of information systems such as automated information-measuring systems, automated control systems, pattern recognition, diagnosis or identification.

Problem statement. In works [1] and [2] the measuring converter offered by the author [3] has been considered. It is an iteratively integrating code-voltage converter with additive correction of errors. Analysis of errors of this converter due to no ideality of its units [1] and with accounting of imperfection of its blocks with the exception of integrator [2] was produced. This article deals with the analysis of errors of this converter with accounting of imperfection of integrator.

Main equations without taking into account of imperfection of blocks. The structural scheme of iteratively integrating code-voltage converter with additive correction of errors is shown in Figure. Here I is integrator; SH is sample-and-hold device; SW1 and SW2 are analog keys; RFG is reference frequency generator; CC1 and CC2 are code converters; CTIC1 and CTIC2 are converters of code into the time intervals; STI is shaper of time intervals; E_0 is reference voltage; $N = \lambda + \mu$ are the input code; U_{out} is output voltage; OC is output converter, BC is back converter.

The equation of transformation and the main equations for definition of errors of this measuring converter without no ideality of his components are given in work [1].

Output voltage value relative to a value of U_0, corresponding to input code $N = 0$ dB:

$$N\,(\text{dB}) = 20 \lg U_{out} / U_0.$$

Equation of converting of this potentiation converter:

$$U_{out} = U_0 10^{N/20}.$$

If the submit an input code N as the sum of two terms (for example, integers and tenths) $N = \lambda + \mu$, conversion equation can be transformed to:

$$U_{out} = U_0 10^{\lambda/20} / 10^{-\mu/20}.$$

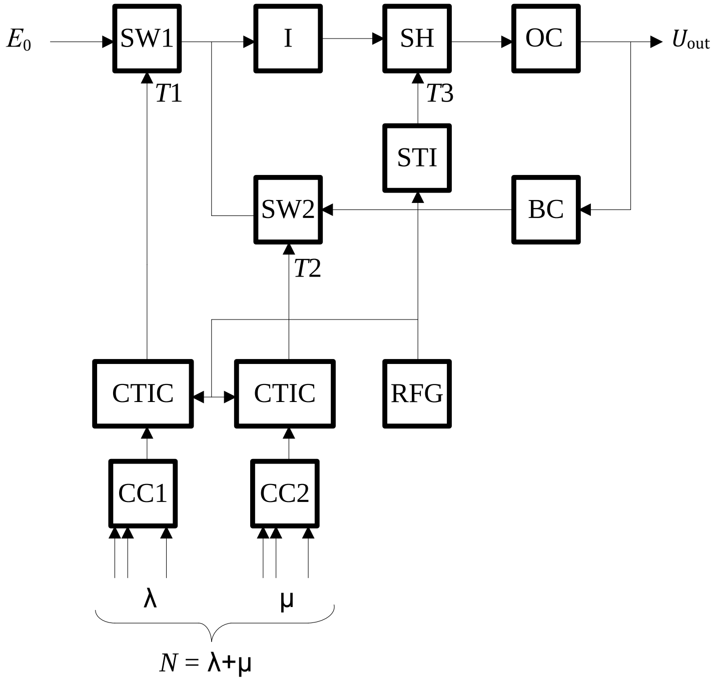

Figure. Potentiation digital-to-analog converter

After the ending of the first and second conversion cycles the output voltage U_{out} is equal to:

$$U_1 = (E_0 \lambda K_\lambda K_{SH} K_{RP} K_A / f_0 RC) - U_0 Q_H$$

and

$$U_2 = (E_0 \lambda K_\lambda K_{SH} K_{RP} K_A / f_0 RC)(1 - Q_H) - U_0 Q_H,$$

respectively, where: K_λ , K_μ, K_{SH} and K_{RP} , K_A , K_{VD} are transfer coefficients of the devices CC1, CC2, SH, OC and BC respectively, f_0 is reference frequency; R and C resistance and capacitance of integrator's resistor and capacitor respectively; and

$$Q_H = 1 - \mu K_\mu K_{SH} K_{RP} K_A K_{VD} / f_0 RC.$$

Output voltage of the code-voltage converter after the end of nth cycle; $j = \overline{1, n}$:

$$U_n = (E_0 \lambda K_\lambda K_{\mathrm{SH}} K_{\mathrm{RP}} K_{\mathrm{A}} \,/\, f_0 RC) \sum_{\mathrm{j=1}}^{n} Q_{\mathrm{H}}^{\mathrm{j-1}} - U_0 Q_{\mathrm{H}}^{n}$$

$$= \frac{E_0 \lambda K_\lambda}{\mu K_\mu K_{\mathrm{VD}}} (1 - Q_{\mathrm{H}}) - U_0 Q_{\mathrm{H}}^{n} = U_\infty - \Delta U Q_{\mathrm{H}}^{n}.$$

where U_n is output voltage of the code-voltage converter after the end of *n*th cycle; $j = \overline{1, n}.$

If the condition $|Q_{\mathrm{H}}| < 0$ is fulfilled, output voltage of the potentiation digital-to-analog converter at the steady-state condition ($n \to \infty$) is determined by the expression

$$U_\infty = \frac{E_0 \lambda K_\lambda}{\mu K_\mu K_{\mathrm{VD}}} = \frac{E_0}{K_{\mathrm{VD}}} 10^{(\lambda + \mu)/20},$$

where

$$K_\lambda = \frac{10^{\lambda/20}}{\lambda}, \qquad K_\mu = \frac{10^{-\mu/20}}{\mu}.$$

The relative error of conversion γ_n :

$$\gamma_n = \frac{U_n - U_\infty}{U_\infty} = \frac{\Delta U Q_{\mathrm{H}}^{n}}{U_\infty},$$

where $\Delta U = U_\infty - U_0$.

Number of cycles *n*, corresponding to this error γ_n:

$$n = \left[\frac{\ln \left| \dfrac{\gamma_n U_\infty}{\Delta U} \right|}{\ln |Q_{\mathrm{H}}|} \right] + 1.$$

Main equations with taking into account of imperfection of integrator. Basic expressions for the iteratively integrating code-voltage converter with additive correction of errors with taking into account of imperfection integrator are summarized in the Table (details of the derivation of these expressions can be found in work [4]).

Table

Basic expressions for the potentiating DAC with accounting of no ideality of integrator

$$U(t) = -\frac{U_0 T_L}{RC}\left[1 + \frac{T_H}{T_L - T_H}\exp\left(-\frac{t}{T_H}\right) - \frac{T_L}{T_L - T_H}\exp\left(-\frac{t}{T_L}\right)\right],$$

where

$$T_H = \frac{T_0}{K_0} - RC_{Str}\,; \quad T_L = \left(\frac{1}{K_0 RC} + \frac{1}{R_{Lk} C}\right)^{-1}.$$

$$U_{\infty Nl} = \frac{E_0}{K_{VD}} \frac{1 + A\exp\left(-\frac{T1}{T_H}\right) - B\exp\left(-\frac{T1}{T_L}\right)}{1 + A\exp\left(-\frac{T2}{T_H}\right) - B\exp\left(-\frac{T2}{T_L}\right)},$$

where $A = \frac{T_H}{T_L - T_H}$, $B = \frac{T_L}{T_L - T_H}$.

$$\gamma_{Nl} = \frac{U_{\infty Ni} - U_\infty}{U_\infty} = \frac{T2\left[1 + A\exp\left(-\frac{T1}{T_H}\right) - B\exp\left(-\frac{T1}{T_L}\right)\right]}{T1\left[1 + A\exp\left(-\frac{T2}{T_H}\right) - B\exp\left(-\frac{T2}{T_L}\right)\right]} - 1,$$

$$\gamma_{Nl} \approx \frac{T2 - T1}{T_L - T2},$$

$$U(t) = -\frac{U_0 T_L}{RC}\left[1 - \exp\left(-\frac{t}{T_L}\right)\right],$$

$$U_{\infty Ni} = -\frac{E_0}{K_{VD}} \cdot \frac{1 - \exp\left(-\frac{T1}{T_L}\right)}{1 - \exp\left(-\frac{T2}{T_L}\right)},$$

$$\gamma_{Nl} = -\frac{T2\left[1 - \exp\left(-\frac{T1}{T_L}\right)\right]}{T1\left[1 - \exp\left(-\frac{T2}{T_L}\right)\right]} - 1.$$

Practical results. The test results and operating experience (including implemented in industrial an automated measurement system) have confirmed the correctness of the results of theoretical research.

Conclusion

Potentiation digital-to-analog converter based on iteratively integrating code-voltage converter with iterative additive correction of errors is considered. Analysis of errors of this converter with accounting of imperfection integrator was produced. Test results and operation experience confirmed the correctness of the results of theoretical research. Basic expressions for the calculation of these errors are listed and it allows you to create such high-precision potentiation digital-to-analog converter.

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UDC 625.735

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Automated system of air-to-air refueling civil aircraft

Here are considered benefits of airlift using a phase air-to-air refueling civil aircraft. Such technologies provide in particular for regional aircraft of Ukrainian production their main advantages at long flights. The variants of automation of this phase of the flight are proposed.

Introduction. To optimize the delivery of passengers is requiring for a particular flight not only choose the type of vehicle, but also ensure the effectiveness of its use by applying the modern transport technologies. Improving economic efficiency of air transport services can be accomplished through the use for regional aircraft technology of air-to-air refueling (AAR), which can provide the exploitation of these aircraft on long-haul non-stop flights instead of expensive long-haul aircraft [1].

A striking example of regional jets, for which can be applied, these technologies are modern jets: An -158 (passenger variant) and An -178 (transport aircraft) of the company Antonov. Comparative analysis of the technical characteristics of the aircraft An -158, characteristics of the aircraft of medium-range Boeing 737-900 and the long-range aircraft A330-300 of the company Airbus shows that short-haul (SHA) and medium-haul aircraft (MHA) can well solve the problem of transportation of passengers on long international lines. In this case the characteristics of navigation equipment of the aircrafts approximately the same and a flight comfort on SHA and on MHA is not worse than on the elite long-haul mainline jets (LHA). In addition, service for a smaller number of passengers could be better and it will cost less resource for the airline. The problem of LHA is also the fullness of load flights, which is low for the long international lines.

The technology of AAR can significantly reduce the fuel consumption, will allow several times to increase the commercial aircraft load and reduce the emissions of CO^2, as well as reduce the cost of the flight fleet. In addition, the implementation of direct long-haul flights using regional jets proportion of flights with a stopover in the airline hub is reduced, because passengers can be delivered directly to the destination without change of flights in international airports.

All this emphasizes the urgency of developing technologies of AAR for civil aircraft. The development of this idea is currently engaged in leading aviation research organizations in Europe in the framework of «Recreate» project [2], as well as scientific institutions of Russia and Israel.

Problem statement. Analysis of existing refueling systems shows that the most common and relatively simple system is the «probe-and-drogue system». Therefore this method is taken as the basis for the development of the automated system of AAR for civil aircraft.

But in order to reduce the requirements for pilots of civil airliners in the article is proposed for the «probe-and-drogue» system use the method of «inverse»

AAR. This method requires no special training pilots of the aircraft, which should be refilled. The crew of this aircraft, equipped with a unified outboard unit of refueling, by command of the tanker only let out a flexible hose with the drogue, which trails from the aircraft. The entire alignment process of rapprochement and contact performs a trained crew of the tanker aircraft, which is approaching to the commercial aircraft behind and performing the maneuvers, connects its own fueling system with the extended drogue. Alterations in accordance with the «inverse» AAR exposed only the outboard unit of refueling.

Additionally refueling process can be automated to reduce the load on the tanker aircraft crew. At the same time it's necessary to automate not only the control of the aircraft, as well as the control of a drogue of AAR, equipping the drogue aerodynamic control surfaces and thereby turning it into the remote-controlled UAV, which the crew of tanker will be able to direct on its probe of a refueling system.

The control system of a drogue using their own control arrangements can carry out the stabilization of a drogue in the air, fending turbulent perturbation, and as well as to direct the drogue on the probe of a tanker aircraft in an automatic or automated regime of control.

The statement of the problem can be formulated as follows: for the parry of turbulent perturbations acting on the drogue and impeding the contact process, on the basis of one embodiment of an aerodynamic control of the drogue design the system of its stabilization (SSD), and then based on SSD build the system guidance of the drogue (SGD) at the probe of refueling.

Problem solution. In this paper, on an analysis of possible options for constructing of an aerodynamic control surfaces of a drogue was selected the jet system of a control type FLAVIIR which is based on slit channels (Fig. 1) as the least energy intensive, reliable and easy to maintain.

The jet control system of a drogue used as controls a slotted channel *2* on the casing filling drogue *1*, which ends on the window *3*. Slotted windows *3* are closing dampers *4*, which connected with actuators *5*. Using the technology changes a flow of air jets along an aerodynamic profile of the drogue allows you to change a speed and a pressure flowing stream and thereby change the distribution of aerodynamic forces acting on the drogue, that is, to control a movement of the drogue in an air stream. As the power amplifier of actuators *5* are used the linearized relay amplifier.

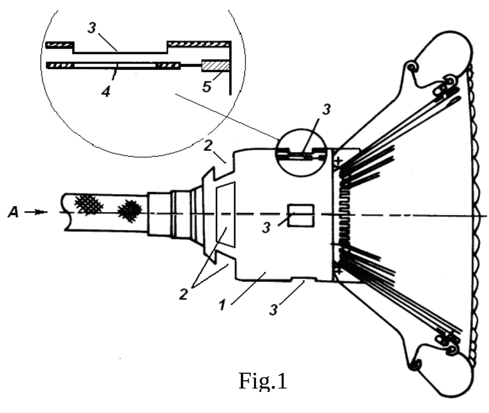

Fig.1

To parry disturbances acting on the drogue while refueling in the air, it is proposed the system SSD, a sensor of which is a small, ultralow power, 3-axis digital MEMS accelerometer, installed under the hood of a drogue. The measuring axis accelerometer coincides with an axis of symmetry of the drogue. Outputs of the accelerometer are connected to two inputs of actuators, which connected with the damper control system, located on a body of the drogue. Each control channel consists of a power amplifier and a calculator forming control laws actuators. The algorithm of the SSD is a classic damper.

Control laws of actuators dampers for vertical and horizontal channels are identical.

$$\delta_h = \left(K_{n_y} + K_{\tilde{n}_y}/p\right)\Delta n_y; \quad \delta_z = \left(K_{n_z} + K_{\tilde{n}_z}/p\right)\Delta n_z.$$

Here δ_h, δ_z – displacements of dampers in vertical and horizontal channels respectively; Δn_y, Δn_z – values of surplus vertical and horizontal accelerations, which are measures ADXL345.

A basis for the system SGD is the technology RTK [4], which provides a measure of relative provisions of objects with an accuracy of about 10 mm at baseline distances of ~ 20 meters.

On the drogue of the refueling outboard unit are located (see. Fig. 2): the receiver GPS, the command radio line transceiver, the linear notifier of an entrance of the probe in a basket of the drogue and SSD.

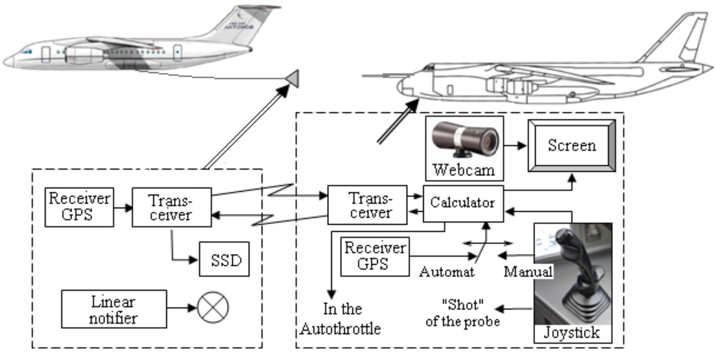

Fig. 2

The equipment of a tanker aircraft includes a telescopic probe with the GPS receiver and the webcam, the command radio line transceiver, the joystick remote control of a drogue of co-pilot, the indicator screen and the calculator of SGD. Information from the calculator SGD also direct in the autothrottle of a tanker aircraft. The autothrottle working at the control law (1) implements the exponential trajectory change a speed of docking approach ΔV_3, which is proportional to the relative distance of the drogue Δd, which is calculated on the technology RTK, using information two receivers GPS.

$$p\delta_{\text{throt}} = K_{\dot{V}} pV + K_V\left[(V_{\text{des}} + \Delta V_{\text{des}}) - V\right]. \quad (1)$$

Here δ_{throt} – the displacement of throttle lever; V_{des} - the desired speed of flight at the phase of refueling; $\Delta V_{\text{des}} = -\Delta d / T$ - the change desired speed of approach; T - the time constant of exponent.

However, the use of such a law greatly increases time of approach, because direct contact a probe with the drogue theoretically will be realized only in infinity. To avoid this, the asymptote of the exponential must be located behind a drogue at a distance Δd_{as}. In this case, the trajectory of an approach is realized in the form of:

$$\Delta V_{\text{d}} = -\left(\Delta d + \Delta d_{\text{as}}\right) / T\ .$$

Control laws of actuators of the drogue at the stage of automatic guidance on the refueling probe are of the form:

$$\delta_h = \left(K_{n_y} + K_{\tilde{n}_y} / p\right)\Delta n_y + K_h \Delta h; \quad \delta_z = \left(K_{n_z} + K_{\tilde{n}_z} / p\right)\Delta n_z + K_z \Delta z.$$

Here Δh, Δz are vertical and lateral deviation of the drogue from the axis of the refueling probe, which are calculated similarly to the calculation of the distance Δd .

In automatic mode, the control signals Δh, Δz in control laws are replaced with the signals from the joystick remote control co-pilot, which are received by the command radio line with tanker aircraft.

The research of the proposed loop stabilization drogue conducted by mathematical simulation using the program Simulink, which is part of the mathematical package MATLAB programming.

In researches the model of the dynamic of drogue was introduced as a system of linear differential equations,

$$\begin{aligned} &a_{\ddot{h}} \Delta \ddot{h} + a_{\dot{h}} \Delta \dot{h} + a_h \Delta h + a_{\delta_h} \Delta \delta_h + h_{\text{tur}}(t); \\ &a_{\ddot{z}} \Delta \ddot{z} + a_{\dot{z}} \Delta \dot{z} + a_z \Delta z + a_{\delta_z} \Delta \delta_z + z_{\text{tur}}(t). \end{aligned}$$

The mathematical model of the drogue motion dynamics was obtained by simplification the known model motion of hose points [3]:

$$\rho \frac{\partial^2 u}{\partial t^2} = F \frac{\partial^2 u}{\partial x^2} - \rho g - D \frac{\partial u}{\partial t} - A \frac{\partial u}{\partial x} + A \alpha_{\text{tur}}(x,t)\ ,$$

and given boundary conditions on the right and left ends of the hose respectively:

$$\begin{aligned} &M_{\text{dr}} \frac{\partial^2 u}{\partial t^2} = -M_{\text{dr}} g - D_{\text{dr}} \frac{\partial u}{\partial t} - (C_y + F) \frac{\partial u}{\partial x} + C_y \alpha_{\text{tur}}(x,t) |_{x=L}, \\ &u(0,t) |_{x=0}\ . \end{aligned}$$

where u, (Δh, Δz) – functions of coordinate deviation of hose points (drogue); $\Delta\delta_h, \Delta\delta_z$ – impacts of the drogue control system; M_{dr} – mass drogue; ρ – linear density of the hose, t – time, g – acceleration of gravity, D – the damping coefficient of antihunting, D_{dr} – the damping coefficient the drogue, A – the coefficient of the linear aerodynamic force; F – the force of a hose tension, $\alpha_{\text{tur}}(x,t)$, $h_{\text{tur}}(t)$, $z_{\text{tur}}(t)$ – components of gusts turbulent atmosphere; L – the hose length, C_y – the aerodynamic coefficient of the drogue, x – the coordinate along the hose;

$a_{\ddot{h}}, a_{\dot{h}}, a_h, a_{\delta_h}, a_{\ddot{z}}, a_{\dot{z}}, a_z, a_{\delta_z}$ – coefficients of the simplified model of a spatial movement of the drogue.

And at the simulation of a turbulent atmosphere was used the generally recognized Dryden model.

$$S_w(\omega) = \sigma_u^2 \frac{L}{2\pi V}\left[1 + 3 \cdot \left(\frac{L}{V}\right)^2 \cdot \omega^2\right] \cdot \left[1 + \left(\frac{L}{V}\right)^2 \cdot \omega^2\right]^{-2}$$

where σ_u - the mean-square value of the speed of a random eddy wind; L – the linear scale of an atmospheric turbulence; V - the flight speed.

In researches of dynamics of movement in an air the components of a spectral density of an atmospheric turbulence can be extracted from a random noise by means of the shaping filter

$$\Phi_w(p) = 1/(T_f\, p + 1).$$

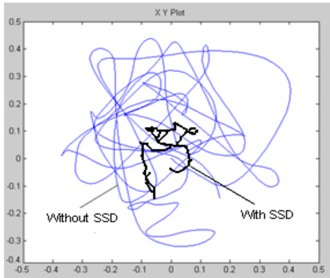

Fig. 3

Simulation results (see. Fig. 3) showed the efficiency of developed algorithms SSD and SGD, even when refueling in a turbulent atmosphere. In particular, the amplitude of bumpiness of the drogue in a turbulent flow is reduced by almost four times. Significantly reduces the docking time and simplifies the process of piloting a tanker aircraft.

Conclusions

The technology in-flight refueling of regional jets will allow: to increase their commercial payload; significantly save fuel and reduce CO^2 emissions into an atmosphere.

The proposed systems SSD and SGD greatly facilitates the piloting technique at the contacting stage, even when refueling in a turbulent atmosphere, and substantially reduces psychophysical loads of pilots.

Regional aircraft of type An -158, An -170, equipped with the proposed air refueling system on routes Europe - South-East Asia may be out of competition.

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Computer-aided design system of unmanned aerial vehicles during preliminary design

The CAD system for UAV during preliminary design when you want to define layout and basic design parameters of the newly created aerial vehicles is considered. CAD system includes methods of structural synthesis and accelerated analysis in the construct and choice of aerial vehicles variants that is based on the existing system and application software with additional application of software module.

The analysis of the existing methodological material on designing aerial vehicles [1]-[3], that includes set class unmanned aerial vehicles (UAVs), the most responsible stage design is the preliminary design, so as the cost of work there is a small percentage of the total project cost and eliminate errors not associated with large material and time costs.

At the stage of preliminary design is formed (outline technical) future appearance of UAV - selected aerodynamic scheme, defined the basic dimensions, weight, type of power plant, designed layout and determined the board equipment configuration.

To choose the best variant form of UAV is analyzed of a large number of alternative layouts and optimization of the basic geometric parameters – wing aspect ratio, wing taper ratio, swept wing, body aspect ratio, wing and tail longitudinal position.

Preliminary design is iterative process, because there are many relationships between the various parameters and characteristics of UAV. The result is a technical preliminary design proposal - drawing the general form of UAV with the values of basic geometric parameters, estimates aerodynamics, weight and trajectory characteristics.

The sequence of work that is performed on the stage of preliminary design set class of UAV, shown in Figure 1.

As shown in Figure 1, the design work begins on preparing the initial data, which includes information that is contained in the design task, the initial flight conditions of UAV, features selected propellant, construction materials, coefficients in the semi-empirical formulas and statistics data on previously established set class of UAV.

In the synthesis of the first approach UAV’s form is chosen aerodynamic scheme, geometric parameters of the body, wings and tail, type and parameters of the power plant, control system, typical flight trajectories.

The value of the aerodynamic characteristics during the first approximation calculation is defined on basis of statistics or previously calculated results of the engineering method, which is shown, for example, in [4].

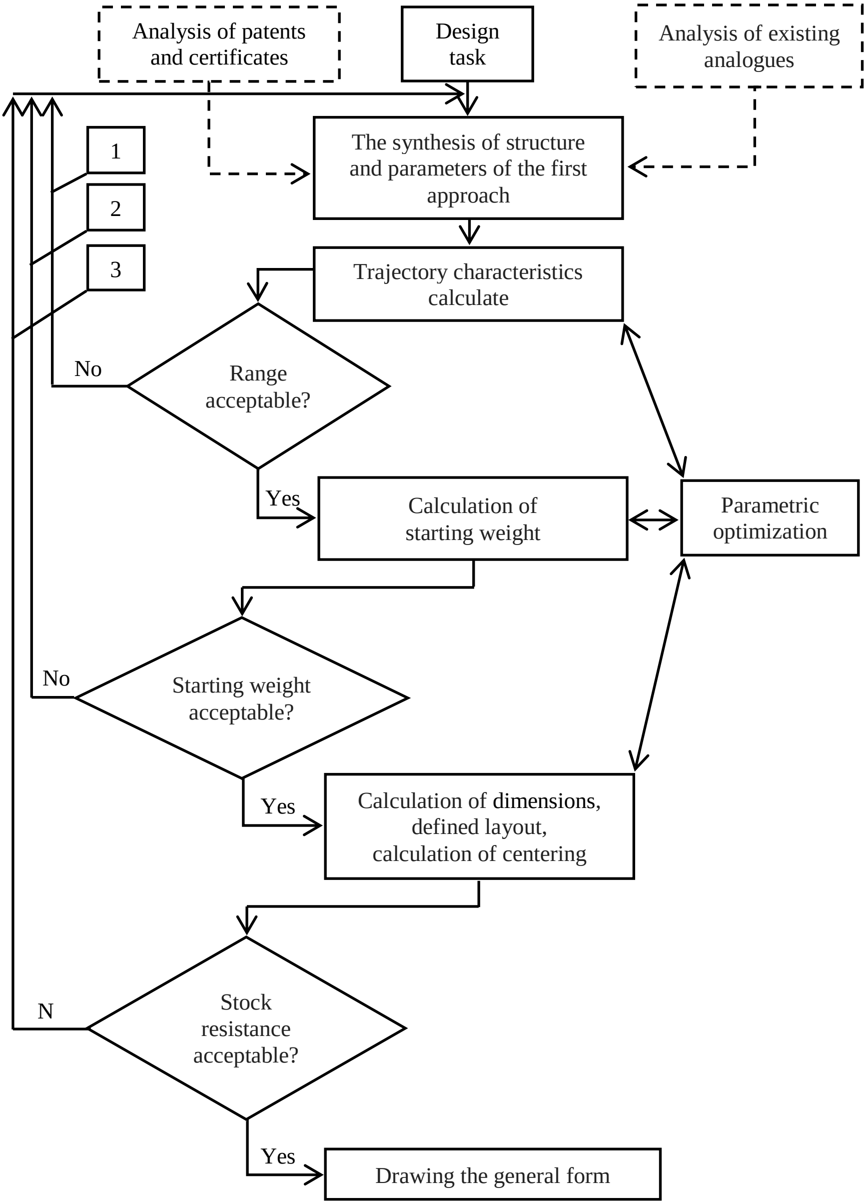

Figure 1. Block diagram aided design UAVs at the stage of preliminary design

During trajectory characteristics is calculating it is defined relative weight of propellant, thrust-to-weight ratio, trajectory and velocity profile of UAV that satisfy the design task.

At the stage of calculating the starting weight is defined the relative weight of components (μ_{pp} , μ_{con}) and starting weight of UAV using a mass balance equation:

$$m_0 = m_{pl} /(1-(\mu_{prld}+\mu_{pp}+\mu_{con})), \qquad (1)$$

where m_0 - starting weight UAV; m_{pl} - weight payload, μ_{prld} - relative weight of the propellant; μ_{pp} - relative weight of the power plant, μ_{con} - relative weight of the construction. From the expression (1) it follows that if the sum of the relative weight - μ_{prld}, μ_{pp} and μ_{con} greater than one, the value m_0 will be negative. It indicates the impossibility of producing UAV in the selected initial data.

After acceptable result of starting weight is gotten, go to the defining dimensions, layout and centering of UAV.

At this stage of design work defines absolute values of UAV dimensions, wings span, wings and tail area, wings longitudinal position, internal layout and centering of UAV. Calculating dimensions, layout and centering of UAV ends by analysis of static stability reserve ratio and flight angles longitudinal balancing values.

At the same time with the calculation of trajectory characteristics, starting weight, dimensions, layout and centering can be performed parameters optimization and comparing alternatives UAVs.

Solving these tasks is complex iterative process that requires repeated correction of initial data.

At the stage of calculating the trajectory characteristics is evident that the selected initial data is not reached the desired height or range of the flight. It may also happen in some areas trajectory when velocity decreases or angle of attack increases to unacceptable values.

To resolve these problems it is necessary to come back to the beginning of the design and modify such basic data as the aerodynamic configuration of UAV, specific impulse propellants, propellant consumption program (feedback 1).

A number of problems can arise at the stage of calculating weight, even under normal completion calculate trajectory characteristics when UAV's weight becomes unacceptably large or acquire negative value according to the formula (1). In this case also need to return to the beginning of the design and change the initial data for reduce the relative weight μ_{prld}, μ_{pp} and μ_{con} (feedback 2).

During calculating dimensions, layout and centering of UAV can also be complications, such as unacceptable discrepancy centering, wings and tail overlap or wings location beyond the length of UAV.

Thus, it is necessary to correct initial data again (feedback 3), which are related to changes in external or even internal layout of UAV.

Unlike the parametric design, the structural design base on the combination of discrete variables with conditional logic constraints very badly formalized so it is required new engineering methods with possibility of their use in computer-aided design systems (CAD).

To solve the problem of finding new variants structure of UAV is proposed structural synthesis method based on the use structural models of UAVs in the form of morphological tables or morphological trees, quality factor variants indicators of UAV and estimates of these factors, received by experts.

The structural synthesis method is the decomposition and allocation the most essential indicators of UAV, which can be subsystems and construction elements.

Importance of indicators is assessed depend on their impact on the performance of the main functions of UAV. For each indicator sets alternatives, that may be the existent technical solutions and technical solutions that are contained in the legally existent patents and copyright certificates. The indicators of UAV and their alternatives create a morphological set.

A variant UAV's structure is determined by combining one alternative from each indicator.

As a result of combining all alternatives indicators of UAV can create enormous values of possible variants for the structure, for narrower region of feasibility is used a number of restrictive rules.

Firstly, from the directories patents and certificates are chosen more recent alternative indicators.

Secondly, all the alternatives indicators are checked for compliance with specified requirements and compatibility with each other, as shown in [2] and [5].

Thirdly, for each indicator defines their set of local quality factors. For each local quality factors are defined total normalized scale assessments (values selected with using expert estimates methods) where by compares alternative indicators. The measure estimation of quality alternatives indicators is complex criterion F^i (where i - number of alternative indicators), which is the sum of local quality factors alternatives indicators with their weight coefficient. Criterion F_i is defined by the formula: $F^i = c^i_1 F^i_1 + c^i_2 F^i_2 + \ldots + c^i_j F^i_j, + \ldots + c^i_k F^i_k$, where c^i_j – weight coefficient j-th quality factor and i-th alternative indicator; F^i_j - j-th quality factor and the i-th alternative indicator; k - number of quality factors. The weight coefficient to each quality factor appoints the expert, in according to degree of influence the quality factor to perform the design task, as shown in [6].

The final stage of selection structure variants of UAV is an assessment of compliance with design requirements by accelerated analysis method.

Accelerated analysis method enables to define the kinematic flight parameters of UAV, influence start conditions and propellant capacity during range parametric calculation.

Quality assessment criterions variants of UAV are star weight m_0, velocity V and permissible overload n_y. In the area of possible solutions are imposed restrictions on long-range and short-range boundary terms of possible launches zone.

The long-range boundary condition of possible launches zone is energy support and short-range boundary conditions - providing requirements for maneuverability.

Software implementation structural synthesis method of UAV in CAD, bases on the use products data management SWR - PDM Russian created by company Solid Works - Russia which contains all necessary functional modules and tools to build the structures of UAV.

Accelerated analysis method is implemented in the environment of Mathcad and it is corresponds an application programming module, which is stored in a library application archive server of CAD. Working with the library and archives, is realized by using the database bases on SQL.

Conclusions

The proposed structural synthesis method allows to improve the validity of the design decisions and increase the number layout variants of UAV, among that a choice is done.

Using the accelerated analysis method it is possible at the early design stage of UAV to estimate the variants of layout on accordance to the requirements of design task.

On the basis of the considered algorithm of aided design process, structural synthesis method and accelerated analysis method, existent and additional developed software can be created CAD of UAV, which can significantly reduce the time of design and increase its effectiveness during preliminary design.

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Corrected testing algorithms components based on pilots education process limitations

A new approach of pilots knowledge testing taking into acccount external limitations is proposed. The control-educational testing algorithm and control-examination testing algorithms are shown. The examples of improved algorithms with some limitations are given.

Knowledge testing of pilots. The testing and evaluation of applicants for airman certification is an essential element in assuring aviation safety. The testing is an effective and reasonable method from didactical and physiological aspects. It has proved to diversify evaluation process, activate acquisition of new information by future pilot as it implies thoughtful choice, analysis or match.

For pilots certification [1] the tests of professional competence, which are called knowledge tests are used. It is one of the perfect means for a comprehensive evaluation of the training quality that can be used not only for certification specialists, but also for the selection of candidates to fill the positions or others.

Out of all testing methods available today, computer adaptive testing (CAT) [2] provides the maximal balance of accuracy and efficiency. Over the past few decades, computer adaptive testing has been used extensively in the areas of education, certification, and licensure. CAT is a type of test developed to increase the efficiency of estimating the examinee’s knowledge.

Testing is one of the stages to obtain a license of pilot during theoretical knowledge check. This approach to the verification of the professional knowledge of future pilots save time of the candidates and excludes subjectivity at the evaluation. The candidates must demonstrate their knowledge and skills (for example, knowledge of the aeronautics laws, flight training, etc.).

Computer testing [3] is a tool designed for measuring the pilots’ knowledge level that consists of a set of test tasks, standardized procedure of conducting, processing and results analysis. In general, tests can be divided into closed (where there is a ready answer) and open (with no ready answers, they have to be written by students).

Computer testing on the simulator [4] can be divided into two main types: control-educational (the purpose is to determine the topics that is necessary student to repeat before an exam) and control-examination testing (the aim is to determine the exact level of knowledge of the listener).

Control-educational test (Fig.1) is a set of theoretical questions or training sessions in the simulation environment. After each wrong answer listener has the opportunity to repeat the theoretical material concerning corresponding questions in electronic textbook, or watch an example of correct behavior in the simulated environment.

Control-examination test (Fig.2) is represented by certain number of summarized questions/training sessions. Each correct answer contributes to increasing the assessment. As a result, after passing the test listener can see on the screen its own result (final evaluation).

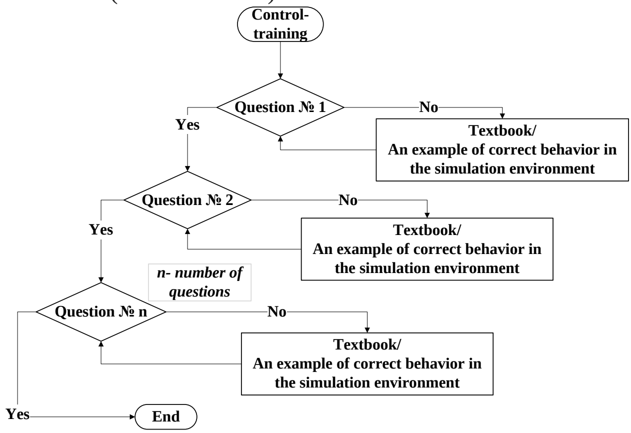

Fig.1. Control-educational testing algorithm.

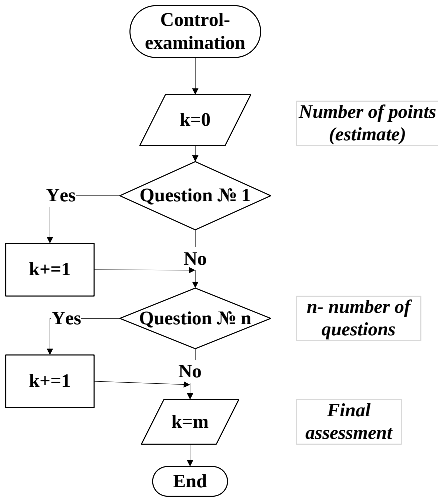

Fig.2. Control-examination testing algorithm.

Limitations in testing algorithms.

1. Time limit

Testing can be limited in time - for the whole test, and for each question. At the same moment, the amount of time allocated to each question can be different.

The use of computer testing in terms of time limits allows to increase the amount of verifiable knowledge and significantly increase the objectivity of the assessment due to standardizing the tests and testing procedure.

Throughout the testing takes place check of time. If there is enough time, the candidate continues his work. If the timer is shut down, automatically stops the testing program and user has the opportunity to view his results. If student have answered on all the questions of the test in the allotted time, the percentage of correct answers is taken into account in the final mark. At the same time there is the possibility of accounting complexity of the task. If the student did not answer on all test questions, and the time allotted for testing is over, the questions that were not answered are equal to the questions on which was given an answer with an error.

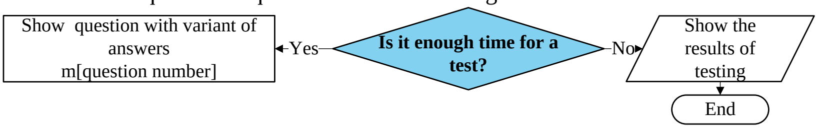

Fig. 3.1. Time limit for the whole test

In the case of a time limit on a separate task of the test the calculation of results is the same. But in this limitation taken into account time of each question and if the candidate is not kept within the specified time, the wrong answer to the question is set, and the program automatically switches to the next task.

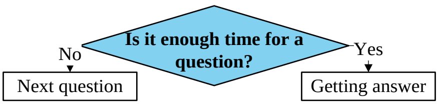

Fig. 3.2. Time limit for the question

2. Accuracy limitation

Testing accuracy depends on the type of the task. When checking the general theoretical information with imaginations of devices there is no need in minute detail to inspect, it is sufficient that the candidate can be oriented in information. On the other hand, when working with the simulator candidate must accurately determine the course, angles and to demonstrate a high flight training.

Also is set the value of accuracy, which candidate could achieve with the passage of the test. Accuracy of the answer may be a binary, the accuracy of up to tenths (10% ... 20%), the accuracy of up to 5% (5%, 10%, 15%), etc.

Given accuracy is divided on all questions so that each task has its own value of accuracy (depending on type). In consequence of this, after each correct answer is checked the achieved value and compared with a predetermined value. While accuracy will not match the desired result, the candidate will receive the following question.

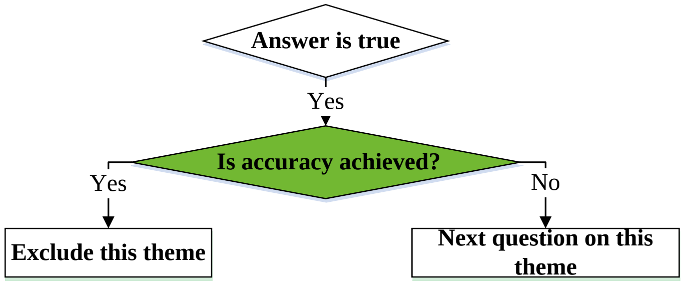

Fig.4. Accuracy limitation

3. Limitations according to the number of attempts

When passing the test in the training format, the candidate obtains right to make mistakes, repetition of the material and re-passing task. The number of attempts may be limited on the whole test or on every single question.

When the test results are unsatisfactory, depending on the number of given attempts, the pilot has the ability to take the test again until all attempts have been exhausted. After that, if a candidate failed to achieve the desired result, he gets a «fail» and goes for re-training.

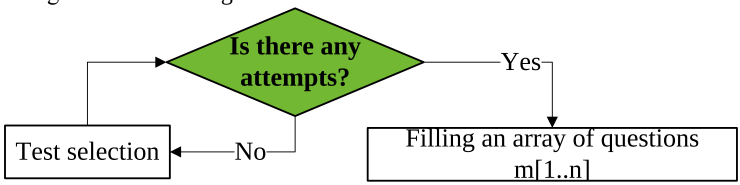

Fig.5. Attempts limitation

Conclusion

In this paper pilots oriented knowledge control limitation analysis based on their professional activity peculiarities was proposed.

Standard algorithm of control-educational and control-examination testing applicable for pilots was represented and taken as basic.

Testing algorithm correction according to the analyzed limitations including time, accuracy and attempts is suggested.

In further researches corrected algorithms for simulation part of knowledge verification and learning components of general pilots education process may be observed along with wider description of more limitations and their determination for each pilot in person.

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Review of some important innovations not yet implemented in aviation

Work is dedicated to the problem of objective identification of high aerodynamic coefficients (ADC) and balancing characteristics (BC) of aircraft on the accuracy of which depends the quality and stability of the aircraft control systems and, consequently, safety of flight.

In creating new models of aircraft, as well as maintaining airworthiness of existing ones, an important component is to identify ADC and BC according to results of field tests. Considered innovations have their efficiency theoretically and experimentally proved, but aren't implemented yet.

Innovation №1. Definition of balancing nonlinear characteristics $f(U)$ (BH) depending on arbitrary dynamics modes of longitudinal (PM) and lateral (LM) [1] movement of aircraft.

Incorrectness occurs when $f(U)$ is being approximated by a polynomial of U, when from the equation

$$\varepsilon(t) = x_i(t) - \sum_{l=0}^{m} b_l \varphi_l[U(t)] + \sum_{j=1}^{n} a_j \frac{d^j x_i(t)}{dt^j} \tag{1}$$

with $x_i(t)$, $U(t)$ and their derivatives being inexact and linear dependence of variables it is needed to identify $m+n$ unknown values. Let's assume that in (1) only first and second derivatives are linearly independent. Then let's estimate the coefficients of equation (1) not depending on minimum mean square error condition, but depending on the $f(U)$ smoothness condition:

$$(a_1, a_2) = \arg\min_{(a_1, a_2)} \sum_{k=1}^{N} \left(\frac{d^r x_{\text{ск}}(t_k)}{dU^r} \right)^2, \tag{2}$$

where r is $f(U)$'s smoothness degree. Then dynamically compensated value of $x(t_k)$ as non-linear output of $f[U]$ is equal to:

$$x_{\text{ск}}(t_k) = x(t_k) - a_1 \frac{dx(t_k)}{dt} - a_1 \frac{d^2 x(t_k)}{dt^2}. \tag{3}$$

In practice instead of derivatives (2) finite differences are used, which are being calculated using previously smoothed out and ordered by U ascending data sets.

<u>The test sample.</u> $f(U)$ (Fig. 1, dotted bar) is dependence

$$f(U) = 4U - 60\sin(0{,}065U). \tag{4}$$

Input is eight levels from $-U_{\max}$ to $+U_{\max}$.

$$U(t) = U_{\max}\left[-1 + \frac{1}{8}\sum_{k=1}^{16} 1(t - k\Delta t)\right].$$

There is a 20% white noise imposed on $x^*(t)$. OLS-estimation of coefficients b_i and a_1, a_2 of models for $n = 2$, $m = 1,2,3,4,5$ (Fig. 1 has all curves except dash-dotted) shows that the increase of m has not led to the recovery of model (4). Results of nonparametric estimation of nonlinearity using $f(U)$'s smoothness condition (2) for *r = 2* almost coincides with the model (4).

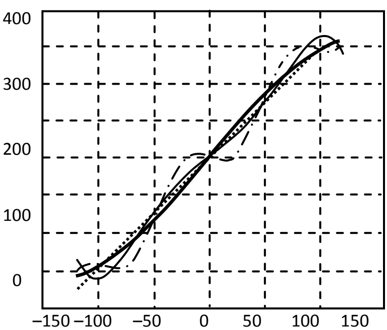

Fig. 1. Approximation of dependence (4)

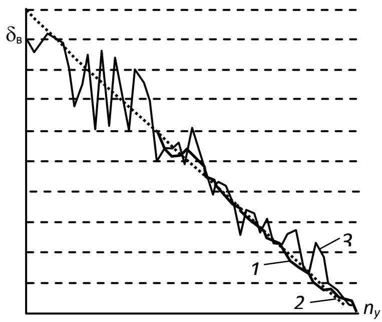

Fig.2 Balancing dependences graph

<u>A real example</u>. Fig. 2 shows the balancing dependence $\delta_B(n_y)$ of M-17 plane which is obtained from dynamic modes (Fig. 4) provided (2) is true (line *1*) and approximated by a line *2* and polyline *3* which is sorted by dependence n_y built without dynamic compensation.

In addition to determining $f(U)$ the method makes it possible, if the regime is quite dynamic, to correctly evaluate linear dynamic component of the model (1) later.

Innovation №2. Unbiased high-precision ADC estimation as partial derivatives, that is, linear component of nonlinear dynamics of PM and LM of aircraft.

ADC is a derivative of the moment or force at the relevant variables, taken at a fixed point in space - time. This ADC definition is identical to non-linear models coefficients only if the deviation tends to zero. But then the "noise-signal" ratio grows to infinity and ADC estimation will become impossible. The compromise between the linear model which is true for small deviations and complete nonlinear nonstationary model which is for all modes of flight will be the model presented by the first and second members of nonlinear model's Taylor decomposition. For example, for $m_{z_1}(t)$:

$$m_{z_1}(t) = m_{z_1}(t_0) + \left.\frac{\partial m_{z_1}}{\partial \alpha}\right|_{t_0} \Delta\alpha(t) + \left.\frac{\partial m_{z_1}}{\partial \bar{\omega}_{z_1}}\right|_{t_0} \Delta\bar{\omega}_{z_1}(t) + \left.\frac{\partial m_{z_1}}{\partial \delta_B}\right|_{t_0} \times \Delta\delta_B(t) +$$

$$+\frac{1}{2}\cdot\left.\frac{\partial^2 m_{z_1}}{\partial \alpha^2}\right|_{t_0} \left(\Delta\alpha(t)^2\right) \times \left[+ \left.\frac{\partial^2 m_{z_1}}{\partial \bar{\omega}_{z_1}}\right|_{t_0} \left(\Delta\bar{\omega}_{z_1}(t)\right)^2 + \left.\frac{\partial^2 m_{z_1}}{\partial \delta_B}\right|_{t_0} \left(\Delta\delta_B(t)\right)^2 \right] + \quad (5)$$

$$+\left.\frac{\partial^2 m_{z_1}}{\partial \alpha \partial \bar{\omega}_{z_1}}\right|_{t_0} \cdot \Delta\alpha(t)\cdot\Delta\bar{\omega}_{z_1}(t) + \left.\frac{\partial^2 m_{z_1}}{\partial \alpha \partial \delta_B}\right|_{t_0} \Delta\alpha(t)\times\Delta\delta_B(t) + \left.\frac{\partial^2 m_{z_1}}{\partial \bar{\omega}_{z_1} \partial \delta_B}\right|_{t_0} \Delta\bar{\omega}_{z_1}\Delta\delta_B(t).$$

Equation (5) takes into consideration asymmetry of pitching and diving modes. But a large number of its members, mutual correlation, limitations and proximity of measurements and limited regime time by change in speed and height are making the task of evaluating all ADCs impossible. For more accurate ADC estimation let us plan the experiment so that all the variables of the equation (5) were close in form to steps and exponent. Then (5) can be approximately represented as follows:

$$\Delta m_{z_1}(t) \cong a_2 \Delta\alpha(t) + a_1 \Delta\omega_z(t) + b_1 \Delta\delta_B(t), \quad (6)$$

where $a_1 = m_{z_1}^{\bar{\omega}_z} + \left[m_{z_1}^{\alpha\bar{\omega}_z} \Delta\alpha(\infty) + m_{z_1}^{\bar{\omega}_z^2} \Delta\bar{\omega}_{z_1}(\infty) + m_{z_1}^{\alpha\delta_B} \Delta\delta_B(\infty) \right]$;

$$a_2 = m_z^{\alpha} + \left[m_z^{\alpha^2} \Delta\alpha(\infty) + m_{z_1}^{\alpha\bar{\omega}_z} \Delta\bar{\omega}_{z_1}(\infty) + m_{z_1}^{\alpha\delta_B} \Delta\delta_B(\infty) \right];$$

$$b_1 = m_z^{\delta_B} + \left[m_z^{\delta_B\alpha} \Delta\alpha(\infty) + m_z^{\delta_B\bar{\omega}_z} \Delta\bar{\omega}_{z_1}(\infty) + m_z^{\delta_B^2} \Delta\delta_B(\infty) \right].$$

By changing the $\Delta\delta_B(\infty)$ amplitude we can proportionally change the offset of a_1, a_2, b_1 coefficients with respect to required ADCs: $m_{z_1}^{\bar{\omega}_z}$, $m_{z_1}^{\alpha}$, $m_z^{\delta_B}$.

<u>Numerical example.</u> Non-linear model:

$$y(k) = \sum_{j=1}^{3} x_j(k) + \sum_{j,q=1,\, j\ge q}^{3} x_j(k) x_q(k) \quad (7)$$

with unit coefficients for the four samples of different $X_{\max}$ amplitudes has been approximated by its linear part. Estimations of $\hat{\beta}_j (j = 1,2,3)$ were calculated using OLS. Index $\varepsilon^{\mathrm{T}}\varepsilon$ of error ε of approximation of $y(k)$ by linear model $y(k) = \hat{\beta}_1 x_1(k) + \hat{\beta}_2 x_2(k) + \hat{\beta}_3 x_3(k)$ is two orders of magnitude less than the norm $\|\Delta y\|$. Approximation problem is being solved with enough precision. But coefficients $\hat{\beta}_i$ are significantly biased (Fig. 10.1).

The linear dependence of displacements $\Delta\beta_j$ (j = 1, 2, 3) from $x_{\max}(l)$, (l = 1, 2, 3, 4) converge to zero; thereafter estimations $\hat{\beta}_j$ converge to real β_j =1.

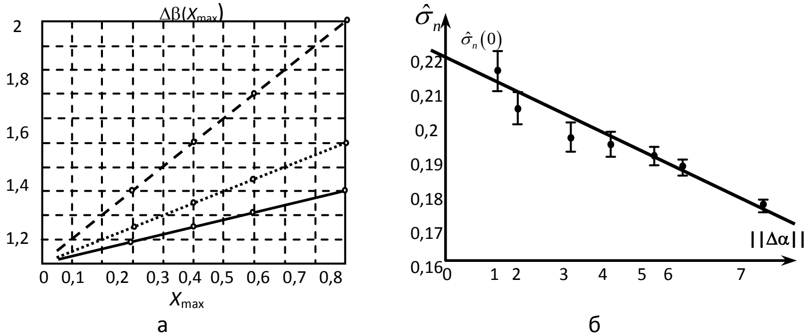

Fig. 3. Dependencies: a) $\beta(x_{\max})$, where ----- $\Delta\beta_1$; ····· $\Delta\beta_2$; —— $\Delta\beta_3$;

b) $\hat{\sigma}_n\left(\|\alpha\|\right)$

<u>A real example.</u> Fig. 4 shows seven modes of different amplitude of changes elevator $\delta_{в}$, angle of attack $\alpha(t)$ and angular velocity $\omega_{Z_1}(t)$ of the aircraft M-17 in pitching movement. Complete dependence $\dot{\omega}_{Z_1}(t)$ on $\delta_{в}(t)$, $\alpha(t)$ and $\omega_{Z_1}(t)$ is similar to the model (5). In each of the modes evaluation model coefficients $\hat{\beta}_j,\ j=1,2,3$ are calculated and biased due to the model approximation. Aperiodic stability reserve $\hat{\sigma}_n$ is calculated using them.

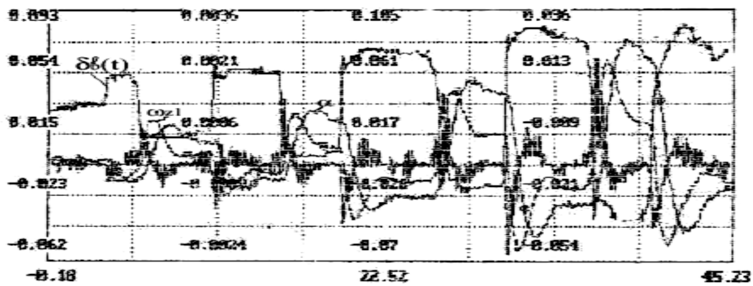

Fig. 4. Oscillograms of changes of elevator, angle of attack and angular velocity

Reserve was approximated by OLS-dependence (8) in $\|\Delta\alpha\|$ function (Fig. 3b):

$$\hat{\sigma}\left(\|\Delta\alpha\|\right)=0,22-0,075\|\Delta\alpha\|, \qquad (8)$$

where 0,22 is required unbiased estimation.

Simple averaging results in understated estimate $\hat{\sigma}_n = 0{,}188$. Further $\hat{\sigma}_n$ refinement is achieved by approximation of $\hat{\sigma}_n(0)$ by regression dependence on other flight parameters (speed, height etc).

So, Table. 1 shows the linear regression dependence of ADC on the initial angle α (coefficient a_1) and its derivative (coefficient a_2) of the AN-72 plane. Considering only α and $\dot{\alpha}$ made it possible to multiply the accuracy of ADC estimates by two on average.

Table 1

ADC estimation dependence on α and $\dot{\alpha}$

DC	a_0	a_1	a_2	FCS appr.	Average	FCS avg.
$m_z^{\bar{\omega}_z}$	–8,54	–0,2289	–0,0112	0,01	–10,61	0,02
m_z^{α}	–0,0092	0	0	0,007	–0,0091	0,007
$m_z^{\delta_в}$	–0,0161	–0,0012	0	0,003	–0,02	0,009
$m_z^{C_y}$	–0,0873	–0,0029	0	0,004	–0,0928	0,006
σ_n	–0,2301	0,0071	0,0001	0,001	–0,2119	0,002

Table 2 contains data which confirms effectiveness of stability reserve σ_n refining by dependence on different flight parameters ΔX .

Table 2

Plane type	СКП, %		Dimension of ΔX	Modes amount
	моделі	середнє		
AN-72	5	102	6	190
IL-86	7	31	2	25
TU-154	4	13	4	70
MIG-29	7	50	4	50
M-17	0.5	1.5	2	15

In general, for correct identification problem statement it is important to distinguish between *signal* and *parametric* approaches. The generality of them is in minimization of $\varepsilon^{\mathrm{T}}\varepsilon$, the difference is in the requirements for $\varepsilon^{\mathrm{T}}\varepsilon$ functional as $\hat{\beta}$ evaluation function (according non-strict and strict convexity).

Innovation №3. Flight test (FT) planning to define weak cross-linking in the dynamics of aircraft LM.

Since the problem of identifying aircraft ADC is ill-conditioned, one experiment can't be enough to achieve the required accuracy for estimates of all parameters. Therefore, coordinate-wise optimization is used provided:

$$\Phi_k^p = \min_j \| j_k - i_k \|_p = \min\left(\sum_{i=1}^{m} | j_{kl} - i_{kl} |^p \right)^{\frac{1}{p}}, \tag{9}$$

where j_{kl}, i_{kl} are elements of k-th row of second derivatives matrices of the optimizable and required indices respectively; p is norm index. Table 3 shows results of ADC identification of MIG-29's LM

Table 3

Parameters identification by coordinate-wise optimization criteria

Model parameters	$m_x^{\bar{\omega}_x}$	$m_x^{\bar{\omega}_y}$	m_x^{β}	$m_x^{\delta_н}$	$m_x^{\delta_е}$
	–0,358	–0,073	–0,0751	–0,00516	–0,055
	$m_y^{\bar{\omega}_x}$	$m_y^{\bar{\omega}_y}$	m_y^{β}	$m_y^{\delta_н}$	$m_y^{\delta_е}$
	–0,068	–0,037	–0,139	–0,034	0,01012
	–	–	c_z^{β}	$c_z^{\delta_н}$	$c_x^{\delta_е}$
	–	–	1,02911	–0,06271	0,00021

Then, during the data composition process dependence of LM ADC on the angle of attack is restored:

$$\begin{aligned}
&m_x^{\bar{\omega}_x}(\alpha) = -00{,}64 + 0{,}024\alpha; \quad && m_y^{\bar{\omega}_y}(\alpha) = -0{,}66;\\
&m_x^{\beta}(\alpha) = -0{,}143 + 0{,}0095\alpha; \quad && m_x^{\delta_i}(\alpha) = -0{,}068 + 0{,}0047\alpha;\\
&m_x^{\delta_e}(\alpha) = -0{,}068 + 0{,}0027\alpha; \quad && m_y^{\bar{\omega}_x}(\alpha) = -0{,}21;\\
&m_y^{\bar{\omega}_y}(\alpha) = -0{,}565 + 0{,}064\alpha; \quad && m_y^{\beta}(\alpha) = -0{,}124 + 0{,}01\alpha;\\
&m_y^{\delta_i}(\alpha) = -0{,}14 + 0{,}01\alpha; \quad && m_y^{\delta_e}(\alpha) = -0{,}018;\\
&c_z^{\beta}(\alpha) = -1{,}41 + 0{,}097\alpha; \quad && c_z^{\delta_i}(\alpha) = -0{,}36 + 0{,}025\alpha;\\
&c_z^{\delta_e}(\alpha) = -0{,}045 + 0{,}0032\alpha.
\end{aligned} \tag{10}$$

Therefore, to evaluate weak ADCs it is advisable to carry out mode which is optimal by criteria (9).

Innovation №4. Structural and parametric identification of nonlinear multidimensional dependencies from experimental data.

In the wall studies partial sections $y(x_i)$ are taken for constant x_j $(j = \overline{1, n-1},\ j \neq i)$. Taking advantage of $y(x)$'s smoothness, let's represent this dependence by a multiple Taylor series of its power equivalent:

$$y(x) = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} x_i x_j + \cdots \ . \tag{11}$$

For k-th partial section with $x_i = \text{const}$, $i = \overline{1, n-1}, i \neq k$ let's obtain single-dimensional dependence from (11) using OLS:

$$y(x_k) = \beta_{0k} + \beta_{1k} x_k + \beta_{2k} x_k^2 + \cdots. \tag{12}$$

Then, coefficients of partial models are being sequentially approximated as functions of other variables.

Example. Wind tunnel blowing data (Fig. 5a) almost coincided with the aerodynamic corrections y model as a function of angle of attack x_1 and flaps position x_2 of TU-144 plane.

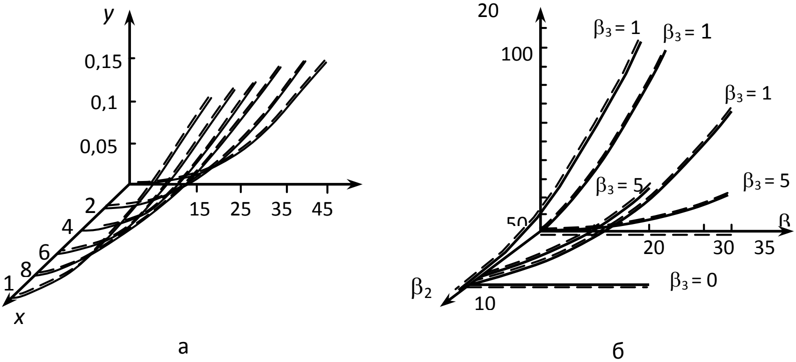

Fig.5 TU-144 plane dependencies: a) $Y(x_1, x_2)$; b) $J(\beta_1, \beta_2, \beta_3)$

Here from local models $y(x_2) = \beta'_{i1} x_2 + \beta'_{i2} x_2^2, \quad x_1 = \text{const}, i = \overline{1,6}$ by linear with respect to x_1 approximation of coefficients of model $\beta''_{i1}(x_1) = \beta_1 + \beta_2 x_1; \quad \beta''_{i2}(x_1) = \beta_3 + \beta_4 x_1$ the complete model $y = \beta_1 x_2 + \beta_2 x_1 x_2 + \beta_3 x_2^2 + \beta_4 x_1 x_2^2$. is obtained. Maximum approximation error was 2% of $y_{\max}$. Dependence $\hat{J}(\beta_1, \beta_2, \beta_3)$ (Fig. 5b) is obtained in a similar manner, where J is a correction of aerodynamical force of motion drag of TU-144 plane, β_1 is flaps position, β_2 is angle of attack, β_3 is a blow-off parameter

$$\begin{aligned} &J(\beta_1) = \alpha_{1ik}\beta_1 + \alpha_{2ik}\beta_1^2, \quad \alpha_{jik}(\beta_2) = \alpha'_{jk}\beta_2 + \alpha''_{jk}\beta_2^2, \\ &\alpha_{jk}^{(l)}(\beta_3) = \alpha'_j\beta_3 + \alpha''_j\beta_3^2 \quad i = 1,2,3; \quad k = 1,2,3; \quad j = 1,2. \end{aligned} \tag{13}$$

After correspondent coefficient substitution we get:

$$\hat{J}(\beta) = -0{,}96 \cdot 10^{-6} \beta_1\beta_2\beta_3 - 0{,}61 \cdot 10^{-2} \beta_1\beta_2^2\beta_3^2 + 0{,}9 \cdot 10^{-2} \beta_2^2\beta_3^2 +$$
$$+0{,}23\beta_1^2\beta_2\beta_3^2 + 0{,}04\beta_1\beta_2\beta_3^2 - 1{,}72\beta_2\beta_3^2 - 0{,}24 \cdot 10^{-4} \beta_1^2\beta_2^2\beta_3 +$$
$$+0{,}46 \cdot 10^{-5} \beta_1\beta_2^2\beta_3 - 0{,}0232\beta_2^2\beta_3 - 0{,}0126\beta_1^2\beta_2\beta_3 + 0{,}133\beta_1\beta_2\beta_3 + 1{,}02\beta_2\beta_3.$$

Approximation error does not exceed 0.5% of the maximum value of J.

Innovation №5. Analytical description of piecewise analityc dependencies.

The results of experimental investigation have provided the dependence (Fig. 6) of the weight amortization intensity

$$K_v = 10^3 \cdot \Delta V \cdot \left(S_k L\right)^{-1} \ , \tag{14}$$

where ΔV is the weight amortization; S_k is the area of contact; L is a friction way on the specific load P and sliding speed V for steel slider bearings 30ХГСА which are used in the torsion links joints, control nodes in the chassis' bushings and the joints in the beam units of levers of aircraft flight control system [2].

Graphical dependencies (points in Fig. 6) require further processing on the basis of piecewise analytic approximation method using selective functions [3].

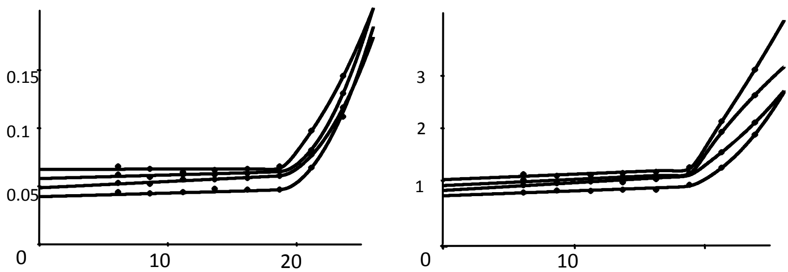

Fig. 6 Experimental data and its approximation

Fig. 6 shows (by continuous lines) usage results of method of piecewise analytical approximations using selective functions, where dependencies $K_v\left(P,V\right)$, $I\left(P_i,V_i\right)$ and $K\left(P,V\right)$ have acquired the following analytical representation:

$$A(z) = \left[\left(a2 \cdot z + a1\right) \cdot \eta_1(z) + \left(b2 \cdot z + b3 \cdot z^2 + b1\right) \cdot \eta_2(z)\right] \tag{15}$$

where $\eta_1(z) = \dfrac{1.4 \cdot 10^{51}}{z^{40} + 1.4 \cdot 10^{51}}$ $\quad \eta_2(z) = \dfrac{z^{40}}{z^{40} + 1.4 \cdot 10^{51}}$

The resulting dependencies smooth out inaccurate data points and make it possible to predict K_v and K for emergency settings.

Innovation №6. Method of obtaining unbiased effective estimates ADC equations of PM or LM movement in terms of aircraft state variables noisiness.

OLS-estimates are being found as the coordinate point of minimum of $\varepsilon^{\mathrm{T}}\varepsilon$ functionals which is averaged for the final time interval value of the square of ε

where ε is a mixture of wanted signal $Y^* - X^* \beta$ and random disturbance $N_y - N_x \beta$. Therefore, $\varepsilon^{\mathrm{T}} \varepsilon$ as a function of β is not accurate and the differentiation operation $\frac{\partial}{\partial \beta}\left(\varepsilon^{\mathrm{T}} \varepsilon\right)$ of the noisy function $\varepsilon^{\mathrm{T}} \varepsilon$ is incorrect. This causes low precision of OLS estimates on short noisy data samples. It is desirable to reduce the spread of the functional values without reducing its curvature at the extremum area. This can be done by additional averaging over the set of quasistatistically independent functionals close to the mean-square:

$$I = \frac{1}{2} \int_{-\tau_2}^{\tau_1} \eta(\theta) \int_0^T \varepsilon(t) \varepsilon(t+\theta) dt d\theta, \tag{16}$$

where $\eta(\theta)$ is the weight function

Requirement of minimum value of I by β leads to the system of normal equations:

$$A \cdot \hat{\beta} = B \ , \tag{17}$$

where for discrete in time t samples A is a $n \times n$ matrix consisting of $a_{ik} = \sum_{1=-p}^{p} \eta(l) \sum_{j=1}^{M} \left[(x_i(j+l)) x_k(j) + x_i(j) x_k(j+l) \right]$, B is a $n \times 1$ column matrix consisting of $b_k = \sum_{1=-p}^{p} \eta(l) \sum_{j=1}^{M} \left[(y(j+l)) x_k(j) + y(j) x_k(j+l) \right].$;

System (17) solution leads to desired estimation $\hat{\beta}$.

Provided the uncertainty of disturbances N_x and N_y weight functions selection should be performed by external (main) index I in the class of symmetrical with respect to $m = 0$, finite functions. The parameter γ affects the pulse width $\eta(m)$, and θ affects its asymmetry relative to maximum (Fig. 7a).

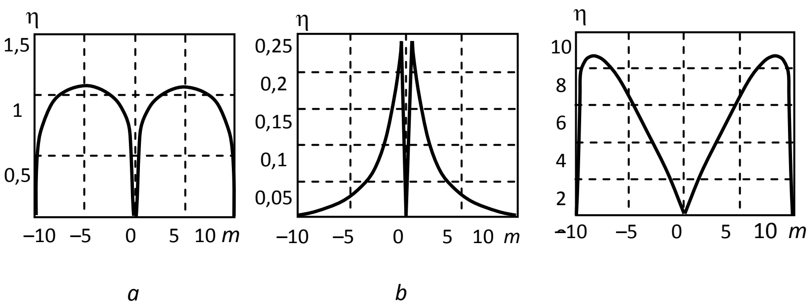

Fig. 7. Dependence η(*m*, θ, γ):

By changing θ and γ, if I is at extremum, the optimality of β estimation can be assured.

Innovation №7. Target-orientation of subsystem of primary information transducers on the problem of aircraft ADC identification, that is, a hierarchical system with ordered quality indicators at each level of the hierarchy.

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Formation of an integrated model based on dynamic data integration and simulation procedures of the production system

Presented approaches related to the integration of optimization and simulation procedures in the design of complex objects can be summarized in the following conclusions.

Introduction. Production systems are one of the most important classes of complex hierarchical systems, to optimize various aspects of which are given at the moment a lot of attention.A feature of the production systems is the inability to adequately describe them using analytical models.Production and sales process in an industrial plant is exposed to numerous external and internal factors and is characterized by instability, irregularity and stochasticity [1,3].This makes it necessary to use in the optimal design of integrated simulation procedures, which allows you to search the best options for production systems based on dynamic and stochastic aspects of their functioning.

In forming a complex simulation model of the supply system it is advisable to use a block-hierarchical approach that is carried out on the structuring of the generalized model of interconnected blocks, corresponding to the individual sub-systems, with the possibility of co-ordination and sharing.This enables simulation of different levels of detail (Fig. 1).

In the simulation of the production system we use the conventional hierarchy of production and economic systems:

- PM - the level of process modules, implemented on the basis of special processing equipment;
- TO - the level of technical operations, implemented within the workplace;
- P - level processing system (or process) is implemented, as a rule, within the plant or production site;
- PS - the level of the production system is implemented across the entire production process;

Wherein$PM \in TO \in P \in PS$.

The main structural elements of the production system will be considered production units and storage units [2].Generalized structure of the production system can be represented as a result of the combination of production units linked to each other through the storage units in a single technological chain.Structuring of the simulation model is proposed to carry out to the level of detail-oriented production sites.

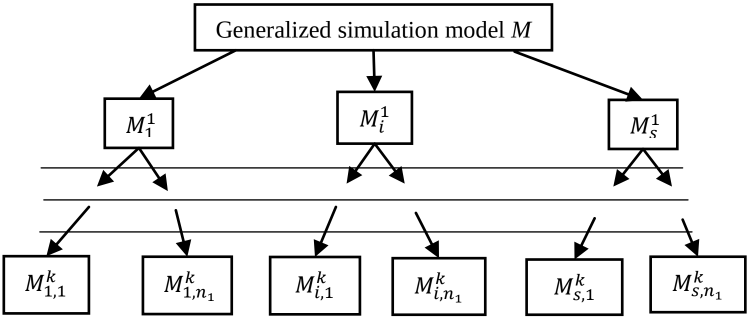

Fig. 1 Structure of generic simulation model

It is advisable to use the device queuing networks for formalization of simulation models of production systems [3].At the same time as the structural elements of the model are considered elements of the following types:

- $w \in W$ - stream service applications (the flow of components and materials entering the production areas);
- $K_i \in K$ - channel queuing (production units);
- $H_i \in H$ - applications drives (line of accessories to production units);
- $u_i \in U$ - stream service at production sites;
- $y_i \in Y$ - output stream applications (machined parts) coming from industrial sites.

Main results. In accordance with the common terminology, each i-th elementary act of service can be represented as P_i device maintenance (Fig. 2), which converts the input stream to the output of applications in accordance with $A_i \in A$ operation algorithm, a set of rules defining the behavior of applications in the system.

The functioning process of P_i service device can be viewed as the process of changing the state of its components in time $g_i(t)$. Transition to a new state P_i means a change in the number of applications that it contains (in the channel K_i and drive H_i). Thus, the state vector for the device P_i has the form: $G_i = (g_i^H, g_i^K)$, where g_i^H - state of drive H_i ($g_i^H = 0$- the drive is empty, $g_i^H = L_i^H$- in storage are L_i^H requests waiting for service); g_i^K – status of channel K_i ($K_i = 0$- the channel is free, $K_i = 1$- the channel is busy).

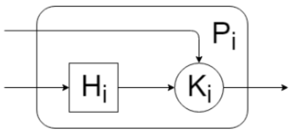

Fig. 2. The device of requests servicing

Multiphase queuing network can be collectively represented as Q-scheme which is formed by the elementary composition $P_i$of service devices. This P_i devices and their parallel composition are connected in series using the operator interface $R_i \in R$, reflecting the relationship between the elements of the structure itself. Own (internal) parameters of Q-scheme will be a number of phases L_{ϕ}, the number of channels in each phase $L_{kj}, j = \overline{1, L_{\phi}}$, the number of drives each phase $L_{Hi}, i = \overline{1, L_{\phi}}$, the capacity of the m-th drive L_m^H.The flow of components and materials can be represented as a simple density requests with flow $f(\tau) = \lambda_i e^{(-\lambda_i * \tau)}$ (with λ_i- the intensity of the receipt of applications for the i-th type).The types of requestsdiffer by distribution laws, or by mathematical expectations for the same distribution law.This takes the assumption of independence of the service times for different requests of the same type, it is correct for most real systems.It is assumed that the service time has an exponential distribution density:$f(\tau_{об\ j}) = \lambda_i e^{(-\lambda_i * \tau_{об\ j})}$. The simulation uses nonpriority expectations of discipline and service.Modeling is performed on the queue FIFO principle (first in, first out) [2].Maximum storage capacity (maximum queue depth) is considered equal to infinity.In this regard, the effluent is only served from requests (finished products and semi-finished products defective).The whole set of internal parameters for Q-scheme is denoted by S.Therefore, Q-diagram describing a process operation of production system can be defined as:

$$Q = < W, U, S, G, R, A >$$

The Q- a generalized diagram corresponding discrete type production is shown on Fig. 3.

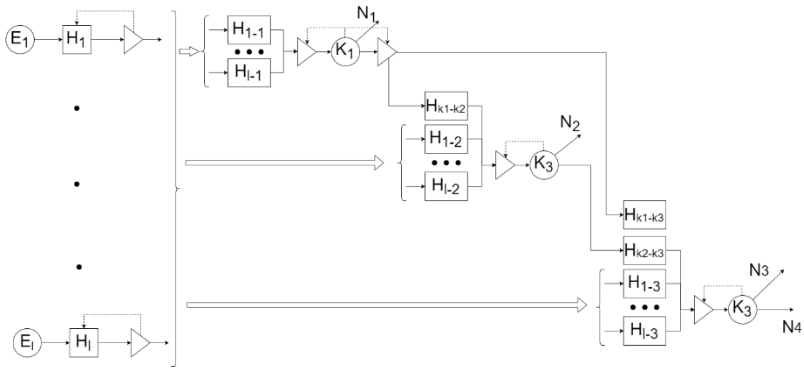

Fig. 3. Generalized Q-diagram of a production system

Event sources $E_1 - E_l$ are flows of components and materials, which after entering the production system are placed at the warehouse ($H_1 - H_l$ drives).Service channels ($K_1 - K_3$) of harvesting (K_1), of the machining (K_2) and assembly (K_3) stages of the production process, typical for discrete manufacturing. The drives before each channel reflect the location of components and materials in line for each item. There are requests in the drives before each channel witch are coming both from the entrance, and the previous service channel. The flows($N_1 - N_3$) correspond to the rejected products, N_4flow - finished products.

Optimal design is associated with structural and functional analysis of the production and sales processes throughout the enterprise. In this regard, before the simulation stage it is advisable to implement a phase of functional modeling that allows the formation of an integrated model of production and distribution systems, taking into account the various aspects of its activities [4].One of the most promising areas of the structural and functional modeling of production systems is the use of CASE-technologies and related tools.

Summary

Presented approaches related to the integration of optimization and simulation procedures in the design of complex objects can be summarized in the following conclusions.

The need to address the dynamic and stochastic properties of complexsystems leads to a sharing process of optimumdesign optimization and simulation procedures. Considered various patterns of interaction simulation and optimization models for optimal design. Presented a generalized scheme of integration optimization and simulation procedures on the principle of "feedback", the possibility of solutions based on its various classes of problems of optimal design.

Optimization-simulation approach is proposed to be used to solve the problems of parametric and structural synthesis of production systems. Discussed the problems of formation of simulation models of production systems using the apparatus of queuing networks.

Decomposition approach was used for the optimum design of production systems of their structuring on the interconnected blocks of varying degrees of detail with the ability to make optimal design decisions at both the individual block level and at the level of the whole system. Proposed a structure for multi-level decision support system, each element of which corresponds to a specific unit of the production system, and includes a simulation model of the unit and complex optimization models, designed to address different classes of optimal design problems. For the organization of directed simulations is proposed to use adaptive algorithms for continuous and discrete optimization.

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Algorithm of correlation-extreme correction of inertial dead reckoning by linear landmark

Developed algorithm is easy used on UAV board without essential computational costs. It has also been proved the use of extended landmark for such purpose. Images were processed by blob detection method and then obtained some morphological characteristics of objects that are subsequently filtered. As a result, obtained the characteristics of the object with the greatest length, as linear landmark, which allows to estimate UAV location.

Currently existing navigation systems of unmanned aerial vehicles (UAVs) are characterized by a high dependency on the information received from the satellite navigation system (SNS), such as GPS/GLONASS. Application of these systems has several limitations. Firstly, the need to ensure the required accuracy of position detection, and secondly, the possibility of using by opponent SNS signal suppression systems. In nowadays more and more systems of electronic warfare with UAVs using GPS-spoofing are gaining traction. A GPS spoofing attack attempts to deceive a GPS receiver by broadcasting counterfeit GPS signals, structured to resemble a set of normal GPS signals, or by rebroadcasting genuine signals captured elsewhere or at a different time. These spoofed signals may be modified in such a way as to cause the receiver to estimate its position to be somewhere other than where it actually is. Therefore, the problem arises of developing an additional source of navigation information, which should allow positioning of UAV at the times, when the information is not available from the SNS or does not provide the required positioning accuracy. As such, a source of navigation information is proposed to use computer vision system.

Purpose of work is to solve the problem of external orientation by searching linear landmarks on images of geophysical field, received from UAV.

Dead reckoning method. The method is based on continuous calculation of aircraft trajectory by velocity vector data (integration of measured velocity vector in time or double of acceleration relatively the ground surface) taking into account the initial coordinates.

Information about the aircraft velocity can be obtained from inertial navigation system, from Doppler navigator or from air data computer system. With known aircraft heading and taking into account the wind speed and drift angle, it is possible to take the velocity components in the selected coordinate system. Their further integration gives the information about the components of traveled path.

To determine the current coordinates of aircraft the system needs the coordinates of initial waypoint from which the dead reckoning is started.

A disadvantage of dead reckoning method there is error accumulation over time when determine the location of aircraft.

Two straight lines as linear landmark. As an external landmarks used objects such as roads, runways, ground relief items. Geographic coordinates and dimensions of such objects should be known in advance.

Depending on the type of task landmarks exterior orientation it can be solved in several ways, in particular by the line and point (a point landmark), by three points or by two lines. Let's consider the linear landmark algorithm based on two lines landmark. Fig. 1 shows typical situations.

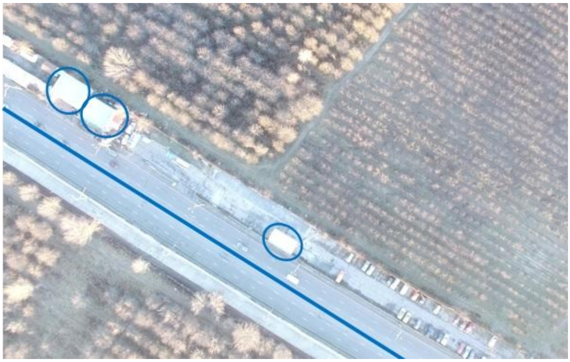

Fig. 1. Different types of landmarks. Linear guidance are marked with blue lines, dot - blue circles.

One of the main tasks of the orientation estimation is the detection of landmarks on the observed scene. For searching and detection of area reference point and small-sized landmarks are used correlation image processing methods, for line detection – methods of allocation of contours and lines analysis. The correlation method is based on the comparison of the images of the observed objects with their reference images stored in the memory.

For searching the linear landmarks is used algorithms for detecting straight line segments. The results of the implementation of certain specific steps of the algorithm shown in Fig. 2 (the original image, the contour image and isolated landmark boundaries image, respectively).

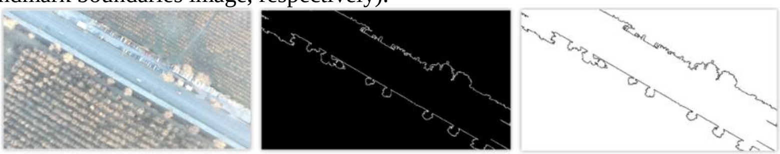

Fig. 2. Allocation of the lines segments

For the edge detection implemented Canny algorithm. Search of straight line segments is based on the use of blob analysis and additional procedures of lines analysis, such as checking the curvature and line merging.

Allocated lines are used to determine the external orientation for the evaluation of height, lateral displacement and angle of the course on the reference object.

Fig. 4 shows the global coordinate system. In the planes OX_aZ_a are parallel lines A and B, which can be viewed as a landmark border, in particular edge of the road.

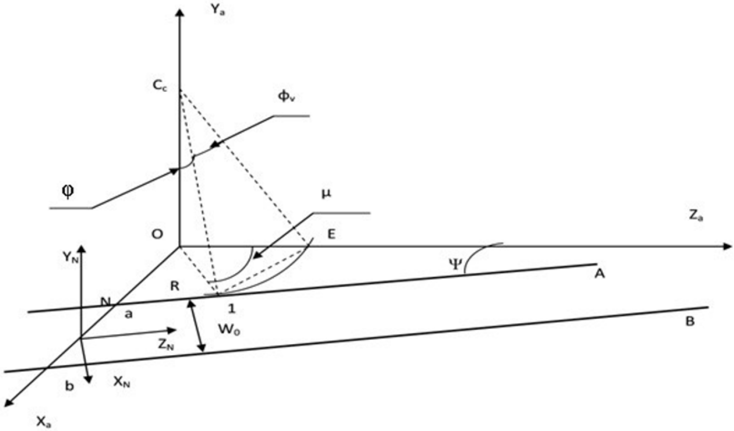

Fig. 3. Estimation of orientation with respect to two lines

In the Fig. 3.4: *A, B* — line boundary of the roadway; W_0 — the width of the roadway; p. C_c — receiving matrix center of the camera; ψ— yaw angle of the UAV relative to the roadway.

In accordance with Fig. 3.4 values of yaw angle ψ, lateral displacement Oa and height OC_c can be determined by the formulas [1]:

$$k = \frac{\left[\tan(\varphi_{A1})\cdot\sin(\mu_{A1}) - \tan(\varphi_{A2})\cdot\sin(\mu_{A2})\right]}{\left[\tan(\varphi_{A1})\cdot\cos(\mu_{A1}) - \tan(\varphi_{A2})\cdot\cos(\mu_{A2})\right]}; \quad (1)$$

$$\Psi = \arctan(k); \quad (2)$$

$$OC_c = ab\begin{Bmatrix}\left[\tan(\varphi_{B1})\cdot\sin(\mu_{B1}) - \tan(\varphi_{A1})\cdot\sin(\mu_{A1})\right] \\ -k\cdot\left[\tan(\varphi_{B1})\cdot\cos(\mu_{B1}) - \tan(\varphi_{A1})\cdot\cos(\mu_{A1})\right]\end{Bmatrix}^{-1}; \quad (2)$$

$$Oa = OC_c\cdot\tan(\varphi_{A1})\cdot\sin(\mu_{A1}) - k\cdot OC_c\cdot\tan(\varphi_{A1})\cdot\cos(\mu_{A1}), \quad (3)$$

where OCc — height above the roadway; Oa— lateral displacement with respect to the roadway; *A, B* — indexes indicating the lines at the corners φ and μ; 1, 2 — indexes designating points on the respective lines.

As seen from the formula for calculating the required quantities using three points – two on the line *A* and one on line *B*. Thus, the above formula can be used for this case and for the other two – determining the orientation by three points landmarks and one linear and point landmarks.

A simple edge model. A number of researchers have used a Gaussian smoothed step edge (an error function) as the simplest extension of the ideal step edge model for modeling the effects of edge blur in practical applications. Thus, a one-dimensional image *f* which has exactly one edge placed at *x*=0 may be modeled as:

$$f(x) = \frac{I_r - I_l}{2}\left(\operatorname{erf}\left(\frac{x}{\sqrt{2\sigma}}\right)+1\right)+I_l. \qquad (4)$$

At the left side of the edge, the intensity is $I_l = \lim_{x\to-\infty} f(x)$, and right of the edge it is $I_r = \lim_{x\to\infty} f(x)$. The scale parameter σ is called the blur scale of the edge. Ideally, this scale parameter should be adjusted based on the quality of image to avoid destroying true edges of the image.

The implementation of this method in Matlab is shown in Fig 5.

Fig. 1 Implemented edge detection.

Flight height calculation. To solve future problem for the development of the algorithm, firstly, we must determine the flight height. To start with we will look at how to build a simple single-lens image in the lens, and then we will show why the results are well suited for complex lenses that combine more than ten consecutive lenses. Scheme path of rays for the camera in a thin lens (Fig. 6):

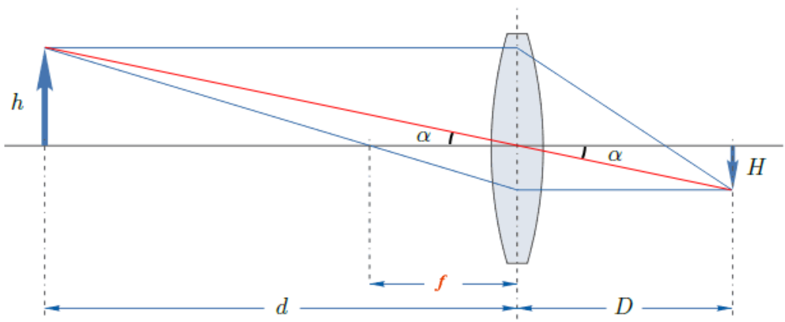

Fig.6. Imaging convex lens

In this scheme d - the distance from the lens to the object, D - the distance from the lens to the image of the object (on the matrix or film plane) and f - focal length of lens[4].

The formula of thin lens connects these three distances:

$$\frac{1}{d}+\frac{1}{D}=\frac{1}{f}.$$

This is very useful as part of our problem, because the distance d, we just do not know the distance D would have to be considered separately, but the focal length of indicated on the lens.

Now look again at the optical system: h is the linear size of your subject, and H is the size of his thumbnail image. It is easy to note that $h = d\tan\alpha$, and $H = D\tan\alpha$ (are properties of a right triangle). Substituting these values in the thin lens formula, we see that tan α is reduced, and as a result we obtain the following equation:

$$1+\frac{h}{H}=\frac{d}{f}.$$

So we have expressed through the known quantities inconvenient to calculate the value D. Now, based on this equation will express the desired distance to the object:

$$d=\frac{f\left(H+h\right)}{H}. \qquad (5)$$

Then according to camera characteristics' we have f=0.015(m) and H=0.0021(m), also h=50(m). After that we can calculate the flight height with response to equation (3.22) and obtain 357 meters.

Obtained photo was not cropped or rotated, so let find out the exact linear size of the object image. Hence, one pixel contains 0.073 meters.

Blob analysis. One of the first and also most common blob detectors is based on the Laplacian of the Gaussian(LoG). Given an input image f = (x, y), this image is convolved by a Gaussian kernel [2].

A main problem when applying this operator at a single scale, however, is that the operator response is strongly dependent on the relationship between the size of the blob structures in the image domain and the size of the Gaussian kernel used for pre-smoothing. In order to automatically capture blobs of different (unknown) size in the image domain, a multi-scale approach is therefore necessary.

A straightforward way to obtain a multi-scale blob detector with automatic scale selection is to consider the scale-normalized Laplacian operator and to detect scale-space maxima/minima, that are points that are simultaneously local maxima/minima of with respect to both space and scale. Thus, given a discrete two-dimensional input image a three-dimensional discrete scale-space volume is computed and a point is regarded as a bright (dark) blob if the value at this point is greater (smaller) than the value in all its 26 neighbors. Thus, simultaneous selection of interest points and scales is performed.

Experimental results. With the help of blob analysis can be extracted such characteristics as eccentricity, orientation and area of linear landmark. Eccentricity characterizes the length of landmark.

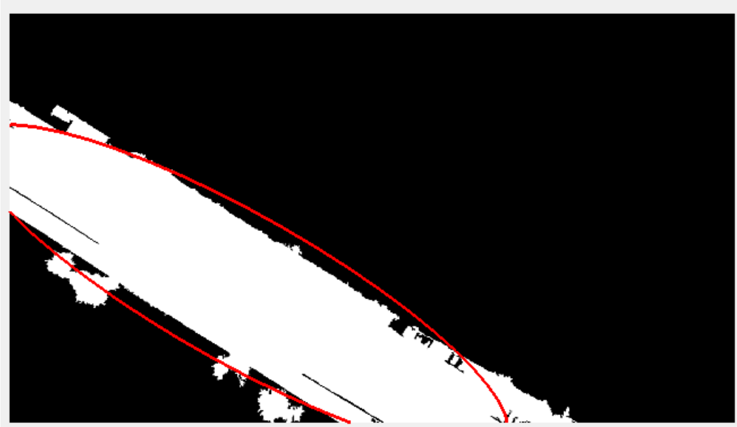

Fig. 7. Object of the image is detected as linear landmark with eccentricity = 0.9703, orientation = -29.3623 and area = 1794973 px.

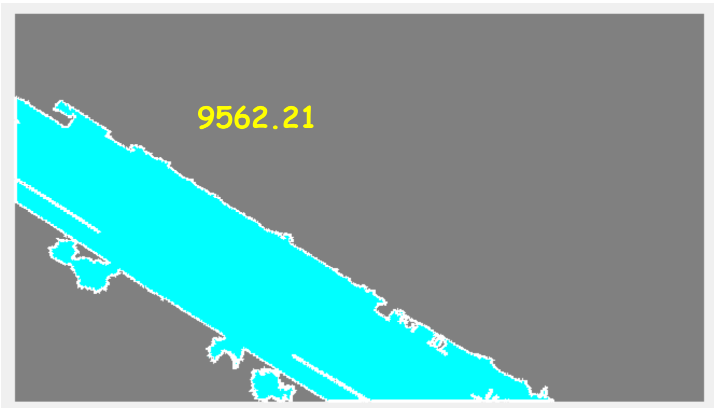

Fig. 8. The total area of viewed roadway equals to 9562, 21 m^2.

After the selection at the output obtain the linear landmarks. After the experiments it was found that a linear object can occupy from 6.4% of the frame and be detected successfully. This algorithm is easy used on UAV board without essential computational costs. It has also been proved why we should use extended landmark for such purpose. Images were processed by blob detection method and then obtained some morphological characteristics of objects that are subsequently filtered. As a result, obtained the characteristics of the object with the greatest length, as linear landmark, which allows to estimate UAV location.

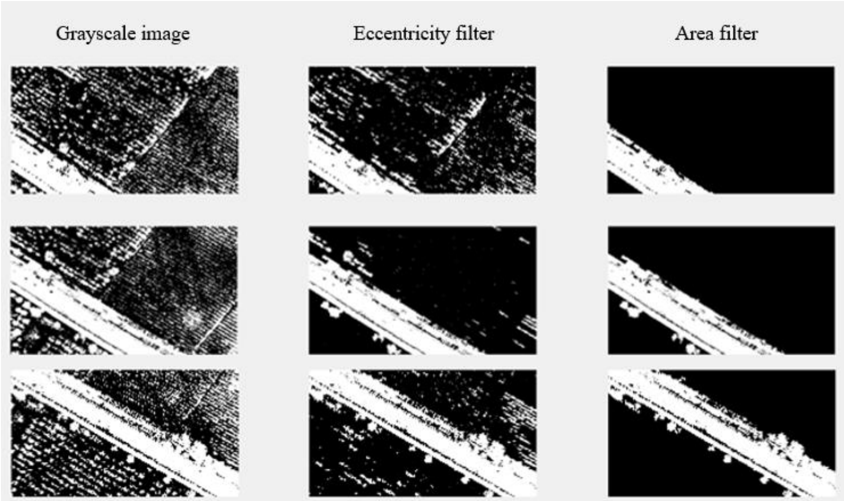

Fig. 9. Stages of processing

The method has a limitation in the choice of technical equipment. The camera must be rigidly secured, that is, its optical axis should coincide with a vertical axis and is oriented perpendicular to the Earth's surface.

Conclusions

Finally, the proposed algorithm of the linear landmark detection by images of geophysical fields has got its realization in MATLAB developing tool and successfully tested. After the experiments, it was found that a linear object can occupy from 6.4% of the frame and be detected. The analysis of the effectiveness of the INS correction is equal to 99.7% and shows that the algorithmic software gives as correct results of location determining as possible.

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Onboard monitoring system of ground aircraft download

Analysis of aircraft ground loading process is given. The need to measure the weight of the loaded characteristics of the aircraft is shown. Brief overview of chassis construction and characteristics of its deformation of the support piece is shown. It is proposed to combined construction device for measuring deformations of the support piece with capacitive transducers. Conditions for implementation of monitoring system for ground aircraft download are considered.

When loading the aircraft proper stowage and securing reliable it is essential for safety. Placement of cargo on the plane should not shift the position of its center of mass (alignment) of range. Placement of cargo from the boundary alignment value degrades the stability and controllability of the aircraft, doing weight off and landing, increases the load on the pilot, to a certain extent affect the fuel consumption. Analysis of the causes and circumstances of many emergency situations shows that the availability of the actual alignment of the front outside of the permissible value increases the rate of descent. One reason for this uncertainty is ground loading.

Calculation of alignment and load the plane carries traffic service organization. The main document for calculating alignment, when loading the aircraft - «Руководство центровочной загрузки (РЦЗ)» ("Manual centering download") Formulas and download charts in this document are shown. At airports, where this service is not available, the center of gravity position calculation holds crew and the work load of the ship and cargo consolidation - Loader airport under the supervision of one of the crew members. Work on verification of serviceability and preparing to use the on-board handling equipment, its maintenance and repairs carried out by employees of АТБ (Aero technical base). Ground measurement of factual weight characteristics and to determine the alignment of the loaded airplane is unfortunately absent. Necessary to develop and implement on-board systems of technical means for monitoring the weighting characteristics of the aircraft after it is downloaded.

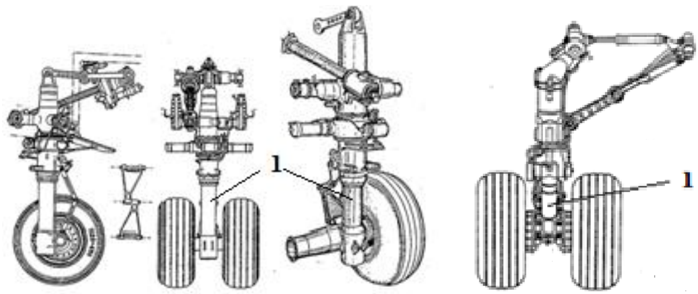
With a view to finding ways of solutions this problem the methods and technical means to determine the total weight of the aircraft and its alignment are considered.

Review and analysis of existing technical means for weighing shows, that weighing of aircraft is performed by ground aircraft scale with electronic display, such as the ВАТ-23. Aerial scale divided on platform and rack (mounted on racks). Determination of weight characteristics is performed for an empty or fueled the aircraft after its manufacture or repair at the factory and is recorded in the aircraft logbook.

Aircraft scales are intended for determination mass aircraft and location the alignment of airplanes and helicopters. Strain gauges of aircraft scales provide electrical signal in the form of a voltage proportional to the measured weight of the aircraft, after it signals introduced to a computer, where they are processing.

The data allow us to calculate the position of the center of gravity of the aircraft. The result can be reflected on a computer monitor. In particular, constructed and operated weighbridge for AN-2 aircraft, the An-24, -26, -30, -32, Mi-2 and Ka-26, and rack the weight for the An-12, An-24, An -26, Yak-40, IL-76. For SOEs "Antonov" designed rack scales for super heavy aircraft carrying up to 300 tons.

All considered devices are ground and placed in the factory hangars. For control weighting characteristics of the aircraft after calculated load after the voyage it is necessary to develop measuring deformation based on the definition of basic parts of the chassis. Consider the typical constructions of the typical chassis of the aircraft.



a) **б)**

As seen in Fig.1. all designs have a cylindrical part (1), which determine the deformation of the chassis load [1]. Consider the deformation of the cylindrical parts (Fig.2.). When the load force F decreases its length l, the diameter increases. The maximum increase is in his mid-parts ***x.*** ε_l relative to the longitudinal and transverse deformation ε_s carrying information about the load size F [3].

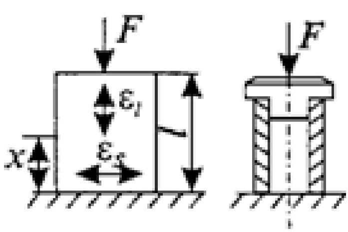


Fig.2.

To convert strain into an electrical signal often used gage sensors. But on the chassis of the aircraft often affect shock loads. This occurs when boarding the aircraft, especially during rough landing, the rolling-out an emergency landing at the limit bandwidth, if the path to ground aircraft traffic accident foreign objects. The deformation of the cylindrical parts while beyond the boundaries of the operating range gage and he goes down.

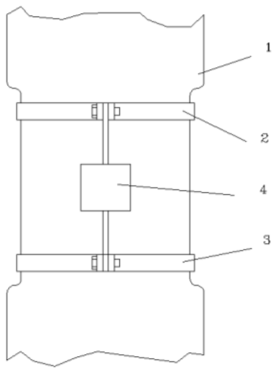


Fig.3. Construction of the sensor longitudinal deformation of the cylindrical chassis parts: 1-cylindrical part of the chassis; 2-the upper fastener; 3-bottom fastener; 4-capacitive

To solve the problem is proposed use capacitive transducers. The construction of longitudinal deformation sensor with a capacitive transducer (Fig.3) is consided. In the upper fixed core delighted with the electrodes of the capacitive transducer. In the lower fixed fastened grounded rod. His move changes the balance of electromagnetic fields two capacitors included in the scheme of transformer bridge [2]. Unbalance signal carries information about the amount of deformation rack. chassis and its load.

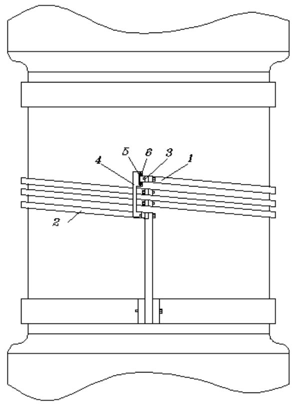


Fig. 4. The design of the sensor transverse deformation of the cylindrical chassis parts: 1-upper annular elastic element; 2 - lower annular elastic element; 3- rolling grounded electrode capacitive transducer; 4 - piece placed on high potential electrode capacitive transducer; 5, 6 - high potential electrode capacitive transducer.

In this same cylinder on the opposite side of the transverse strain sensor is placed. Its design (Fig. 4) consists of 3 elastic metal rings pressed against the surface of the cylinder and fastened together. The end of the lower elastic element attached to the rod, the other end is attached to the lower delighted.

The final surface of the upper elastic element, when no load, is on the base line parallel to the axis of the cylinder. When loading gear cylinder diameter increases and the final surface elastic element deviates from the baseline. Distance deviation is about the size of the rack chassis deformation, and it is about load. To measure the variation applied capacitive transducer. At the upper end of the rod that is fixed on the lower part attached fastener at the upper end of which is placed capacitive transducer design. It consists of two high potential electrodes placed on the bottom plate and the low potential electrode placed on the plate with high potential electrodes. Rolling grounded electrode capacitive transducer is placed between them. In the absence of abnormalities transformer bridge circuit is connected to this differential capacitor balanced. The load causes deformation rack chassis and unbalance the bridge.

The design has the following features. If some load increase the radius of the cylinder in the control reaches 1 micron (10^{-6}m), rejecting one elastic element from baseline to 6.28 microns, and 3 elements - 27,84 microns. That is, this design has a sensitivity of about 30 times higher.

As discussed above in determining the weight of the aircraft and its alignment on aviation scales obtained information is transmitted and processed by computer. The calculated data can be displayed on the monitor. This equipment and the structure of the system can be used in the developed onboard monitoring system ground aircraft loading. The necessary electrical signals from strain gauges rack chassis and front right and left landing gear converted to discrete form and send in an onboard computer. The program of processing and imaging data is introduced by crew members.

Also consider the impact of weather conditions: wind, rain, snow. To avoid these effects is proposed to use a mobile hangar as a collapsible structure, covered with a tarpaulin. Upon entry into the hangar front and rear curtain is lowered. This hangar is most expedient to place the edge of the taxiway, where and load the aircraft before takeoff. If this is a passenger aircraft, the exercise load control and possibly correct the alignment.

A load control system onboard the aircraft will significantly improve safety. Measuring strain landing gear will allow the state to exercise control design of the chassis and prevent the possibility of damage [4]. Capacitive transducers have high sensitivity and allow measurements of sufficiently small displacement.

The implementation of monitoring system for ground aircraft download is advisable.

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Quality estimation of an unmanned aerial vehicle in acceptance sampling

It is proposed a new method of quality estimation of an unmanned aerial vehicle (UAV) in acceptance sampling, taking into account its different expected operating conditions and minimum test volume.

The acceptance test of UAV is assigned to confirm the required probability W_R of its quality, i.e. its operation accuracy, and the hypothesis $W \geq W_R$ has to be assumed with a high confidence level γ .

The operation accuracy is associated to the success of operation target according to the UAV type (target and decoy, reconnaissance, combat, research and development, civil and commercial UAVs). For example, the operation success of an object tracking drone is thought to be the fall of all the parameters of the tracking sensor within a specified range during one test.

Of course, the acceptance tests must be full-scale, i.e. conducted in real operating conditions (climatic and mechanical influencing factors and operating modes), which can fundamentally diverse. Thus a sample data drawn from the test may be considered heterogeneous (different) and dependent upon the operating conditions.

Then the value W has the sense of total probability, W_T :

$$W_T = \sum_{j=1}^{r} S_j W_j, \tag{1}$$

where W_j – a conditional probability, S_j – a prior probability for j – condition, $\sum_{j=1}^{r} S_j = 1$.

We will use the binomial sampling plan (Bernoulli's formula) for processing of results and test of hypothesis about UAV quality, a modified truncated sequential analysis method for heterogeneous conditions. In this method the successful and failure operations of the UAV are summed up during the tests in different conditions. According to the observations the hypothesis of the total probability W_T is verified and one takes the decision of test termination or continuation.

In the acceptance procedure several sampled vehicles can be tested in the different places, conditions and at different times or in parallel. In this case the number of tests is summed up.

The formula of Bernoulli was introduced earlier exclusively for the samples with a constant failure probability $q=1-W$ in each independent test, i.e. for the same (homogeneous) operational and test conditions. But in fact q is not a constant value when the tests are performed in different conditions.

The acceptance procedure provides testing of the hypothesis $W_T \geq W_R$ with the type II error $\beta = 1 - \gamma$ (the risk of erroneous acceptance of the hypothesis $W \geq W_R$). In case of faultless control according to the Bernoulli formula:

$$\beta_0 = W_T^{N_0}, \tag{2}$$

where N_0 - is a sample amount.

The proposed method is based on the new introduced and proved theorems of failure probability for the series of independent tests. It is based on expanding of application limits of the Bernoulli's binomial acceptance plan to the case of a heterogeneous proportional sampling.

In this method the prior probabilities $S_i, i = \overline{1,r}$ of the different operational conditions of the UAV are assigned, where r is a total number of conditions (or groups of conditions). The partial probabilities of the success W_i can be left undetermined. If the values S_i are unknown, the equal probable values $S_i = n^{-1}$ are assigned for the test.

The scope of a proportional heterogeneous sampling is:

$$N = \sum_{i=1}^{r} N_i = \sum_{i=1}^{r} S_i N. \tag{3}$$

Then the non-failure probability (the risk) of such a sampling is as follows:

$$\beta_0^* = W_1^{N_1} \cdot W_2^{N_2} \cdots W_r^{N_r} = \prod_{j=1}^{r} W_j^{N_j} = \left(\prod_{j=1}^{r} W_j^{S_j} \right)^N \tag{4}$$

If we consider an equivalent homogeneous sample of the same volume N with a constant failure probability q in each test, equal to the total failure probability for the relevant heterogeneous one:

$$q_T = 1 - W_T = 1 - \sum_{j=1}^{r} S_j W_j = \sum_{j=1}^{r} q_j S_j, \tag{5}$$

then the non-failure probability of such a sampling is given as follows:

$$\beta_0 = W_T^N = \left(\sum_{j=1}^{r} W_j^{S_j} \right)^N \tag{6}$$

As $\left(\beta_0^*\right)^{\frac{1}{N}}$ - is a weighted average geometrical value, and $\left(\beta_0\right)^{\frac{1}{N}}$ - is a weighted average arithmetic value. Since $\left(\beta_0^*\right)^{\frac{1}{N}} \leq \left(\beta_0\right)^{\frac{1}{N}}$ always, we can assert that for a proportional sampling without any failure of any operational conditions size, for any values S_j and W_j,:

$$\beta_0^* \leq \beta_0 \tag{7}$$

For example, from (6) for $W_T = 0.95$, $N_0 = 45$, $\beta_0 = 0.1$ .Thus the heterogeneous sampling of the size $N_0^* = 45$ may consist of the single tests of equally probable conditions.

It is proven that in the case of one failure (k=1) the risk β_1^* of erroneous acceptance of the hypothesis $W_T \geq W_R$ is not more than the risk β_1 for a homogeneous sample of the size N_1, and $N_1^* = N_1$. At that all the test conditions can be divided into the two groups: simple and complex ones. The prior probabilities S_1, S_2 and the probabilities W_1, W_2 can be different, but $W_T = S_1W_1 + S_2W_2$.

It is proven that when the acceptance number of failures is 2 (k=2), the risk β_2^* of erroneous acceptance of the hypothesis $W_T \geq W_R$ is not more than β_2 for a homogenous sample of the size N_2, but at $S_1 = S_2 = 0.5$ and at $N_2^* = N_2$.

Thus, this method provides the required reliability of decisions on quality of the finished UAV (s), based on the minimum amount of testing and taking into account the different operational conditions, as well as the acceptable customerrisks of the wrong decisions. The decisions are accepted based on the natural tests in the conditions appropriate to the real operational ones.

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General principles of decision-making support in provision of guaranteed level of safety

For solving of problem under uncertainty condition, quantitative methods are the most effective, taking into account existence of uncontrollable factors. Using these methods, there is a problem of choosing appropriate optimality principles. In this article is considered the possibility of the principles of the guaranteed result and guaranteed losses.

Innovative development of aviation industry is connected with a high risk which is determined by hazards and unpredictable dynamics of the environment in which microenvironment is considered (designers, developers, flight-technical and air traffic supervisory staff, managers at various levels, consumers, competitors, investors, lenders, and so on. d. and the microenvironment (political situation, natural conditions, financial policy of the state). [1,2]. The presence of uncertainty complicates the optimal decision-making selection process and may lead to unpredictable results.

The essence of the problem of assessing the effectiveness of management decisions in exercise of aviation activities in uncertainty conditions is as follows.

1. In order to achieve safety goals set formed ways to achieve goals:

$$X = \{X_i\}, i = \overline{1,n}$$

X_i is controllable factors. They can be controlled by managing or decision-making person. X_i factors may have economic, management, financial and other content.

2. The environment is characterized by a set of uncontrollable factors:

$Y = \{Y_j\}, j = \overline{1, j}$

The special features of uncontrollable factors include the fact that the probability of their occurrence is unknown. Given factors can’t be controlled by managing or decision-making person. Y_j can be natural factors, inflation, external economic conditions, actions of competitors etc.

3. To evaluate the effectiveness of the analyzed system generates a plurality of parameters:

$K = \{K_m\}, m = \overline{1,m}$

K_m may have an economic, innovative, technical and other content.

4. Determine dependence of the effectiveness index of controlled and uncontrolled factors, i.e. dependence of the:

$K_m = f_m(X,Y)$

5. Composing the effectiveness matrix:

$\|K_m(X,Y)\|, m = \overline{1,M}$

6. Forming the principles of optimality:

$G = \{G_l\}, l = \overline{1,L}$

G_l -principles can be: optimism, pessimism, guaranteed result, guaranteed losses, and others. Appling each of principles for the selection of effective innovative solutions, the following situation:

a) The results of use of each of the principle are equal, i.e.

$X_1^0(q_1) = X_2^0(q_2) = ... = X_n^0(q_n),$

where $X_i^0(q_i),$ - effective solution, applying principle q_i

б) Results of applying of the principles is vary, i.e.

$X_1^0(q_1) \neq X_2^0(q_2) \neq ... \neq X_n^0(q_n),$

In this case, all effective solutions obtained by using each of the principles are different.

в) Part of the results of applying different principles is coincident and the other results are not the same, i.e.

$X_1^0(q_1) = X_2^0(q_2) = ... = X_n^0(q_n), X_{m+1}^0(q_{m+1}) \neq X_{m+2}^0(q_{m+2}) \neq ... \neq q_n^o(q_n)$

7. Using the effectiveness matrix and formed optimality principles, it is used to select the optimal solution (X_0,Y_0) In this case, the presence of uncertainty due to the influence of uncontrollable factors, leads to additional uncertainty caused by the use of contradictory principles of efficiency.

Following the basic principles of assessing the effectiveness of the analyzed system, in the face of uncertainty, and illustrates the problem discussed above of their use for the selection of optimal solutions.

To select effective solutions apply the principles of the guaranteed result and guaranteed losses.

The principle of a guaranteed result[1,3]:

$\varepsilon_{gr} = \max\min \varepsilon_{(x,y)}$.

$X \in X_y \in Y$

This principle shows a guaranteed result we get in the presence of uncontrollable factors, operating the most unfavorable way.

The effectiveness matrix for the principle of guaranteed result is shown in Table. 1.

The effectiveness matrix for the principle of guaranteed result

$$\begin{Bmatrix} y,x & y_1 & y_2 & \cdots & y_n & \varepsilon_{\min} \\ x_1 & \varepsilon_{11} & \varepsilon_{12} & \cdots & \varepsilon_{1n} & \varepsilon_{1\min} \\ x_2 & \varepsilon_{21} & \varepsilon_{22} & \cdots & \varepsilon_{2n} & \varepsilon_{2\min} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ x_m & \varepsilon_{m1} & \varepsilon_{m2} & \cdots & \varepsilon_{mn} & \varepsilon_{m\min} \end{Bmatrix}$$

On base of initial effectiveness matrix (Table. 1) loss matrix is forming (Table. 2).

Table 2

Loss matrix

$$\begin{Bmatrix} y,x & y_1 & y_2 & \cdots & y_m & \eta_{\max} \\ x_1 & \eta_{11} & \eta_{12} & \cdots & \eta_{1m} & \eta_{1\max} \\ x_2 & \eta_{21} & \eta_{22} & \cdots & \eta_{2m} & \eta_{2\max} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ x_n & \eta_{n1} & \eta_{n2} & \cdots & \eta_{nm} & \eta_{m\max} \end{Bmatrix}$$

The principle of guaranteed losses is stated as follows:

$$\eta_g = \min\max \eta(x,y)\ , \ \ X \in X_y \in Y$$

$$\eta_{(x',y)} = \varepsilon_{(x',y)} \max - \varepsilon_{(x,y)}$$

where x' – fixed value x.

This principle defines deviation (loss) efficiency due to the influence of uncontrollable factors.

If the optimal solution obtained using the principles of the guaranteed result and guaranteed losses are not the same, there is a need to harmonize these solutions using the Pareto principle.

Evaluation and selection of optimal decisions under conditions of uncertainty is a serious problem. Aviation Administration as a regulator of aviation activities must constantly respond to the impact of the external environment by adapting its objectives, structure, technology and policies to changes in external conditions. Therefore, it is necessary to solve the following problems:

1) taking into account the uncertainty in the choice of effective innovative solutions;

2) harmonization of decisions made using various optimality principles.

Selecting a single principle for determining the optimal solution may lead to loss of a species. For example, using the principle of optimism predict real conditions may differ considerably for the worse, which may cause poor decisions. The coincidence of optimal solutions in the application of several principles is not always possible. Most often they do not coincide. Therefore, there is a problem matching solutions obtained by using each of the principles.

Therefore, these principles should be applied optimality using multi-criteria approach, particularly Pareto principle. Its use is not associated with any additional terms and conditions that are imposed on the performance indicators of the decisions [2]. It allows you to avoid using inefficient alternatives and form an effective innovative solution. However, when using the Pareto principle is not always possible to identify a single optimal solution [1].

Thus, this method allows you to select the most efficient innovative solution in the face of uncertainty and multicriteriality.

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Information technology of integrated competency assessment of specialists in 3D modeling

A new approach of testing of integrated competency assessment of specialists in 3D modeling is proposed. The result Information technology of integrated competency assessment is provided.

Introduction

Technical preparation of production of competitive products (from the vacuum cleaner to the aircraft) in the industrialized countries of the world made tools 3D modeling and three-dimensional design of modern CAD/CAM/CAE systems. Such systems are now used in almost all Ukrainian enterprises. Starting from a lower level of complexity such as AutoCAD systems to high-end functionality for example CATIA v6-type systems. Virtually all technical colleges specialized students learn the basics of computer modeling and design. However, the level of use of these systems in enterprises remains very low, and thus the quality of developments, timelines and costs are significantly inferior to foreign analogues.

High-quality design process of complex high-tech products requires not only the existence of theoretical knowledge and practical skills, but also a certain amount of expertise and skills to the spatial imagination. That is, the developer must have the professional competence to perform 3D modeling and design. Unfortunately, not all university graduates and specialists of enterprises meet these requirements. Furthermore, the design of complex parts and products in general tend collective, i.e. design office, group or department should carry out mutually agreed project work. This team should have competence for integrated 3D modeling and in time to carry out mutually agreed performance.

At this time, there are no methods that would be able to implement an effective distribution of functions and scope of work, taking into account the interests of consistency of development, their interaction and professional competence.

This report, based on 20-years of experience in 3D modeling and design of complex high-tech products and the research presents the results of models, techniques and appropriate information technology as an integral assessment of the competence of specialists in 3D modeling.

The main indicators that determine the professional competence of a specialist in the field of 3D modeling are: the level of knowledge and skills (KSB), the availability of professionally important qualities (PIQ) and the level of motivation (MT), as well as additional factors (AF).

To quantify the level of integrated competence (R_K) uses the expression $R_K=\Sigma\alpha_i\times R_i$, where α_i – weighting coefficients, R_i - individual level of competence.

Using the possibility of decomposition of R_K index into components based on the division of competence in the category, as well as the basic components obtained detailed model of competence and integrated components of the vectors α-sections of the membership functions (α_{KSB}, α_{PIQ}, α_{MT},) [1, 2].

Method of estimation of integrated competency specialist 3D modeling is based on the use of the individual employee's competence, which includes as the vector components KSB signs, PIQ and MT. Each component can be viewed as a set of attributes, measured using various scales.

For each of the experts (comparing objects - OC), which extends the competence level assessment personogramma filled. Personogramma contains three group estimates are obtained for the four-level scale or converted to these values.

The sequence of data processing is as follows:

1. For each group of a plurality of equilibrium properties (characteristics) conformity coefficient calculated competence j-th specialist by the formula

$$\overline{O} = \frac{\sum_{i=1}^{n} O_i k_i}{\sum_{i=1}^{n} k_i} \quad (1)$$

where O_i - average (ranking) score of the i-th expert;
$k_i = I/D_i$ - weighting factor of i-th expert;
D_i - variance estimates the i-th expert;
n - number of experts.

$$k_{Bj}=S_{\Pi j}/S_E \quad (2)$$

2. Formed matrix V of dimension mxk, where m- number of comparison sites, k - the number of groups (subgroups) signs object comparison.

$$V = \begin{pmatrix} k_{CBKSB_1} \; k_{CBKSB_2} \dots k_{CBKSB_j} \dots k_{CBKSB_k} \\ k_{CBPIQ_1} \; k_{CBPIQ_2} \dots k_{CBPIQ_j} \dots k_{CBPIQ_k} \\ k_{CBMT_1} \; k_{CBMT_2} \dots k_{CBMT_j} \dots k_{CBMT_k} \end{pmatrix} \quad (3)$$

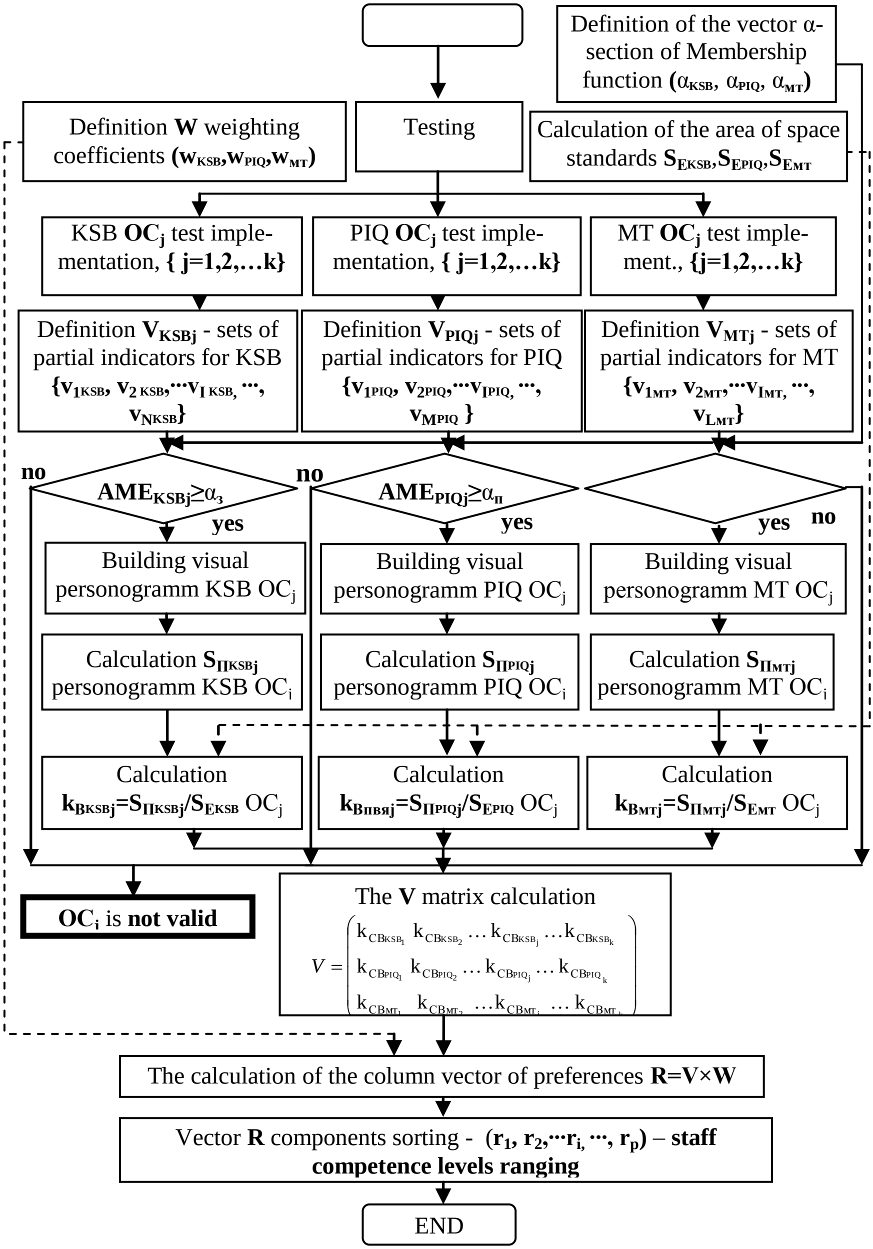
3. Calculate the R column vector, the components of which are (r_1 ... r_n) from the expression: $R = V \times W$, where W - column vector of weighting coefficients of the signs, which is defined by experts.
4. Select specialist competence which corresponds to the maximum value of the element of the column vector R or several objects in order of decreasing values r_j estimates. In the case that the level of competence of r_j assessments of individual experts estimated, on the set of quasi-formed elements, for example, for the five experts who evaluated:

$$m_1(R) \succ m_3(R) \succ m_2(R) \succ m_4(R) \succ m_5(R) \quad (4)$$

Here the sign of ">" marks the relationship of an advantages.

5. A number of advantages (4) and the final statement about each of the evaluated professionals with respect to their levels of competence available to the decision, as a conclusion.

Algorithm evaluation method integrated competency specialist 3D modeling presented in the figure below.


Definition of the vector α-section of Membership function (α_KSB, α_PIQ, α_MT)
Definition W weighting coefficients (w_KSB, w_PIQ, w_MT)
Testing
Calculation of the area of space standards S_EKSB, S_EPIQ, S_EMT
KSB OC_j test implementation, { j=1,2,…k}
PIQ OC_j test implementation, { j=1,2,…k}
MT OC_j test implement., {j=1,2,…k}
Definition V_KSBj - sets of partial indicators for KSB {v_1KSB, v_2KSB,…v_I KSB, …, v_NKSB}
Definition V_PIQj - sets of partial indicators for PIQ {v_1PIQ, v_2PIQ,…v_IPIQ, …, v_MPIQ }
Definition V_MTj - sets of partial indicators for MT {v_1MT, v_2MT,…v_IMT, …, v_LMT}
no
AME_KSBj≥α_з
yes
no
AME_PIQj≥α_п
yes
yes
no
Building visual personogramm KSB OC_j
Building visual personogramm PIQ OC_j
Building visual personogramm MT OC_j
Calculation S_ПKSBj personogramm KSB OC_i
Calculation S_ПPIQj personogramm PIQ OC_i
Calculation S_ПMTj personogramm MT OC_i
Calculation k_BKSBj=S_ПKSBj/S_EKSB OC_j
Calculation k_Bпвяj=S_ПPIQj/S_EPIQ OC_j
Calculation k_BMTj=S_ПMTj/S_EMT OC_j
OC_i is not valid
The V matrix calculation
V = (k_CBKSB1 k_CBKSB2 … k_CBKSBj … k_CBKSBk; k_CBPIQ1 k_CBPIQ2 … k_CBPIQj … k_CBPIQk; k_CBMT1 k_CBMT2 … k_CBMTj … k_CBMTk)
The calculation of the column vector of preferences R=V×W
Vector R components sorting - (r_1, r_2,…r_i, …, r_p) – staff competence levels ranging
END

1.8.3

These models and methods in conjunction with the test information and software to form a new integrated information technology assessment competence of experts in the field of 3D modeling.

Conclusions

Thus, the presented methods and developed tools to better assess the competence of professionals in the field of 3D modeling and professionally to form project groups and the Bureau on the implementation of such works.

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Modern information technologies and prospects of precision agriculture in Ukraine

The experience of precision agriculture applying in the world and Ukraine is analyzed. The basic principles and foundations of information technology implementation in agro-technological processes and management are offered. The conclusions of topicality and prospects of use the domestic resources in Ukraine are proposed.

In today's world the problem of food security does not lose relevance. It is important not only to maximize the effectiveness of resources in economic terms, but also provide them with environmentally friendly for many years. The answers to these challenges can give modern science and technology. Major trends in the coming years in the industry – is to use precision agriculture (PA), remote sensing, robotic and intelligent systems. So as we can see from the Tractica’s report [2], robotic equipment used in agriculture to grow rapidly (Fig. 1)

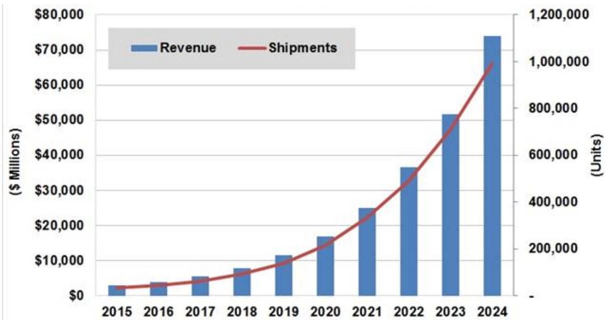

Figure 1. Agricultural Robot Revenue and Shipments, World Markets: 2015-2024. Source: [2]

In developed countries such as Germany, USA, Canada, implementing PA is a common past few decades [3, 4, 5]. In Ukraine this issue involved experts from leading agrarian academic and research institutions [6, 7]. Besides the technological aspects of optimizing the use of resources, modern systems of management of the agricultural enterprises should include issues of ecological, quality and safety of products according to standards [8]. The main problem of implementation of precision agriculture in Ukrainian reality is the need for new equipment and software, the need for highly qualified specialists. Ready foreign decisions in most cases are not optimally adapted to specific business environments.

The main objectives for the mass implementation of PA in Ukraine:

– in soil science and land reclamation – is the identifying of soil characteristics and its effect on agrocenosis;

– in crop – assessment of productivity potential of plant varieties in certain environmental conditions and their sensitivity to fertilizers, plant protection, etc.;

– in agro-physics – building models of mass and energy exchange in the system "soil–plant–atmosphere", study of agrophysical soil characteristics that allow to forecast crop;

– in agricultural meteorology – development of new methods of weather conditions forecasting and their impact on production, creating autonomous agrometeorological stations with automatic data aggregation.

Implementation of the PA in particular enterprise requires the collection of the above information and building a number of thematic digital maps:

– maps of soils and soil samples;

– initial map of soils and their properties, humidity, salinity, content of exchange cations of calcium (Ca) and magnesium (Mg), pH;

– map of soil productive capacity with data on phosphorus and potassium, exchange acidity, etc;

– maps of the actual yield distribution in the field, etc.

Yield map allows you to set the zones with high and low levels of productivity. Based on this you can decide on the rational use of fertilizer and other technologies of growing crops [8].

In addition to technological problems, PA systems need to solve the problem of integration with management systems for agro-enterprises. The use of software and hardware components from different vendors can be a problem.

National University of Life and Environmental Sciences of Ukraine and NGO "KRYVBASACADEMINVEST" created in cooperation the "AgroMine" software, as it is one of the successful examples. The program has a powerful ERP subsystem, provides a complete electronic directory and set of calculation modules of optimal fertilizing and agrochemical determine regulatory indicators. The system also offers GIS module that solves the following problems:

– creation of contour maps of fields with the ability to use GPS;

– creation of relief maps based on photo pictures;

– creation of division map with land differentiation for the purpose;

– color separation of substances content and other characteristics;

– overlay vector objects to bitmaps, incl. processed of satellite images;

– creation of soil and agrochemical maps;

– creation of maps of differential fertilizing, tools etc.

GIS module allow to build automatically a relief model according to the survey, the contours of fields through the use of GPS-navigation (Fig. 2).

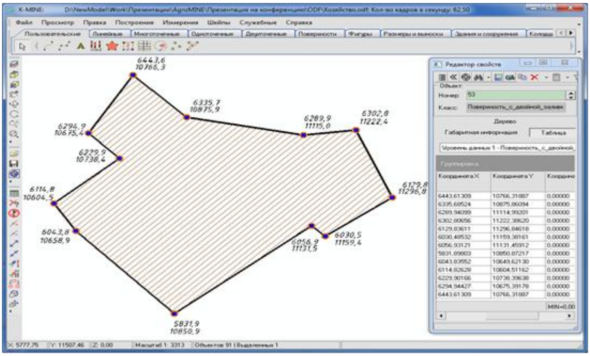

Figure 2. The contours of the field, automatically built based on GPS.

Generating of maps based on soil attribute parameters (conductivity, soil samples analysis) to create tasks of optimal use of resources (fertilizers, crop rotation mode, etc.) are implemented. The system offers a module of mapping for the differential fertilizer etc. (Fig. 3).

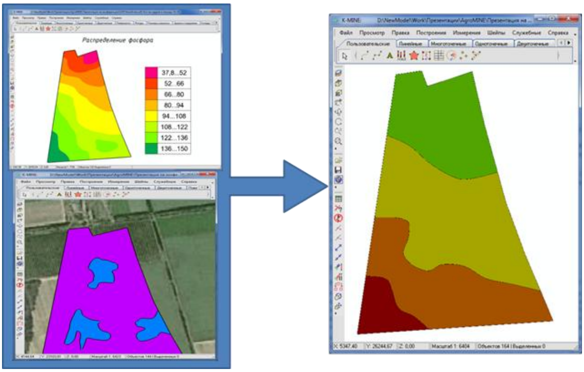

Figure 3. Map of differential fertilizer.

Unfortunately, the use of modern technology in agriculture of Ukraine is not yet prevalent. Inadequate funding, lack of investment in R&D, lack of specialists hinders the implementation of PA.

In recent years, we can access to many tools, software and communications capabilities for more sophisticated information systems of PA, including those that have become available as a result of the conversion. For example, there are many results related to GIS, large-scale maps and real-time systems, the V.Glushkov Institute of Cybernetics of NAS of Ukraine [9].

Conclusions. Global trends indicate a greater need for high technologies for food security. The main areas are the use of robotic systems, remote sensing and precision agriculture technology. The article describes the main approaches and example of a software for domestic agricultural enterprises.

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Programmatic means for forming and reflection movable symbol of air object on the map

This article contains information about system digital maps and plans on which displayed graphic model building own character and actions implemented over her conclusions on the work done.

Introduction

The geographic information systems (GIS) are the informative systems, intended for collection, storage, analysis and visualization of spatial data. Modern GIS of the system must provide possibility of introduction, transformation, maintenance and reflection as the dynamic stage of difficult movable symbols [1].

Actuality of work is conditioned by a substantial rev-up and amount of objects, that move in circumterrestrial space, as a result, the increase of complication of tasks of their reflection, recognition on the screen of operator and co-operation real-time.

Basic part

For forming and reflection of movable symbol of air object on the screen it is necessary to work out a cartographic background for creation of visualization of dynamic situation real-time and to work out methods and facilities of construction, maintenance and conclusion on the screen of operator of any symbols of objects of different complication.

For today there is a great enough choice of programmatic methods and facilities for creation of cartographic background. The monopolists of development of programmatic foods in the field of it mainly foreign developers are - markets captivated the programmatic packages of MapInfo, AutoCAD, ArcGIS et al. At the same time there are home developers, for example the "Scientific and production enterprise "Geosystem" (Vinnytsya), that offers the national product of creation of maps, namely raster-vectorial digital maps and plans of any scales.

In dissertation work of I. Ivanyk comparative description of above-mentioned GIS of packages (table 1) is offered [2].

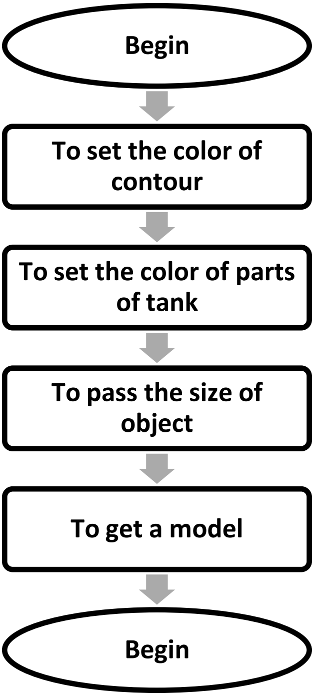
Thus coming from the above-mentioned for forming and reflection of movable symbol of air object on the screen more expedient in all to use GIS package of Digitals.

Table 1

Name of GIS - packages of different producers	**AutoCAD**	**Arc Gis**	**MapInfo**	**Digitals**
A country is a producer	USA	USA	USA	Ukraine
Cost of hrn. (local / network (20) to the license)	15750 / 105000	42000 / 350000	36850 / 710200	1350 / 13500
The Ukrainian / Russian version	The Russian version	The Ukrainian / Russian version	The Russian version	The Russian version
Tasks that decides	corrects a draft, created in computer-aided technologies (CAx), helps to get rid from doublets and incorrect information, it is possible to create classifications for forming of reports on an only standard.	Work is with maps; Compiling and editing of sets geogiven; The use of geoprocessing is for automation of work and implementation of analysis; Organization of bases geogiven and documents of ArcGIS and management by them; A publication of documents of maps is as cartographic services	Creation and editing of graphic and tabular data; making alteration is both on maps and in semantic data. Supports all widespread layouts of data, including office formats, such as Microsoft Excel, Access, formats of relational and spatial databases	Creation of digital maps is in conventional signs, reading and record of In4 and other formats, design of relief, calculation of areas and volumes, printing of state acts and other graphic documents
Possibility to finish off	Closed code / it Is not	Closed code / it Is not	Closed code / it Is not	there Is possibility

Also we are offer an algorithm, that allows on the basis of the real object to build him adequate and clear graphic model, rice. 1.

On the form of main window the programs are represented two buttons .. Pressing on the first the graphic model of tank increases, accordingly, pressing on a friend, a tank diminishes.



Rice. 1. Algorithm of forming of symbol

Conclusion

The systems of construction of digital maps and plans are investigational, their defects and advantages are educed on the basis of these researches the algorithm of forming of symbol is offered.

For the performance of the put objective a programming of C# and environment of development of Visual Studio 2013.

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Professional activity informational model database structure

In the article basic structure of profession activity information model is presented. Structure includes main databases, that are built on the basic National Classifications

Information technology analysis and evaluation of professional activity involves the collection, processing and storage of information processed in information systems, enterprise resource management and information technology systems of working hours.

Analytical review of software designed to meet the challenges of human resources management, carried out in the article [1,2], allowed to classify software into five major classes introduced by signs that describe its capabilities on a standardized set of operations in terms of personnel management.

With these classes only three of them solve to some extent the problem of management qualification characteristics and lists of occupation (work) competences.

However, each software differs own approach to build business and presentation logic, making them difficult to use in the integration of the modules of information technology, solving the problem of analysis and evaluation of professional activities as requiring conversion data in defined formats to make calculation algorithms of expert system logic machine output work correctly.

Obviously there is a problem due to the lack of practical use of these data in enterprise resource management systems, which is due only to the marketing policy development companies, which led to the creation of functional declarative direction in these systems.

Consider standardization of relevant databases structures for subsequent use in the development of automated systems for evaluation of professional activity (fig. 1)

Database "**National classification of professions**" (NCP), subsequently laid DK 003: 2010. Classifier built on methodological principles of ISCO-88 concerning the provisions on work and training, construction and structural characteristics of the main professional groups, but unlike the standard specified in the classifier uses additional feature - qualification work performed.

In this regard, the said DB associated with DB «**National Classification of employees trades characteristics**" (NCETC).

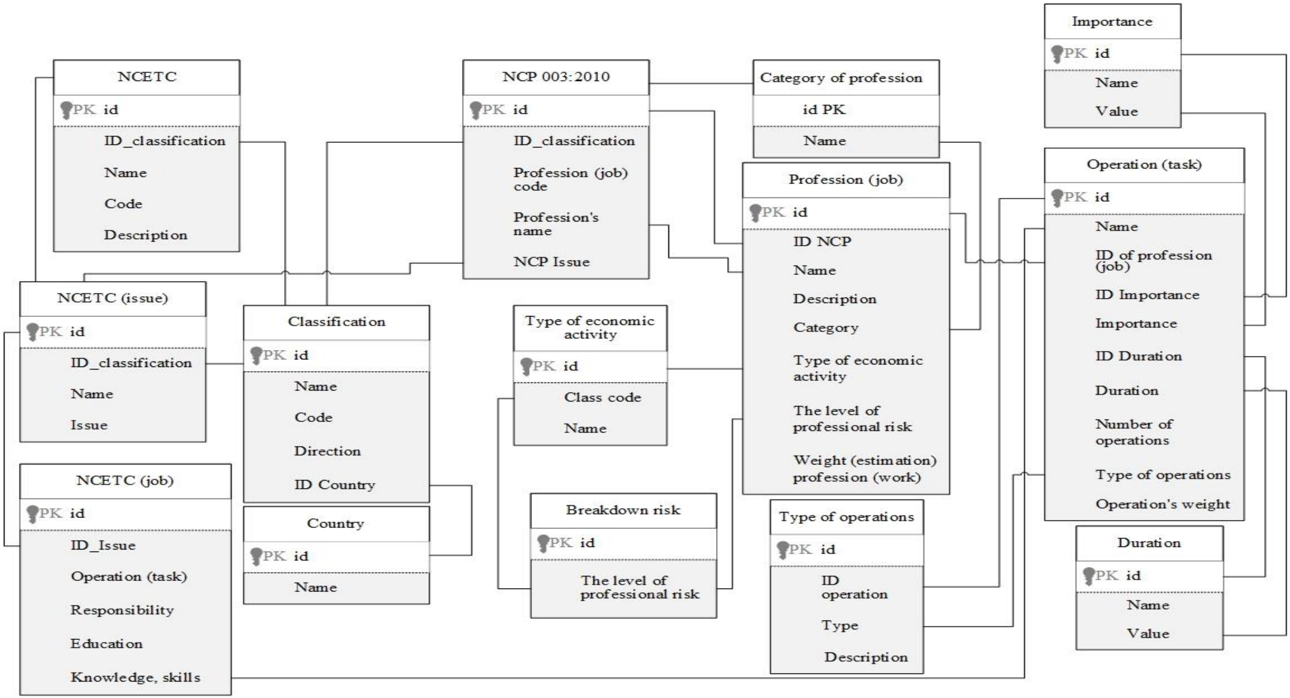

Fig. 1. Information model database structure.

Classifier introduced and used the following concept of job. Job - a certain tasks and duties have performed, are being executed or will be carried by one person.

Database «**National Classification of employees trades characteristics" (**NCETC**).**

National Classification of employees trades characteristics — classified by economic activity collection of professions descriptions in Ukraine, which are mentioned in the **National classification of professions** created to systematize the qualifying characteristics of trade's workers.

The Guide (NCETC) is normative document, which is obligatory for personnel management in enterprises, institutions and organizations all forms of property and economic activities and consists of the issuance and release sections, grouped by major economic activity, production and operations.

The Guide defines the list major jobs that are inherent in a particular position, and ensure unity in determining qualification requirements for certain posts.

The guide serves as a basis for:

- develop job descriptions for employees fixing their duties, rights and responsibilities;
- develop regulations on structural units that define their role and place in the management of the enterprise (institution, organization);
- documentation of the employment contract (hiring), professional growth, reassignment, suspension from work, suspension and termination of contract;
- assigning categories and improve on the post according to mastery by a person full amount of knowledge and the results of work qualification attestation;
- organization of educational process in educational institutions that prepare employees for occupations relevant educational and qualification levels.

In information systems analysis and evaluation of the complexity of the work is mostly used section devoted to the description of work performed in certain positions. These are basic descriptions of works in case analysis and evaluation of existing jobs in the company.

In fig. 4.3. the structure of the database to the transactions and relationships between the basic attributes of the respective entities are presented.

Database "**Classification of economic activities DK 009:2010**.

Classification of Economic Activities establishes the framework for preparing and dissemination of economic statistical information. The basic principle of the classifier is to bring together companies that produce similar products or services or use similar processes to create products or services (raw materials, production processes, methods or technologies) in the group.

The main economic activity - a defining feature in the formation and stratification sets of statistical units for state statistical observations.

Database "**Breakdown risk**" describes the category of professional risk - the class of professional risk for a particular industry, characterized by an integral factor of professional risk.

Database "Occupation (work)" describes the attributes of professional activity, which is analyzed and evaluated in terms of these earlier database, that is - the name, the work of the classifier professions, the category of work, economic activity, to which this work, the relevant class of professional risk and the weight of job which is calculated in the relevant modules of the information system.

Database "Operation (task)" contains data for each transaction (tasks) that are performed within professional activities at the attributes needed to calculate the weight of each operation and performance attributes of entities, discussed in detail in [3,4]: models of decision-making, communication, educational qualification of others.

The database consists of two areas, one of which describes the attributes (Fig. 1) necessary for calculating the weight of operations, and the other is used to store the results of assessments and calculations attributes of basic and complete professional activity models [5].

Conclusion

The framework database information model professional activity can be considered as a technical problem during the development of the information system of analytical evaluation of professional activity

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Optimize selection strategy in systems of technological complex continuous type

In article are considered main questions of operational management of technological complexes of continuous type. The authors propose the construction of a mathematical model of operational management of technological complexes of continuous type, in which the best strategy of development of TC continuous type on the basis of performance evaluation.

Modern methods of complex organizational and technological objects based on a complex combination of operational and strategic management. These include technological complexes (TC) continuous type in various industries (food, including sugar, chemical, etc.). [1]. The essence of these methods is to present knowledge about management and facility management methods using logical and linguistic models, fuzzy logic, procedures, training and synthesis to generate management decisions by comparing the current situation with the planned for the construction of multi-solutions [2].

Given the conditions of uncertainty and complexity of the organizational and technological facilities, the initial knowledge of such objects and methods of control may not be quite full. Therefore, a comprehensive system of operational and strategic management of complex organizational and technological objects under uncertainty must be able to adjust their knowledge about objects and methods of management. To this end, under the operational control is necessary to develop the appropriate knowledge base with the assistance of experienced experts of the facility management of its operations, methods of management and knowledge base of indicators and performance criteria and appropriate strategic decisions.

To this end, under the operational control is necessary to develop the appropriate knowledge base with the assistance of experienced experts of the facility management of its operations, methods of management and knowledge base of indicators and performance criteria and appropriate strategic decisions. Performance Index is formed by determining the most important characteristics p_i (performance of the) continuous TC type and is defined by the formula:

$$W = \sum_{i-1,\dots,n} \mu(p_i) w(p_i), \quad (1)$$

where $w(p_i)$ - the weights of certain performance indicators TC p_i, corresponding to the subsystems of the TC and drive the development of the technological component of profits; $\mu(p_i)$ - the corresponding values of the membership functions p_i.

Thus, the effectiveness of TC continuous type is defined as:

$$ef(F_{st}, F) = W \quad (2)$$

The original function $f(s,w)$ and criterion function efficiency

$E(s, w, f(s,w))$ allow us to evaluate the effectiveness of organizational-technological object is changed by law:

$$x = f(s,w) \qquad (3)$$

where s – is the strategy selected according to a certain performance index w.

The set W is the set of the indices of effectiveness W. The initial condition x_0 for equation (3) is considered as parameter perturbation belongs to the set of indexes of efficiency of W, i.e.

$$x_0 = w \in W \qquad (4)$$

The objective function associated with the criterion function of the efficiency E is determined using the equation:

$$Z(s,w) = E(s, w, f(s,w)) \qquad (5)$$

The expression (5) allows us to determine directly the dependence of the objective function Z in contrast to the criterion function E is selected from strategy s and index of the efficiency w. Indirectly through the function of the efficiency E of the objective function Z based on (3) depends on the value of x, that is affected via the function f of the decision y.

Then you need to choose a strategy on the feasible set of strategies S

$$\bar{s} \in S, \qquad (6)$$

to all w from W the inequality:

$$Z(\bar{s}, w) \le \varphi(w) \qquad (7)$$

where φ – function is enabled, specifies the maximum allowable value of the objective function Z, which coincides, according to (5) with the criterion function E.

To solve the formulated problem of selecting the best strategy for TC continuous type on the basis of an evaluation of the effectiveness of TC (3) - (7), the authors proposes an intelligent method, which is based on a combination of the methods of expert estimates, decision tree, dynamic programming, and heuristics.

In the process of building strategic tree the set S of all possible strategies divide into subsets $S_1, \ldots, S_m$, where each strategic decision $S_j,\ j = \overline{1,m}$ is assigned the index of the efficiency w_j, i.e:

$$S_j = \sum_{j=1}^{n} s_j(w_j) \qquad (8)$$

$$f(S_1, S_2, \ldots, S_m) = \max_{x_i \in X_i} W(p_1, p_2, \ldots, p_n)$$

$$i = 1,2,..,n;\ n = 1,\ldots,N; \quad j = 1,\ldots,m;\ m = 1,\ldots,M \qquad (9)$$

We introduce the resource limits for each strategy S_j:

$$\sum_{k=1}^{l} r_{jk} \le R_j,\ l = 1,2,\ldots,L \qquad (10)$$

According to the optimality principle of Belman [3] to have:

$$f_n(S_{1n}, S_{2n}, .., S_{mn}) = \max_{w_n \in W_n} \left\{ f_{n-1}[W_{1n} - w_{1n}(p_n), W_{2n} - w_{2n}(p_n), \ldots, W_{mn} - w_{mn}(p_n)] + Z(s_n, w_n) \right\}$$

The algorithm of solving the problem of choosing the optimal strategy based on the index of the efficiency TC continuous type is as follows:

1. Assesses the effectiveness of the functioning of the TC continuous type in the time interval τ_n by defining a index of the efficiency W_n.
2. Defines the set of admissible strategies S_n, $n = 1,..., N$ according to the index of the efficiency W_n.
3. The solution of the functional equation (11) in the time interval τ_n and determination of the sequence $f_n(S_{mn})$, $m = 1,..., m$ and corresponding dependencies $p_n(f_n), n = 1,..., N$ and also functions $S_{jn}(f_n)$, $j = 1,..., M$.
4. The definition of $E = \max_{w_n} f(S_{mn})$ which are the constraints (10) for $m = 1,..., M$.
5. Restoring optimal strategy according to dependencies $f_n(S_{mn})$ and $p_n(f_n)$.
6. The end of the algorithm.

Conclusions

Effective management of complex organizational and technological relation TC continuous type in market conditions requires the introduction of new information technologies and a radical improvement of information support of management activities. The main ways of increase of efficiency of functioning of TC continuous type is not only the optimization and modernization of production, reduction of production losses and technological consumption of energy, but effective innovation, increase the reliability and speed of obtaining information necessary for making strategic and operational management decisions under uncertainty and risk. Therefore, decisions taken at a specific point in time, is a part of the General implementation of the chosen strategy. For selection of control at a certain stage it is necessary to evaluate the effectiveness of the operation of the control object, and also to predict the results of the decision in the current situation.

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The adaptive strategy collision risks avoidance for a high quality service and unprecedented traffic safety of the vehicles operations drivers

The strategy information and analytical components for improving of safety quality of the program-apparatus complexes vehicles navigating guaranteed – adaptived control are announced. An experts common know knowledge's intellectualization is fixed by active semantice and ontological nets means. Their developing possible anticipation and approaching to the intrusion or catastrophically appereances achieves by predicative synthesis.

Intelligent transport systems (ITS) have been constantly improving the computerization of providing the safety for passengers, freight and infrastructure. It is carried out for transport of all classes and of various purposes in accordance with the objectives of polyergatic manufacturing organizations (PEMO) that define their routes and trips in space and time continuum (STC) [1-3].

Semantic and ontological bases of corporate social knowledge about the structural models of relationships between the notions of a complex dynamic system (CDS) are formalized in the processes of vehicles monitoring and observation under the influence of zone none safety operation surroundings (ZNOS) current factors. They form the real levels of danger for ITS. The development of scientific and methodological bases of axiomatization of relationships between the concepts within the ontology and semantic models of knowledge bases should increase the efficiency of detecting early effects of threats. The aims to ensure vehicles traffic safety for the current situation and phases of the event development in zone predicated risks problem (ZPRP) are the reliability of cause-and-effect development, assessment quality and systematic decision making support (SSMD) in real conditions of limited resources.

A predicative description of the key relationships between the concepts of objective technologies for transport ITS guarantees further improvement of current methods and vehicles automation means in extreme situations STC [4-7].

The axiomatization of mathematical (computer and design) modeling of CDS key concepts is carried out. In ZPRP this processes reacts to threatening ZNOS noise and disturbance. Any real problem of ITS operation can be presented by a corresponding network of interconnected tasks of a complex nature. Each task PEMO, in its turn, can be presented as a graph algorithmic connection of subtasks [2].

Creating formal semantic and ontological descriptions for information and analytical components (IAC) of relationships between important concepts starts with the definition of the concept [5] of risk STC by the following sentences.

0.1 Risk is a category of danger, threat, loss of resources under the conditions to continue acting as before in STC (to continue actions without changes in technology and CDS organization).

0.2 Risk is a chance to continue the actions without protection (ignoring external or internal influences) from ZNOS.

0.3 Risk is a threatening chance for any variations of circumstances to appear that require a change of motion direction (direction vector STC) of vehicles.

0.4 Risk is a force majeure peculiarity of external influences that may eventually reach significant losses, such as end states (fires, explosions, epidemics, wars, death), the objects of which have died and can not be repaired and recovered.

0.5 Risk is an assessment of possible substantial losses (damage), when it is impossible to counteract the factors of the given situation with long processes of object design destruction.

0.6 Risk is an assessment of probability to get other results that in homogeneous, the same conditions mean the existence of smaller variations and deviations for most options.

0.7 Risk is a characteristic of SSMD for uncertainty, ignorance, unpredictability of processes [5] with the adverse effects of CDS changes.

In memory program-apparatus complexes (PAC) with the apparent description of content, characteristics, the peculiarity of ZPRP phase states and the corresponding risk [5]. All the above mentioned statements PEMO may form a vehicles life safety programme [2,3,6,7] by the following algorithmic steps.

S1. To identify internal and external sources – the object of risks.

S2. To record – to make a full table for categories of kinds of risks.

S3. To classify the options for conditions of threatening circumstances – groups of simultaneous but different risks of different monitoring, acceptance and data processing procedures.

S4. To assess the probability and ranges of each type of risks in certain conditions STC.

S5. To present known previous cases of past events of overcoming threats, disturbances, interference, prohibitions and final consequences of the results when the risks were known in advance.

S6. To synthesize – to design effective programmes for counteracting risks that may be detected by ZNOS modern monitoring means and vehicles surveillance in ZPRP.

S7. To control all forms strategic, tactical and operational PEMO bodies of adaptive CDS life cycle management within the global ITS by a paradigm of a life safety primate and functional stability under extreme operating conditions.

Conceptual protection depends on IAC knowledge as an integrated system with its structural and functional adaptation to the ZNOS effects.

The implementation of the suggested CDS system safety within the ITS necessarily requires the coordination of all participants during the real operation, when the following principles of accident-free operation of every vehicles are not violated:

- the protection is carried out continuously, without interruption, without resources reduction to provide efficiency level logistics in STC;

- the control of operations, processes, technologies implemented under the agreed laws, rules, regulations is carried out totally, systematically and has diagnostic results indicating the objective violations, illnesses, work refusal;

- the rehabilitation of reliable (but most important) elements of CDS is performed consistently, quickly, efficiently without reducing system indicators of reliability, survivability, functional stability necessary for continued safe operation of a concrete ITS [2, 3, 6, 7];

- the acceleration of effective safety functions due to robots, machines, computers that are capable of self-learning, self-adaptability and self-organization during all modes of their operation PEMO;

- strengthening forms, methods and means of protection through multiple control, cascade adaptation, preventive flexibility and network telecommunication is made by electronic technologies (cryptography, encryption, situational encoding of SSMD key components);

- loading telecommunication channels by a hybrid mix of public, official and secured (classified) traffic on both sides of the connection is not contrary to the procedures of mass computer interaction of various IAC;

- the integration of heterogeneous tools at every level of the hierarchical mass protection to ensure the mechanisms for evaluating audit, accounting, inventory, identification ensures the resulting efficiency PEMO. The desired levels of prediction, stability and efficiency of the transport function of each vehicles under any circumstances of ITS operational modes are results in unsteady environment with real ZPRP.

The predicative synthesis is necessary for defined element-connection creation and step-by-step complication from characters - letters of the alphabet to words – terms IAC [3,6,7]. The definitions of PAC design objects allows to adapt: to determine on this basis, obviously to make the description (of the existing things contained in memory); to decide on the basis of PAC really existing material and time resources restrictions; to constructively perform algorithmic calculations.

Due to predictive (predicates and quantifiers) design algorithms this stepwise semantic system guarantees getting problem solution practice PEMO, if the integral PAC system explicitly has design objects (operands and operators, concepts and relations, proof logic and statement result). The explicit description (algorithmic form) of the formal entry in the symbols of mathematical logic of a calculation machine clearly provides a result as a variety of objects IAC .

The final result under the indicator function determines whether the expression $\Im(x)$ is true (exists) or to receive an objection $\neg\Im(x)$ within the meaning the statement does not exist (not true) that can be complicated with multiple design elements – arguments $(x, y, z,...., s, t)$ [3,6]. A clear result (computable) means that the given object $\Im(x)$ exists, it is already built algebraically and symbolically, verified, monitored, certified because it complies effective transformation rules and mathematical logic. In all other circumstances, when there is not enough knowledge to get the result $\Im(x)$ according to the principle of "external addition" [1,2] IAC is added by (additional) design objects [3,4,7].

Thus, to get a result in algebraic constructive form of "what is to be done for VEHICLES life safety» is possible only in conditions when the built-in memory of common PAC will have full knowledge about living conditions: the root causes of incidents; their transformation into collisions; deviations with violation of rules and regulations permitted; the emergence of threats; turning them into increasing risks; approaching these risks to a critical point of emergency forms.

Conclusions.

1. Now and in future it is appropriate to use computer information technologies, which according to the monitoring and observation (remote sensing) data determine the appearance of specific risks of threatening impact of ZNOS factors. SSMD simultaneously activates respective programmes for protecting biodiversity lives in specific areas STC of high risk of catastrophic events.

2. Each act (phase, stage, action, process) of anti-crisis or protective and safe management should take into account the dynamics of changes of multi-situational interaction. The attention PEMO is paid to these processes: within an integrated comprehensive programme of vehicles traffic safety to the given routes throughout evolutionary development (approximation) of risks; natural contact interactions of heterogeneous set of circumstances in the local space-time continuum; the state of protective actions and consuming resources and reserves for appropriate levels of safety.

3. The protection from really inevitable and force majeure circumstances, worsening vehicles traffic conditions should always be done immediately, automatically, without wasting time on personal emotional response of a human operator PEMO. The possibility of adjusting a new state after the automatic maneuver (pre-agreed, verified, proven, standardized by safety technical regulations) provides the renovation of ergatic (polyergatic) mechanisms to improve the processes of ongoing implementation of the basic law guaranteeing the adaptive vehicles traffic control in critical, non-standard, non-optimal situations of a natural conflict, but with a guaranteed prevention of collisions and destruction of life.

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Geoinformational technology for aerial data analysis

For farming and precise farming purposes a software developed to improve the efficiency of sown areas monitoring by using aerial data analysis based on combining digital image preprocessing methods, cluster analysis and result interpretation together with geographic coordinates and map visualization.

Intensive development of information technologies and technological means makes it necessary to review current approaches to the implementation of various tasks. With the spread usage of geographic information systems (GIS) and the development of unmanned aerial vehicles (UAVs), making use of aircraft more affordable for the purposes of air monitoring, it is possible to improve methods of surveillance of areas. That formulates the problem of digital air monitoring data analysis automation. Agriculture is one example of the field in which modern information technologies can be used to improve the efficiency of farming. So sowing areas digital images analysis can significantly reduce the cost and increase speed of analysis results, compared to the classical collection and analysis of samples in the field.

Formulation of the problem. To solve the problem of effective analysis and planning for agriculture a software system should be developed to meet the following requirements:

1. Work with the basic types of geographical data;
2. Review input as images with the ability to navigate in case the image size is too large;
3. The allocation of areas of interest to the user for analysis;
4. Extracting and displaying of the area information;
5. Saving and storing of extracted information.

Also, it is expedient to implement all of the above-mentioned requirements with regard to subjective criteria if intuitive interface and clarity of information display to minimize the required software familiarization and increase its usage efficiency.

To solve formulated problem software system «Vagabond» developed, which consists of two main components: GIS «Vagabond» and a mathematical operations library «Elders».

Mathematical operations library «Elders» is a set of classes that follow a common abstract class Elder and implement mathematical methods (Fig. 1). Each class is singleton [1] (it is possible to create only one instance of the class). Classes divided into two packages - images and math.

The package «images» contains classes with digital imaging methods, such as Converter, Filter and Basic. Converter class is responsible for the transformation algorithms for conversion between color systems RGB, YUC, YCrBr etc. [2] and includes enum Type with systems supported color systems. Class Filter is engaged in image filtering masks that enlisted in the class List, which not presented in the class diagrams. Basic class is a set of simple methods for image transformation, such as linearization, solarisation, equalization, etc. [3].

The package «math» aggregates classes to implement mathematical calculations and statistics. It consists of the General, Primary, MixtureDivision and Splines classes. Each of which performs grouping role for mathematical methods. Thus, General performs the most common calculations such as determining the maximum and minimum value. Primary is the class for primary statistical analysis [4]. It can calculate the original moments of the sample data: expectation, standard deviation, coefficient of skewness and kurtosis and so on. Splines responsible for the B-splines [5] implementation. MixtureDivision implements the mixture distributions division in data [6].

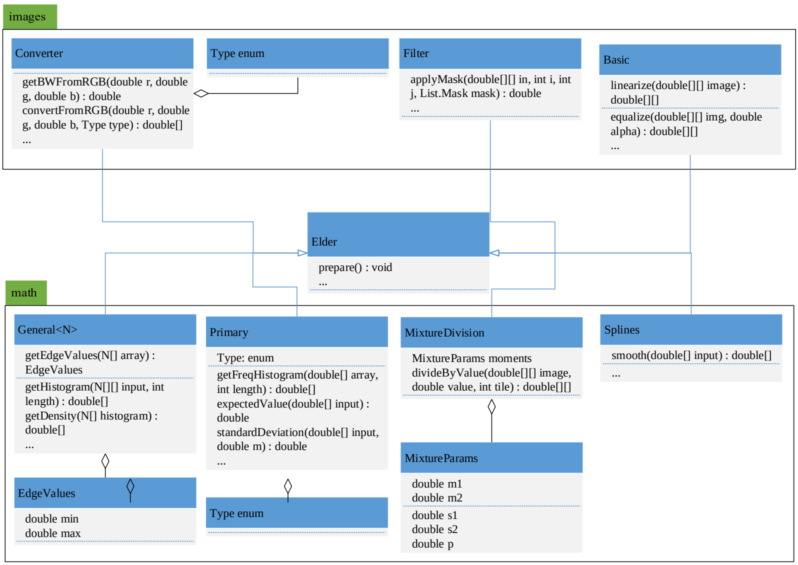

Fig. 1. UML-diagram of «Elders» classes

GIS «Vagabond» responsible for user interaction and information display. Graphical User Interface (GUI) «Vagabond» (Fig. 2) built on the following principles.

Maximum working space. The basis of GIS is the map, because GIS created primarily for working with the map and geographic objects. So the main workspace of GIS should be the map.

Simple interface. The interface should be clear and obvious. The subjective factor, which is important for this GIS not oriented for specialists in information technology to reduce system familiarization time.

Laconic functionality. One of the common problems of modern GIS systems are overloaded lots of features and techniques to meet the needs of a wide range of applications. To build a specialized system for agriculture only methods and functions with the practical application in farming should be implemented.

GUI of the «Vagabond» consists of 7 main parts (Fig. 2) - Toolbar (1); additional information (2); map (3); miniature maps (4); layers (5); display setting (6); main menu (7). Layers and display settings can be minimized.

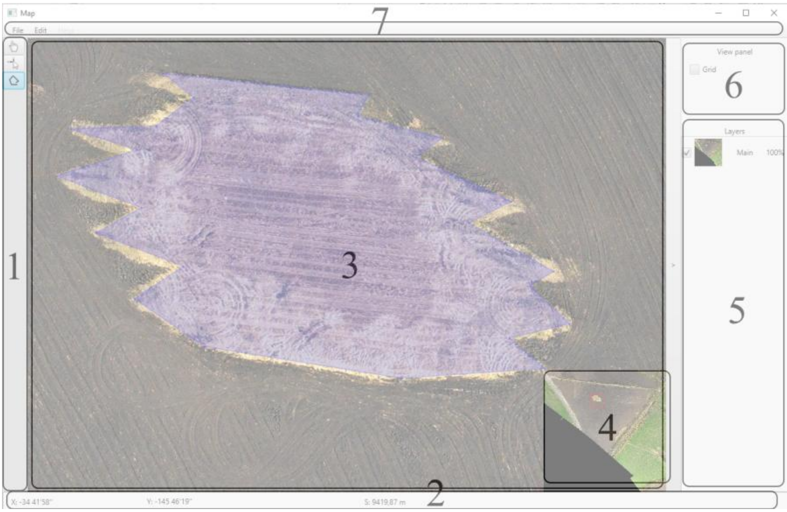

Fig. 2 GUI of the Vagabond

The concept of study element (SE) - an object on a map containing the geographic coordinates, name, description and some history of changes, introduced.

The main idea of the software package focused on SE creation, research and editing. GIS tools used to highlight a certain area on the map and the menus to initiate creation of SE of a dedicated area. To create, edit and research SE a specialized window used (Fig. 3), which also uses the possibility of «Elders» library to transform and analyze selected areas of SE.

The main interest is in the «author methods» section of the menu with the farming methods of aerial data analysis. With the combination of primary image processing and different cluster analysis methods adapted for the certain purposes a several farming analysis methods developed - productivity rating, dryness, impurities and abnormalities detection.

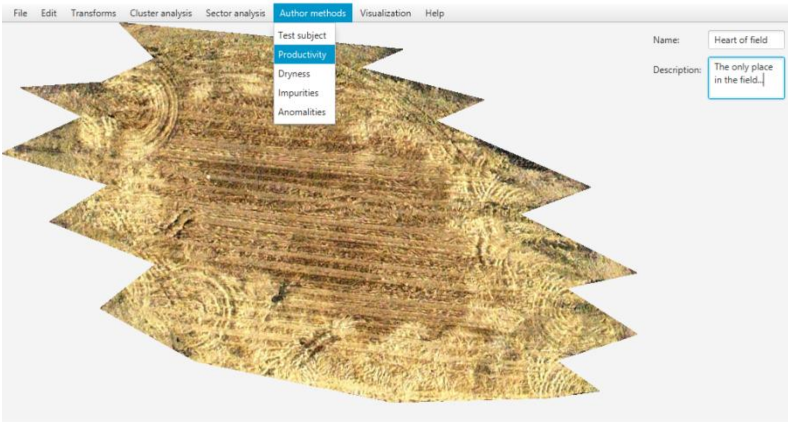

Fig. 3 Specialized window for SE operations in «Vagabond»

Thus, if an established system for air monitoring, the user has the opportunity to plan the economy by analyzing available data and react to deviations from the normal process of individual sections within the same field.

Conclusions

In the scope of the research the following done:

1.Studied the current state of information technology and facilities, and found opportunity to improve planning and analysis stage in agriculture with development of specialized farming GIS.

2.Formulated requirements for building mentioned GIS.

3.Developed software package «Vagabond», consisting of GIS «Vagabond» and mathematical operations libraries «Elders».

Prospects of technology in empowering analysis, methods of interpretation, visualization and GUI development. Developing more specialized software systems for other areas.

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Information technology for data exchange between production purpose integrated automated systems

The architectural solutions and generic requirements for production data integrated information environment development have been proposed. This environment serves for data adding, editing, saving and deletion. The suggested mathematical model is able to transform and present production data in the unified intermediate format. The model uses templates for data transformation and establishes relations between objects of production like integrated automated systems.

Historically every enterprise has different automated information systems that usually work independently and solve particular range of tasks. Some production tasks are being solved not efficiently or not solved at all unless using consolidated data supplied by several systems. This highlights urgency of the information systems integration in data regards. Certainly, the urgency of such integration increases together with the level of users who utilize control system (e.g. for decision making on an enterprise scale it is most probably required to get data from different departments, domains and different automated systems correspondingly).

Usually some partial solutions for data integrations that are intended to set-up data exchange between two particular automated systems are created by IT specialists or companies-contractors when data integrations issue is being solved. It should be admitted that such approach is highly efficient from the viewpoint of data exchange (due to own data exchange mechanism usage) as well as costs perspective. Nevertheless, there are some obvious drawbacks related to flexibility and scalability of such solutions. Ultimately, savings of mentioned above partial solutions may be even to significant expenses required for their support due to constant changes in information environment.

The objective is to represent the results of the production purpose integrated automated system (IAS) technology development on the data exchange layer between users in the enterprise integrated information environment.

The following tasks should be solved to achieve the objective:

- to develop architecture of enterprises unified consolidated information environment;
- to develop mathematical model for data transformation.

XML based data exchange format which allows describing data structure in the unified format common for an enterprise has been used. Any data package can be described and represented using XML. Modern programming tools (e.g. Microsoft.Net or Sun Microsystems Java) have been used and allow creating objects in random access memory based on XML description (known as deserialization procedure). Since in the given architecture central hub is considered as passive element and doesn’t contact other IASs immediately additional attention has been payed in order to organize feedback approach. All calls are being addressed with proper feedback and stored in the database. This allows implementing bilateral exchange between systems by using ‘mediator’ – central concentrator [1, 2].

A concept of ‘data consolidation’ is commonly used in the unified information environment development. Implementation of data consolidation implies development of the unified consolidated environment with a central link – a separate IAS. This IAS manages processes of data integration and exchange between different production systems. The logical relations of data transformations and information about data dislocation are being formed and stored along with data itself in data concentrator. In other words data concentrator is a separate IAS with its own database and can either store or process data in case no data output available. It should be mentioned that data concentrator serves as data storage system and has its own database and corresponding software tools that allow organizing unified consolidated data information environment. Detailed conceptual diagram of the unified consolidated data environment on the figure 1 is represented by the generalized data flow diagram.

The source IASs are placed on the lower level. They are filled with their own registries and directories in their own data structures and formats. Systems transfer data from their databases to the upper level. These IASs can be also considered as source IASs receiving data from higher levels.

It should be noted that data exchange with higher levels implies separate module introduction, namely export-import system of IAS. It can be either internal module of IAS or external module specially developed to create the unified consolidated environment [5].

The central part of diagram is IAS ‘Data concentrator’. The diagram consists of central database and software modules that provide interaction between source data IASs (and with IAS ‘data receiver’) on the one hand, and on the other hand, process data from central database as well as any reporting required within outer counter of the unified consolidated information environment [3, 4].

As depicted on the diagram, it is required to create interaction adapter for each operational IAS (marked as ‘adapter for IAS-i’ where ‘i' is a sequential number of operational IAS). In order to guarantee reasonable time for new IAS connection to the unified consolidated information environment, development costs reduction as well as further architecture support – adapter must be unified and customizable rather than be developed from scratch for each IAS.

To ensure the reliability of data presentation it is required to transform data from one format to another. Transformation issues can be solved in two ways:

1. To write direct data transformation functions from one structure to another.
2. To develop the unified data format which is able to transform any formats of IAS.

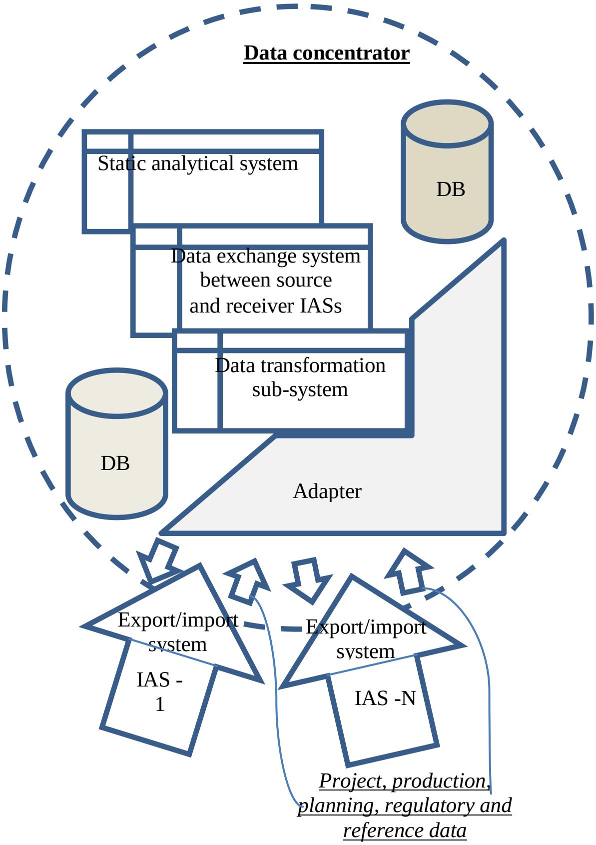

Fig. 1. Conceptual diagram of the unified consolidated information environment.

The first option is used more frequently due to its simplicity: it is required to set correspondence between fields of database and move data using several queries. This is an easy task when data should be transferred from one IAS with more full and certain structure to another simpler one. Though, some difficulties may occur in backward compatibility.

The second option is more versatile for integrating a massive information system which is the basis for information technology of production, regulatory and reference data consolidation and synchronization. The advantages of this option are the following:

1. It is possible to create data representation templates. In future, it may be decided to use this format as standard for existing IAS in case of some changes.
2. IAS's production data transformers can be developed regardless for what IAS data is represented. Data transferred to the template format

can be further transformed to any production purpose IAS included into unified consolidated environment data exchange.

The central concentrator determines whether the prompt response required for the given data package. The prompt response is not sent in case a passive environment for data packages transferring has been used. The concentrator prepares response by processing the data package in case when web-sessions (or analogies) are used.

When identified that the response can’t be sent in time, another system notification is sent mentioning that data package has been received for processing and will be sent later on. An IAS which is supposed to receive data gets data from the central concentrator in 2 ways: active and passive.

The active approach requests certain information. The request is organized in the unified data exchange and sent in the same format. If it were a block of data, the title would be marked correspondingly. If structure fields are filled, the data concentrator considers them as search parameters and uses them to query database. The response is formed in the unified data exchange and sent to requestor IAS.

In passive approach IAS is subscribed to data updates in data concentrator. In accordance to the schedule data concentrator checks data updates in the database depending on registers determined for the given IAS and sends updates package to IAS [6, 7].

As a result of research conducted, the architectural solutions and generic requirements for the consolidated information environment for production data have been developed. This environment is a unified repository where data can be added, modified, stored or removed. Production data comparison and exchange between systems are being performed in the central element, namely data concentrator.

Different IAS format data representation is performed through data transformation using the unifier of data exchange. Unlike other existing architectures the given one provides different production purpose IAS data processing as well as data exchange allowing the establishment of systems linkage by corresponding relations between their objects. In the article was formalized the task of integration of integrated automated system at the level of exchange by data between users.

Conclusions

Technology of exchange is offered by data, that is based on development and use of the integrated informative environment and unificator of exchange data. Researches are based on experience of development, introduction and use of the modern integrated automated system of the productive setting. Architectural decisions and general conditions of construction of the consolidated infomedia of productive data, that is single data base, are worked out, addition, editing, economy and moving away of data, comes in that true.

In a difference from existent architectures, in offer there is possibility of treatment of these different integrated automated systems of the productive setting and an exchange is provided by data between these integrated automated systems, that allows to "link" inter se the systems by creation of connections between objects in the systems. The presented technology of exchange passed experimental approbation data on base for research industrial enterprises of Ukraine.

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Method and technology management motivation IT-specialists

The results developed information technology support management process motivated IT - specialists in an industrial plant which implements theoretical principles, models, methods, algorithms and procedures established by means of automated information subsystem «ICS_MC»

Existing foreign and domestic HRM (Human resource management) - systems and corresponding software modules ERP (Enterprise Resource Planning, Enterprise Resource Planning) - automate basic functions of HR industry. However, important scientific - practical task management specialists motivation has no no scientific or practical solution.

The reasons for this state a few:

- A variety of assessment methods motivated professionals and their criteria;
- Lack of formalization and algorithmic existing methods;
- etc.

The report proposed a new subsystem promoted processes for assessing and managing the motivation that solves this problem.

The main purpose of the study is to develop and create a subsystem for multi promoted the adoption of management solutions preferred choice motivators complex according to the quantity of personnel and their needs, as well as automated calculation of the level of motivation of the personnel in the limited funding based on the analytic hierarchy process.

The author developed information technology support management motivation, realized in the subsystem ICS_MC [1], which solves this problem. An information technology allows us to analyze complex alternative solutions to select a preferred set of motivators of view of the company's employees for their motivation types and levels of provision motivators that meet the relevant requirements of staff. The respective services received tools (software tool) for a decision on the application of a set of motivators.

Management subsystem motivation that is created on the basis of information technology developed, implemented as a module that automatically calculate and use:

- A set of indicators of motivation IT professionals base of enterprise, based on the known and proven provisions on the classification needs and human activities, present state work incentives in the Ukraine, as well as well-known method of functional simulation, allowing a priori to claim the adequacy of the results and to adapt the process of motivation in the company to the needs of IT professionals according to their motivational types that reduce the number of necessary motivators for the company, and consequently to reduce the financial costs against the backdrop of increasing labor efficiency [2];
- Ranging needs of IT professionals, depending on the type of motivation[3];
- Utility function to select complex motivations IT - specialists [4];

- Multi complex algorithm choice motivation IT - specialists in an industrial plant in the limited software that allows managers of companies using different software levels motivators of IT - specialists receive automated assessment of motivation in the enterprise and make decisions on the use of one of the five complexes motivation;

- Ranking algorithm based motivators of rank needs IT - specialists;

- The method of selection of multi complex motivations IT - specialists in an industrial plant in the limited provision [5];

$$vA_j = \frac{1}{m \cdot R_{\max}} \sum_{i=1}^{40} \left(k_i^{\phi} \cdot vf_i \cdot vf_i \left(A_j \right) \right),$$

A_j – selected algorithmically complex multi choice motivation that has a maximum rate of benefits and *kj* - qualitative and quantitative composition of IT - specialists in motivational types;

k_i^{ϕ} – providing motivators factors (local criteria) on a scale from 0 to 1.

$vf_i -$ criteria to maximize meet the needs of IT - specialists of the enterprise with regard to the distribution costs of motivators activities.

$R_{\max}$ - maximize rank of motivators.

m - number of motivators (partial criteria), *m* = 40/

- method for assessing motivation work IT - specialists of industrial enterprises [6];

$$M = \sum_{j=1}^{n} \left(\left(1 - \frac{\sum_{i=1}^{m} \left(r_i^j \cdot \left(1 - k_i^{\phi} \right) \right)}{\sum_{i=1}^{m} r_i^j} \right) \cdot k_j \right)$$

The method consists in obtaining formal evaluation of *M*, reflecting the degree of satisfaction of IT - specialists working conditions in the company in the implementation of the selected set of incentives under the terms of provision of activities and motivators A_j when accompanied by qualitative k_i^{ϕ} and quantitative composition of IT - specialists *kj*.

- etc., which were developed by the author.

ICS_MC subsystem is a software package and information designed to support the adoption of multi management solutions preferred choice motivators complex according to the quantity of personnel and their needs, as well as automated calculation of the level of motivation of the personnel in the limited funding based on the analytic hierarchy process. Developed subsystem information support of the management of motivation IT - specialists, which is closely linked with systems like preservation and delivery of information and other systems, providing the exchange and processing. Storage information is centralized in a single database that is managed by a relational database management system.

Conclusions

The information technology support for motivation of the management of IT professionals in an industrial plant implements theoretical principles, models, methods, algorithms and procedures established by means of automated information subsystem «ICS_MC.» Automated information subsystem allows enterprise managers using different levels of software motivators automated obtain estimates of motivation in the enterprise for each set of indicators motivate IT- specialists base enterprise, and make Multicriteria decision to use a preferred set of motivators that fully satisfies the quantity and quality of personnel and requirements.

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Disruptive industry 4.0 technologies. Opportunities and challenges of the industrial internet

The vision of Industry 4.0 is significantly higher productivity, efficiency, and self-managing production processes where people, machines, equipment, logistics systems, and work-in-process components communicate and cooperate with each other directly.

Raising the topic of a fourth industrial revolution immediately prompts many questions: What does Industry 4.0 really mean? What does digitization entail for manufacturing? The basic principle of Industry 4.0 is that by connecting machines, work pieces and systems, businesses are creating intelligent networks along the entire value chain that can control each other autonomously (Fig. 1). The term "Industrie 4.0" means the digitization of the manufacturing sector, with embedded sensors in virtually all product components and manufacturing equipment, ubiquitous cyberphysical systems, and analysis of all relevant data. It is driven by four clusters of disruptive technologies. The first consists of data, computational power, and connectivity – low-power, wide-area networks are one example. Analytics and intelligence form the second, while human-machine interaction is the third, comprising, for instance, touch interfaces and augmented reality. Digital-to-physical conversion is the fourth: advanced robotics and 3D printing are two examples [3].

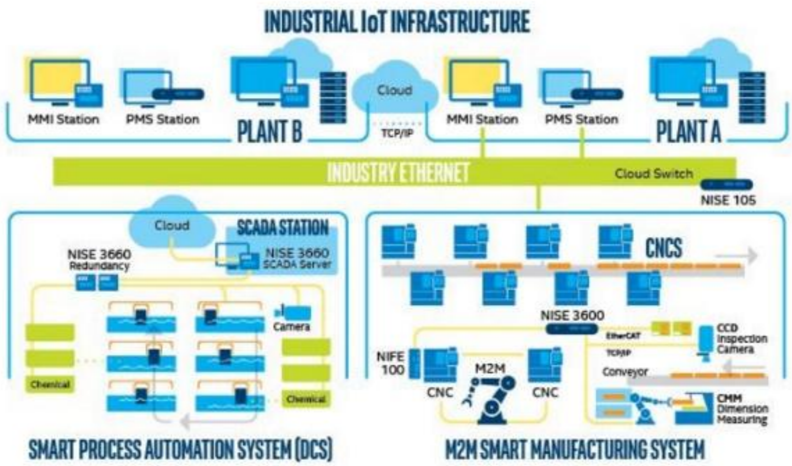

Figure 1. The basic principle of Industry 4.0

Big Data Analytics consists of 6Cs in the integrated Industry 4.0 and Cyber Physical Systems environment. The 6C system comprises:

Connection (sensor and networks)

Cloud (computing and data on demand)

Cyber (model & memory)

Content/context (meaning and correlation)

Community (sharing & collaboration)

Customization (personalization and value).

The Industry 4.0 refers to the idea of a fourth industrial revolution:

First: production mechanization using water and steam power

Second: mass production (Henry Ford often cited as the innovator)

Third: digital revolution (e.g., machine tool numerical control, programmable logic controllers, direct digital control, and enterprise resource planning)

Fourth: Industry 4.0 leveraging cyber-physical systems, embedded computing, Internet of Things technologies (Fig. 2).

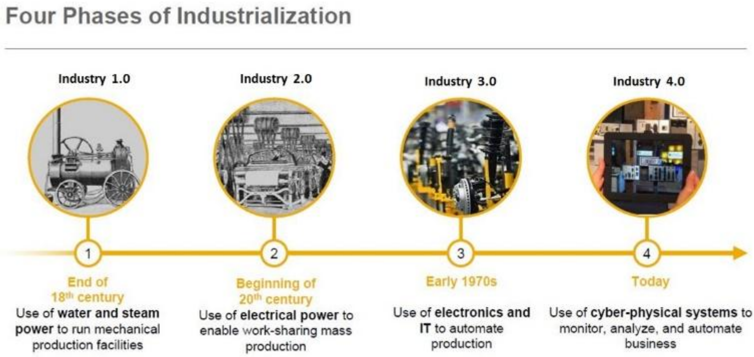

Figure 2. Birth of Industry 4.0

Time to market and customer responsiveness are today's key factors of competitiveness, and companies are investing in automation and robotics technologies that have the potential to meet LCC labor cost levels in any location. The disruptive technologies of Industry 4.0, such as IT-enabled manufacturing and increased computing capacity, hold the promise of smart factories that are highly efficient and increasingly data integrated.

McKinsey's research shows that all of the following technologies, for various reasons, are at a tipping point today and are ripe to disrupt the manufacturing value chain. To be more precise, there are four clusters of technologies that need to be examined [3].

Data, computational power, and connectivity. This cluster, which comprises big data, the Internet of Things (IoT), and cloud technology, is mainly driven by a significant reduction in costs that makes the ubiquitous use of sensors and actuators possible and allows for affordable yet powerful storage, transmission, and processing. For example, in the IoT, sensors and actuators embedded in physical objects are interconnected via wired and wireless networks. These networks churn out large volumes of data that flow to computers for analysis, while all physical objects are able to both sense their environment and communicate autonomously among each other. Today, all prerequisites for IoT applications are finally falling into place: interoperability is made possible by new communication protocols designed especially for seamless machine-to-machine (M2M) interaction. Connectivity is enabled by LPWA technologies that provide the wireless infrastructure to connect thousands of IoT nodes.

Analytics and intelligence. Significant knowledge advances have taken place in this area over the last few years. While for a long period of time, only simple and repetitive tasks could be performed by robots, advances in artificial intelligence and machine learning as well as the exponential increase in available data and improved statistical techniques enable digitization and automation of knowledge work and advanced analytics.

Human-machine interaction. The driver of greater human-machine interaction is increased consumer familiarity with new ways of interacting with machines that come from the growing use of personal devices. Touch interfaces are already ubiquitous in the consumer world today and gesture recognition as well as virtual and augmented reality devices are increasingly in use. Another dimension is the increasing physical interaction between machines and humans, where machines and humans both work in much closer physical proximity and where machines can ease previously strenuous tasks for humans.

Digital-to-physical conversion. Here, a combination of decreasing costs, expanding range of materials, and advances in precision and quality are the drivers of relevance. For example, 3D printing has moved from only being applicable to polymers and metals to a broad range of materials, including glass, biocells, sugar, and cement. It is not just additive manufacturing that is becoming more relevant, but also technologies like advanced robotics and increasingly cost-effective options for storing energy and innovative ways of harvesting energy. Significant advances in artificial intelligence, machine vision, and M2M communication have been made within the field of advanced robotics, along with cheaper actuators.

The combination of technologies from these clusters not only enables the translation of the physical into the virtual world but also facilitates the link back from the virtual to the physical world.

Where applicable (the ideology of Industry 4.0):

Smart automated plants address the need for mass products at low cost and are fully automated, digitized, and highly cost efficient. These plants produce large volumes and commodities.

Customer-centric plants address trend markets. These are ultraresponsive plants producing highly customized products at scale and affordable cost to address the trend towards mass personalization.

E-plant in a box addresses niche and remote markets. This small-scale, low-capex, mobile plant is able to produce a limited range of products at a new location and can be set up quickly to address subscale niche and remote markets.

Industry 4.0 and related initiatives recognize that efficiently building self-managing production processes requires open software and communications standards that allow sensors, controllers, people, machines, equipment, logistics systems, and products to communicate and cooperate with each other directly. Future automation systems must adopt open source multivendor interoperability software application and communication standards similar to those that exist for computers, the Internet, and cell phones. Industry 4.0 demonstrations acknowledge this by leveraging existing standards, including the ISA-88 batch standards, ISA-95 enterprise-control systems integration standards, OPC UA, IEC 6-1131-3, and PLCopen.

A core concept is processing embedded in sensors that communicate with control systems and directly with enterprise systems. The application of Industry 4.0 process automation was demonstrated by the vendors at the 2015 HANNOVER MESSE. They focused on three distinct aspects of Industry 4.0 in process automation: vertical integration with linkages from field-level devices to business control; horizontal integration to optimize value chain outputs; and end-to-end engineering, planning, and process control.

Conclusions. The fourth industrial revolution will affect many areas. A number of key impact areas emerge:

Services and Business Models
Reliability and continuous productivity
IT security
Machine safety
Product lifecycles
Industry value chain
Workers Education and skills
Socio-economic.

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Implementation project management methodologies in airspace industries on the basis impact theory

In this work proposed conceptual basis of methodology impact on the process of implementation of methodologies and technologies management projects in the practice of domestic enterprises.

While there are hundreds of effective project management methodologies, their implementation is the problem, especially in aircraft building enterprises. Compliance with the process of creating each aircraft project activity requires finding specific approaches to the implementation of project management methodology on aircraft building enterprises. But so far almost no one case of successful implementation of project management methodology on aircraft building enterprises. We can call probably only one company that successfully did it. This company is AVK IG "Skaeton". A system of management of labor, material and technical resources that integrate manufacturing and project activity was successfully developed and implemented for this company [1-3].

In our opinion the reason for this is that the managers of aircraft building enterprises think that enough to train managers and project team some well-known project management methodology, and once the aircraft will be going rhythmically, without downtime and losses. After trying this "introduction" speaking at conferences such leaders claim that the methodology of project management in Ukraine is not working.

Project management methodology was created dozens, hundreds, thousands of professional managers for several generations. In our days it is as documents, lectures, etc.. In particular, a summary of knowledgeon Project Management PMBOK (which we most often take for project management methodology) includes 10 areas that unite accumulated worldwide experience in project management. But almost neither in this nor in other methodologies do not cover the issue, and how to make elements of project management methodology effectively implemented and used on aircraft building enterprises?

After analyzing the main project management methodology [4 - 8] The authors identified their key elements, tools, processes and knowledge.

These elements selected from the positions that they contribute to the effective management of the project life cycle and present in a variety of techniques and methodologies (PRINCE2, P2M, OPM3, PMBok, Agile, ect.).

But the methodology there is no component associated with the management by knowledge. Specifically, the organization and planning of the use of knowledge in project management methodology in the implementation of a specific project. For this purpose to create methodology of information influences the process of implementing the methodology of aircraft building enterprises. Subject area of impact management methodology is special, because it determined by the requirements for knowledge and is described in terms of its components. And it used to specify all the information baggage project management methodology an area of knowledge that is best suited to manage a specific project or project-oriented enterprise aviation industry. Then the relationship of project management methodology with the methodology of information influences the process of implementation of project management methodology can be represented as shown in Figure1.

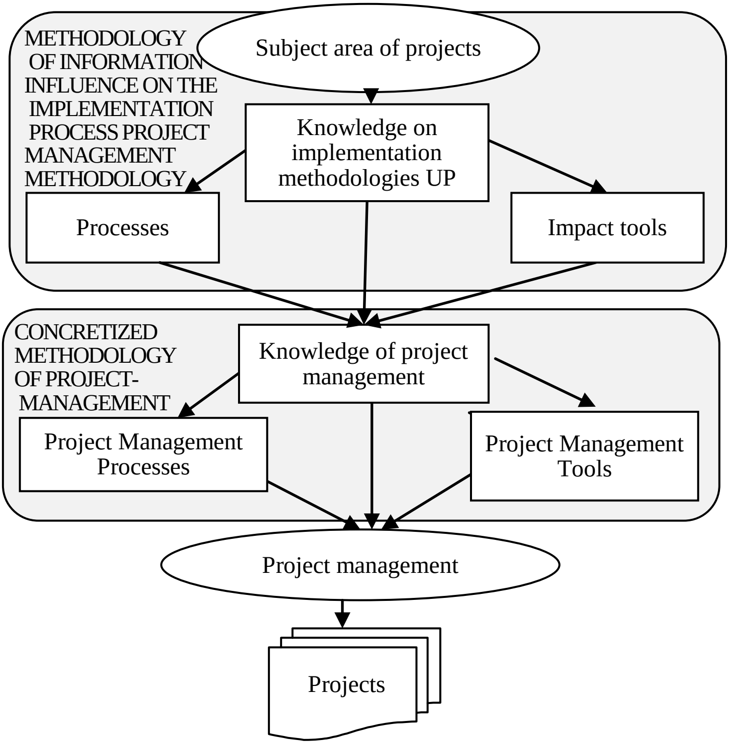

Fig.1. - Relationship methodologies in project management

Investigation of the mechanism in the management areas of knowledge based on the understanding that the projects aviation industry - a complicated, open, non-linear system and implementation methodology is dependent on knowledge.

Formation of knowledge in customized project management methodology depends on the impact on the implementation of this methodology in aircraft building enterprise:

$$U_z^j = d_j(U_z),$$

where U_Z^j – knowledge of concretized project management methodology;

d_j – impact on the process of implementing project management methodology.

Formation of new processes, facilities and management actions and performers is a consequence of existing knowledge in concretized project management methodology:

$$r_j^{\partial} = f_{\partial}(U_Z^j);$$

$$r_j^{n} = f_n(U_Z^j);,$$

$$r_j^{з} = f_з(U_Z^j),$$

where r_j^{∂} – management actions in the project;

$f_{\partial}(U_z^j)$ – function of forming management actions based on knowledge in concretized project management methodology;

r_j^n – project management processes;

$f_n(U_z^j)$ – function of forming project management processes, based on knowledge in concretized project management methodology;

$r_j^з$ – project management tools;

$f_з(U_z^j)$ – unction of forming project management, based on knowledge in concretized project management methodology.

The action disciplines to the project either direct or indirect through the processes and tools depicted as:

$$H(U_Z^j) = d(r_j^{\partial}, r_j^n, r_j^з), \tag{1}$$

where $H(U_Z^j)$ – result of the project, determined action knowledge U_z^j;

$d(r_j^{\partial}, r_j^n, r_j^з)$ – the impact of actions, processes and tools for project results.

This is ideal when the methodology implemented and functioning perfectly, but this utopian version, because the project is always the external impact because the formula (1) can be written as

$$H^*(U_Z^j) = d(r_j^{\partial}, r_j^n, r_j^з) + V,$$

where V – effect of impact on the implementation of the methodology.

Implementation of project management methodology is surrounded by some dynamic environment that produces on it some influence. Difficulty of effective implementation methodology is a variety of processes and management functions, which are presented by areas of knowledge (association of 10 disciplines, 5 groups of processes 3 main functions - 44 communications disciplines with groups of processes). Reaction should be formed at the possible relations with groups disciplines processes and functions. In this case, the theory of non-forcible (information) interaction is a tool for rationalization and improvement of impact processes on implementation and operation of the project management methodology.

Implementation methodology taking into account the impact of information does not require using expensive technologies. But it requires professionalism, especially of the manager and of technological maturity. Technological maturity ensures "implantation" project management methodology in conditions of various internal and external influences. But all this requires further research and improvement of the methodology of impacts on the process of implementing project management methodology.

Objectives of impact methodologyon the process of implementing project management methodology (MVPVMUP) is to achieve the expected condition of the project (quality manufacturing, repair services) through the introduction of tools and project management processes that are most suitable for this project. Project Manager based MVPVMUP make important management decisions on the possible options to help ensure a better functioning of the system, provide better feedback and better integration in the project.

Therefore, a key element of project management methodology in the aviation industry is using the tools of the theory of non-coercive interaction methodology for creating such an impact that will ensure projects achieve maximum results with limited resources:

$$\forall U_z^k \exists U_z^j : Z(H^*(U_z^j)) >> Z(H^*(U_z^k)) \tag{2}$$

where $Z(H^*(U_z^j))$ – assessment project results $H^*(U_z^j)$; $Z(H^*(U_z^k))$ – assessment project results $H^*(U_z^k)$.

Conclusions

It was found out the role of impact in the implementation of project management methodology aviation industry and proposed the scientific and methodological basis using management information actions to improve the application of project management methodology in practice

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Bioresonance

The methods of diagnostics of bioobject are offered on the basis of bioresonance

Introduction. Biomolecules are the radiant of super-high-frequency waves in the organized matter. These waves synchronize biochemical and biophysical processes in muscles, synchronize formation and motion of nervous impulses and so on.

Super-high-frequency waves of biomolecules are a set sharply resonance frequencies, typical for different cells, tissues and organs. The spectrum of these frequencies depends on the state of tissues. As an impedance of cell membrane changes from resistive-capacitive at the healthy state of tissues to cleanly active during their degradation, then resonance frequency changes naturally.

It is known that biotissues consist on 75% of water. It is known also, that biomolecules are surrounded by the structured molecules of water, which carry out the role of passive filter for super-high-frequency waves. As such filters are band pass, then the waves of typical for this organ frequency pass freely through them, traveling inside cells, tissues and organs.

Analysis of research and publication

Logically to assume, that in the degraded cell resonance can be created by not only the change of impedance but also change of frequency, id est exposing a sick organ to calibration frequency rays, it is possible to synchronize its operation by a healthy algorithm.

It is known that person memory has material transmitters which in case of her death emanate in an environment. As a matter is undestroyed, then there is a question of her further fate. Fully possibly, that she is accumulated circumplanetary, forming the informative biofield of Earth. Taking into account absorption of super-high-frequency waves by the molecules of oxygen and water in an atmosphere, there is a question in relation to carrier frequency for super-high-frequency biowaves.

Formulation of the problem

The examples of tasks solution are known, which are well formalized, id est for them mathematical models are worked out and there can be the applied algorithms which are based on guidance of type "if *A*, then *B*". However there are tasks, which it is difficult to formalize, id est find the clear algorithm of solution. Such tasks are:

− Image identification, for example, identification of handwritten and printed character during optical inclusion to COMPUTERS, identification of blood cells types, recognition of language. Thus an object which is recognized is the array of data, which needs to be attributed to one of the classes known a priori;

− clusterization of data (search of regularity). It follows to attribute data inputs to any group (cluster) after inherent to them "closeness", thus the number of clusters is a priori unknown. As criteria of "closeness" can be used distance between the data vectors, value of correlation coefficient and others like that;

− approximation of functions. To find a function which approximates unknown, for example set of experimental data. This task is actual during the simulation of the difficult systems and creation of control system by difficult dynamic objects, for a robust control;

− prognostication. After previous behavior of function, forecast its behavior in the future. This task is actual for a control the systems with prognostication and for the systems of decision making;

− optimization. Aim of these tasks - to find the optimal value of efficiency function which satisfies to the row of limitations.

Search of carrier frequency

It should be noted that a man solves tasks well which difficult to formalizite, - recognizes an image, classifies data, forecasts and others like that. Therefore the idea of artificial intellect creation became actual enough. However for this purpose it is necessary to research principles of man brain functioning from the point of view of information processing.

A man brain is most difficult of the known systems of information processing. There are about 100 milliards of nervous cells or neurons in it, each of them has 10 000 connections in the mean.

Neurons are the special type of cells, basic purpose of which consists in an operative control an organism.

The schematic image of neuron is given in fig. 1 [3].

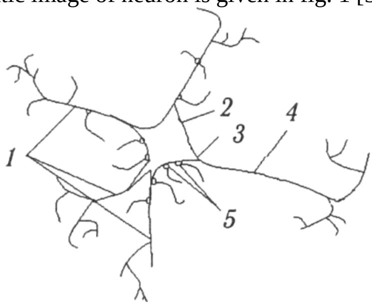

Fig. 1.

A neuron has a body (soma) 2, tree of inputs (dendrites) 1 and outputs (axons) 4. Dendrites are strongly ramified, screaming into comparatively large space round a neuron. The initial segment of axon is axon hill 3, that adjoins to the cell body. As far as a removal from a cell it gradually narrows and a myelin sheath appears on it, which has high electric resistance. On soma and dendrites tippings take place which go from other nervous cells. Each such tipping 5 has the shape of bulge, which is called a synaptic plaque, or synapse. The input signals of dendritic tree (postsynaptic potentials) are scaled and summarized on a way to a axon hill, where an initial impulse is generated. Its presence (or intensity) is the function of the self-weighted sum of input signals. An output signal passes on the axon branches and arrives at synapsis which connect axons with the dendrite trees of other neurons. Through synapsis a signal is transformed on a new input signal for next neurons.

This input signal can be positive and negative (excitative or brake) depending on the type of synapsis. The value of input signal which is generated by synapse can differ from the value of signal which enters synaps. These divergences determine efficiency, or weight of synaps. Synaptic weight can change in the process of synapsis functioning.

The scientists of different specialities did attempts to create the mathematical model of neuron. Yes, biologists tried to get analytic representation of neuron, that would take into account all its functional characteristic is known. However the basic task − information transfer by the nervous impulse was lost − among the great number of parameters which belong to physics of impulses conductivity. Therefore they tried to replace physical description of neuron by logical. Thus a nervous cell was examined as element which passes information. In 1943 the scientists-mathematicians of Mak-Kallox and Pits represented a neuron as simple switcher element which can be in one of two stable state "ON" or "OFF". A neuron triggers, if the algebraic sum of inputs more than threshold in this time. A neuron in such presentation can be used as the COMPUTER element and enables to build a network of neurons with corresponding thresholds and connections, that would realize an arbitrary boole function or truth table. These researches brought to the numerous circuits inventions of information processing, built on recognition and sensory analyzers.

Presently mostly use the model of neuron, represented on fig. 2 [3].

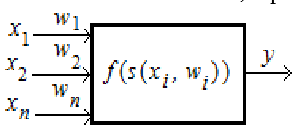

Fig.2

A neuron has *n* of monodirectional inputs (synapsis), connected with outputs of other neurons and output of *y* (axon), signal (stimulation or inhibition) on which acts on synapsis of next neurons. Synapsis is characterized by the value of synaptic connection, or scales of w_i, that after physical maintenance equivalent to electric conductivity. Every neuron is characterized by the current status of *s* by analogy with the nervous cells of brain, which can be stimulated or inhibited.

Current status of neuron depends on the value of its inputs, weight and, possibly, the previous state. Mostly the state of neuron is determined or as the self-weighted sum of its inputs

$$s = \sum_{i=1}^{n} x_i\, w_{i,} \qquad (1)$$

or as distance between the vector of inputs and vector of weight inputs

$$x = \sum_{i=1}^{n-x} |w_{i-}\ \ x_i| \qquad (2)$$

An output of *y* neuron is the function of its state;

$$y = f(s) \qquad (3)$$

The function of $f\,(s)$ is called the function of activating.

The most widespread functions of activating is a step threshold and linear threshold functions, sigmoid curve, linear function and Gaussian, resulted in a table. 1.

Table 1. Functions of neuron activating

Name of function	Determination
Step threshold	$f(s) = \begin{Bmatrix} 0, s < a \\ 1, s \geq a \end{Bmatrix} =$
Linear threshold function	$f(s) = \begin{Bmatrix} 0, s < a_1 \\ ks + b, a_1 \leq s < a_2 \\ 1, s \geq a_2 \end{Bmatrix}$
Sigmoid curve	$f(s) = (1 + e^{-k(s-a)})^{-1}$
Linear function	$f(s) = ks + b$
Gaussian	$f(s) = e^{-k(s-a)^2}$

Function of activation

A neuron network is created as a result of association of neurons outputs with inputs other, thus neurons create layers, connected between themselves.

Neuron network is called a network with the eventual number of layers which consist of one-type elements and different types of connections between the layers of neurons.

Thus the amount of neurons in layers chooses providing of the set quality of task solution, and amount of neurons layers − as possible less for diminishing of solution duration.

The simplest single-layer neuron network which is yet called simple perceptron is represented on fig. 3,*a* [3]. Inputs signals pass through synapses to three neurons, which form a single layer with initial signals

$$y_i = f\left[\sum_{i=1}^{n} x_i w_{ij}\right], \text{ where } j = 1\ldots3.$$

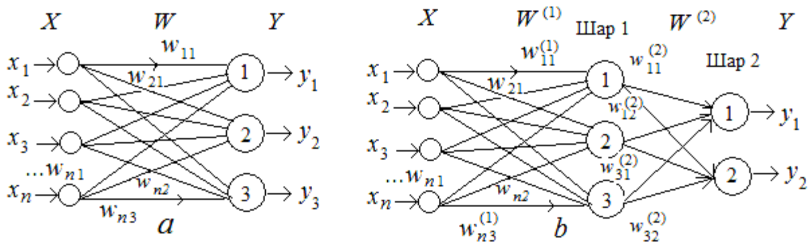

Fig. 3. Single- (*a*) and double-layer (*b*) perceptrons

Double-layer perceptron, got from the single-layer by addition of second layer which consists of two neurons, is represented on fig. 3,*b*. Thus non-linearity of activating function matters very much: if it was not, result of functioning of any *p* - layered neuron network with the weight matrices of $W^{(i)} = 1,2,..p$ for every layer *i* would be taken to multiplying of input vector of signals *X* by the matrix of $W^{(S)} = W^{(1)} * W(^{1)} * W^{(2)} * \ldots * W^{(p)}$, id est actually such *p* - layered neuron network would be equivalent single-layer with the weight matrix of single layer of $W^{(S)}$: $Y = X W^{(S)}$.

Except the number of layers and connections between them, neuron networks are classified as acyclic or cyclic. Shown in fig. 3,*a*,*b* examples belong to the acyclic neuron networks. The example of cyclic neuron network is represented in fig. 4 [3].

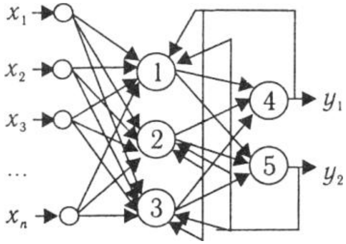

Fig. 4

If to complement the considered charts (see fig. 3 and 4) by thesis about clocking of network (to set duration of neurons operation), then will get an apparatus for the task of different algorithms of data processing by means of neuron networks, which can be used for solution of both the formalized tasks and tasks which it is difficult to formalize.

In the last case the application of neuron networks is based not on implementation of the offered algorithm, but on memorizing by network of examples set to it on the stage of networking and making of results, concerted with these examples, on the stage of task solution.

On the type of signals in a neuron network the last divide into binary (digital) and analog. The binary operate binary sygnals, and the output of every neuron can assume only two values of − 0 or 1. After possibility of adaptation it is possible mark out: neuron networks which construct and teach. In networks which construct, set a number and type of neurons, graph of transneuronal connections, weight of inputs, and in networks which teach, − of graphs of transneuronal connections and weight of inputs which change during implementation of training algorithm.

After the training algorithm the network divide into a network, after which they supervise, does not look after and mixed (hybrid). The first in the process of training compare a priori known result with got. The others receive training, not knowing the correct values of result. They aggregate data-ins so that they formed the same output of network. Such access is used, for example during the solution of clusterization task. At the mixed training algorithm part of weight is determined during a supervision, and part of − is without a supervision.

Conclusion

Thus, an educational hybrid neuron network will define bearing frequency for super-high-frequency biowaves by means of which in the degraded cage it is possible to create resonance, id est exposing to rays a sick organ by reference frequency, it is possible to synchronize its operation by healthy algorithm.

Id est, creating a neuron network with feedbacks, it is possible to design the natural selection of algorithms for diagnostics and treatment of patients.

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Characterization of objects moving in the decomposition of functions in Fourier series

It is shown that to determine the parameters of the object required information about its position or function, describing the move. A continuous movement spread function in Fourier series with subsequent determination of motion parameters of the object.

Speed – a vector physical quantity, it describes the change of position of the object in the selected frame:

$$\vec{v} = \frac{\Delta\vec{s}}{\Delta t},\ (\Delta t \to 0); \quad \vec{v} = \frac{d\vec{s}}{dt}.$$

Acceleration – vector physical quantity that determines the rate of change of velocity of the object and the first derivative of velocity over time:

$$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{s}}{dt^2}.$$

When measurement is important that the speed and acceleration are vectors, that takes into account not only the change in the speed (vector module value), but also change its direction. SI unit of acceleration is m/s^2, and gravity is used as common units gal, which is 1 cm/s^2.

Sharpness (or leap) is a derivative of acceleration for time, ie quantities characterizing the rate of change of acceleration:

$$\vec{r} = \frac{d\vec{a}}{dt} = \frac{d^2\vec{v}}{dt^2} = \frac{d^3\vec{s}}{dt^3}.$$

If the trajectory of the object known coordinates $\vec{r}(t_0) = \vec{r}_0$ and velocity vector $\vec{v}(t_0) = \vec{v}_0$ at some time t_0, and accelerating dependence on time $\vec{a}(t)$, then the integration of this equation are the coordinates and speed of the object at any time t (both before and after the point in time t_0):

$$\vec{v}(t) = \vec{v}_0 + \int_{t_0}^{t} \vec{a}(t)dt; \qquad \vec{r}(t) = \vec{r}_0 + (t - t_0)\vec{v}_0 + \int_{t_0}^{t}\int_{t_0}^{t} \vec{a}(t)dt^2.$$

In the complex movement of the object relative to some reference frame that moves relative to another frame of reference, the absolute acceleration of an object relative to the first frame of reference $\vec{a}_a$ is the sum of the relative $\vec{a}^r$ (relative to the second frame of reference), portable $\vec{a}^e$ and rotary (Coriolis) $\vec{a}^c$ acceleration (Coriolis theorem):

$$\vec{a}_a = \vec{a}^r + \vec{a}^e + \vec{a}^c = \vec{a}^r + \vec{a}^e + 2\cdot[\vec{\omega}\times\vec{v}_r].$$

For problems navigating Coriolis acceleration caused by portable angular velocity of the Earth's rotation and linear relative velocity vector object and is expressed by the product

$$\vec{a}^{c} = 2\cdot\left[\vec{\omega}_3 \times \vec{v}_r\right] = 2\cdot\begin{vmatrix} i_g & j_g & k_g \\ \omega_3 \cos\varphi & \omega_3 \sin\varphi & 0 \\ V_{Xg} & V_{Yg} & V_{Zg} \end{vmatrix}$$

with corresponding projections on the axis $OX_gY_gZ_g$:

$$a^c_{Xg} = 2\omega_3 V_{Zg} \sin\varphi; \quad a^c_{Yg} = -2\omega_3 V_{Zg} \cos\varphi; \quad a^c_{Zg} = 2\omega_3\left(V_{Yg}\cos\varphi - V_{Xg}\sin\varphi\right).$$

The relative change in acceleration $\vec{a}^r$ caused by the relative linear speed $\vec{v}_r = iV_{Xg} + jV_{Yg} + kV_{Zg}$ and movement of the object along the spherical surface of the Earth with relative angular velocity $\vec{\omega}'$:

$$\vec{a}^r = \vec{v}'^r + \left[\vec{\omega}' \times \vec{v}_r\right] = \vec{v}'^r + \begin{vmatrix} i & j & k \\ \dfrac{V_{Zg}}{R} & \dfrac{V_{Zg}}{R} tg\varphi & -\dfrac{V_{Xg}}{R} \\ V_{Xg} & V_{Yg} & V_{Zg} \end{vmatrix}.$$

The last projection ratio relative to the acceleration axis geographic coordinate system:

$$a^r_{Xg} = \dot{V}_{Xg} + \frac{V^2_{Zg}}{R} tg\varphi + \frac{V_{Xg}V_{Yg}}{R}; \qquad a^r_{Yg} = \dot{V}_{Yg} - \frac{V^2_{Zg}}{R} - \frac{V^2_{Xg}}{R};$$

$$a^r_{Zg} = \dot{V}_{Zg} + \frac{V_{Zg}V_{Yg}}{R} - \frac{V_{Xg}V_{Zg}}{R} tg\varphi.$$

Portable acceleration $\vec{a}^e$ due to Earth's rotation angular velocity and is defined as $\vec{a}^e = \vec{\omega}_3 \times \left[\vec{\omega}_3 \times \vec{R}\right]$, where $\vec{R}$ – the radius vector, connecting the center of the Earth and the mobile object. Projections portable acceleration:

$$a^e_{Xg} = \omega_3^2 R \sin\varphi\cos\varphi; \qquad a^e_{Yg} = -\omega_3^2 R \cos^2\varphi; \qquad a^e_{Zg} = 0.$$

In drawing vector portable acceleration $\vec{a}^e$ with vector $\vec{g}_0$ of Earth's gravitational field acceleration produced vector acceleration of gravity $\vec{g}$. Given that the vector acceleration of gravity is directed by geocentric vertical, its components are equal $g_X = 0$, $g_Y = g$, $g_Z = 0$.

As apparent accelerometers measure acceleration components will add gravity acceleration vector components to Coriolis acceleration relative and, as a result we get a projection vector apparent acceleration peaks of trihedron $OX_gY_gZ_g$ on its axis [1]:

$$n_{Xg} = \dot{V}_{Xg} + \frac{V^2_{Zg}}{R} tg\varphi + \frac{V_{Xg}V_{Yg}}{R} + 2\omega_3 V_{Zg} \sin\varphi;$$

$$n_{Yg} = \dot{V}_{Yg} - \frac{V^2_{Zg}}{R} - \frac{V^2_{Xg}}{R} - 2\omega_3 V_{Zg} \cos\varphi + g;$$

$$n_{Zg} = \dot{V}_{Zg} + \frac{V_{Zg}V_{Yg}}{R} - \frac{V_{Xg}V_{Zg}}{R} tg\varphi + 2\omega_3 \left(V_{Yg} \cos\varphi - V_{Xg} \sin\varphi \right).$$

Consider the case of determining the parameters of objects when moving is some continuous function of time $X(t)$ at specified time interval $[t_1, t_m]$. Expansion of such functions in Fourier series is defined by [2]:

$$X(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \left(a_n \cos\frac{2\pi n}{t_m - t_1} t + b_n \sin\frac{2\pi n}{t_m - t_1} t \right) = \frac{a_0}{2} + \\ + \sum_{n=1}^{\infty} \sqrt{a_n^2 + b_n^2} \sin\left(\frac{2\pi n}{t_m - t_1} t + arctg\frac{b_n}{a_n} \right) = \frac{a_0}{2} + \sum_{n=1}^{\infty} A_n \sin\left(n\omega_1 t + \varphi_n \right), \tag{1}$$

and the expansion coefficients are determined as follows:

$$a_0 = \frac{2}{t_m - t_1} \int_{-\frac{t_m - t_1}{2}}^{\frac{t_m - t_1}{2}} X(t) dt; \qquad a_n = \frac{2}{t_m - t_1} \int_{-\frac{t_m - t_1}{2}}^{\frac{t_m - t_1}{2}} X(t) \cos\frac{2\pi n}{t_m - t_1} t \, dt;$$

$$b_n = \frac{2}{t_m - t_1} \int_{-\frac{t_m - t_1}{2}}^{\frac{t_m - t_1}{2}} X(t) \sin\frac{2\pi n}{t_m - t_1} t \, dt; \qquad n = 1, 2, 3, \ldots,$$

where $\frac{a_0}{2}$ – a permanent part of the schedule; $A_n = \sqrt{a_n^2 + b_n^2}$ – the amplitude of the n-th component of the movement; $\omega_1 = \frac{2\pi}{t_m - t_1}$ – the fundamental frequency of the schedule, determined lapse observation; $\varphi_n = arctg\frac{b_n}{a_n}$ – the initial phase of the n-th component.

When measuring motion parameters is necessary to measure the movement and its derivatives over time – speed, acceleration and field, as well as the basic frequency fluctuations, spectral composition and some other problems, depending on the measurement [3].

Thus, the speed $V(t)$, acceleration $a(t)$ and sharpness $r(t)$ are determined by the relations:

$$V(t) = \frac{d\,X(t)}{dt} = \omega_1 \sum_{n=1}^{\infty} nA_n \cos\left(n\omega_1 t + \varphi_n \right) = \sum_{n=1}^{\infty} V_n \sin\left(n\omega_1 t + \varphi_n + \frac{\pi}{2} \right); \tag{2}$$

$$a(t) = \frac{d^2 X(t)}{dt^2} = \frac{d\,V(t)}{dt} = -\omega_1^2 \sum_{n=1}^{\infty} n^2 A_n \sin\left(n\omega_1 t + \varphi_n \right) = \\ = -\sum_{n=1}^{\infty} a_n \sin\left(n\omega_1 t + \varphi_n \right) = -\omega_1^2 n^2 \left[X(t) - \frac{a_0}{2} \right]; \tag{3}$$

$$r(t)=\frac{d^3X(t)}{dt^3}=\frac{d^2V(t)}{dt^2}=\frac{d\,a(t)}{dt}=-\omega_1^3\sum_{n=1}^{\infty}n^3A_n\cos\left(n\omega_1 t+\varphi_n\right)=$$
$$=-\sum_{n=1}^{\infty}r_n\cos\left(n\omega_1 t+\varphi_n\right)=-\sum_{n=1}^{\infty}r_n\sin\left(n\omega_1 t+\varphi_n-\frac{\pi}{2}\right), \tag{4}$$

where $r_n=\omega_1 na_n=\omega_1^2n^2V_n=\omega_1^3n^3A_n=\dfrac{8\pi^3n^3A_n}{(t_m-t_1)^3}$, $V_n=\omega_1 nA_n=\dfrac{2\pi nA_n}{t_m-t_1}$ and

$a_n=\omega_1 nV_n=\omega_1^2n^2A_n=\dfrac{4\pi^2n^2A_n}{(t_m-t_1)^2}$ – amplitude of sharpness, speed and acceleration.

Using the formulas (1)÷(4) to indicate the instantaneous coordinates (or displacement), velocity, acceleration and related at time t_i in the interval $[t_1, t_m]$.

If a continuous function of time is harmonic $s(t)=s_m\sin(\omega t+\varphi)$, then its time the relations determine derivatives:

$$\left.\begin{aligned}
v(t)&=\omega s_m\cos(\omega t+\varphi)=v_m\sin\left(\omega t+\varphi+\frac{\pi}{2}\right);\\
a(t)&=-\omega^2s_m\sin(\omega t+\varphi)=-a_m\sin(\omega t+\varphi)=-\omega^2s(t);\\
r(t)&=-\omega^3s_m\cos(\omega t+\varphi)=-r_m\sin\left(\omega t+\varphi-\frac{\pi}{2}\right).
\end{aligned}\right\} \tag{5}$$

From the relations (5) it follows that the velocity vector of harmonic oscillations ahead vector displacement (offset) on $\pi/2$ and behind the acceleration vector and on $\pi/2$. Vibrational acceleration and displacement as well as the speed and sharpness are pairs of opposite phase (Fig. 1).

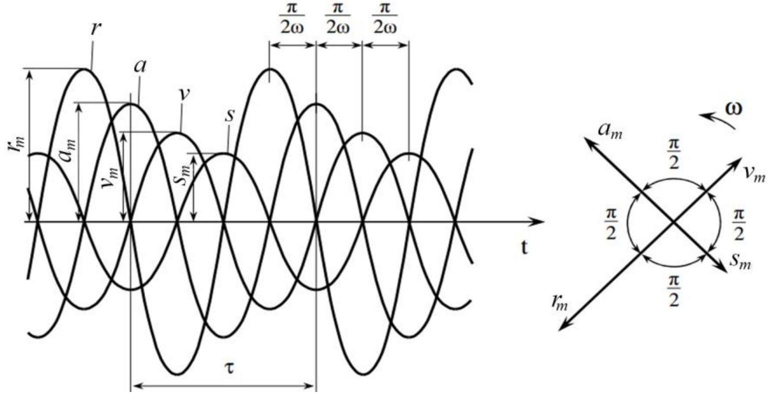


Fig. 1. The phase relationship between displacement *s*, velocity *v*, acceleration *a* and sharpness *r* harmonic oscillations

The amplitudes of displacement, velocity, acceleration and related:

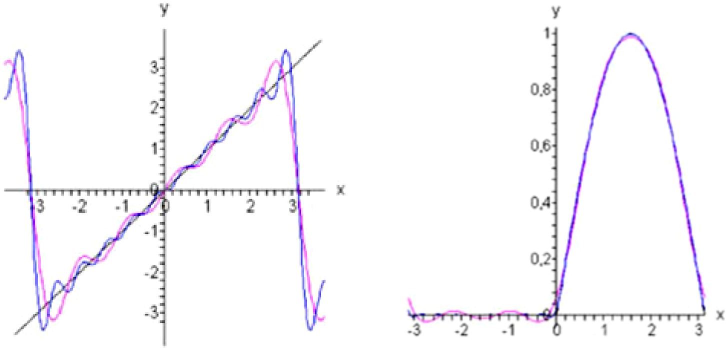
$$\frac{r_m}{\omega} = a_m = \omega v_m = \omega^2 s_m .$$

To illustrate the proposed technique found in a number Fourier schedules for sawtooth function defined on the interval [−π, π] with period 2π (6), and the function type $f(x) = \begin{cases} 0, & якщо\ -\pi \le x \le 0; \\ sinx, & якщо\ 0 \le x \le \pi; \end{cases}$ specified on the interval [−π, π] (7):

$$y = f(x) = \sum_{n=1}^{\infty} \frac{2}{n} (-1)^{n+1} sinnx; \tag{6}$$

$$y = f(x) = \frac{1}{\pi} + \frac{sinx}{2} - \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{cos(2kx)}{4k^2 - 1}. \tag{7}$$

Charts respective functions shown in Fig. 2, which shows that as the increment number of components of the schedule *n* fidelity function increases.



***n* = 5, *n* = 10** ***n* = 2, *n* = 8**

Fig. 2. Decomposition of some continuous functions in Fourier series

Thus, the paper shows that to determine the parameters of the object required information about its position or function, describing the move. A continuous movement spread function in Fourier series with subsequent determination of motion parameters of the object.

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Calculation of industrial LED device

Features of designing LED lights was considered. The mathematical and computer model of industrial lamp was created.

When designing LED lights, you must first determine the parameters of the source. To achieve this task was selected LED XHP 50 firms CREE (USA) with warm white light [5]. The choice of this manufacturer caused the highest quality product on the market, and availability of all necessary to design information also available on the website of CREE.

The next step is to calculate the brightness distribution of luminous body in space. Brightness, according to [6], is calculated as follows

$$L = \frac{dI}{dA\cos\alpha}, \tag{1}$$

where L - brightness surface area dA angle α to the normal N, dI - intensity towards α (Figure 1).

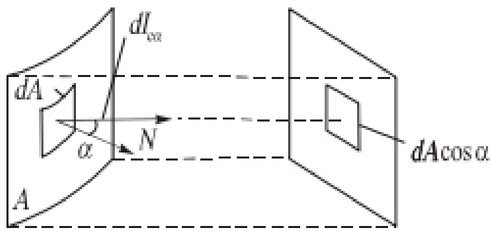

Fig.1. To calculate the brightness of the glow in a certain direction

The problem is that the LED has a very complex photometric body that cannot be replaced by substitutes geometrical important error. Manufacturers also provide only data on the distribution of intensity in the space.

Recovery brightness light source to power its light curve refers to the inverse problem type and detail considered in [7].

However, it is for the LED source is almost impossible to analytically calculate the distribution of brightness, this is possible only in the study in the laboratory.

Considering all above-mentioned nuances LED technology and the fairly large distance that the light beam is compared to the size of the source, we take the assumption of smallness Precision luminous body.

In [8] The calculation is uniformly bright point source

$$L_c = I / (\pi d^2 / 4) \,, \tag{2}$$

where d - diameter of the luminous body, Lc - its brightness, and I - intensity, uniform within the angle dω. It is this expression we used in our calculation of the brightness of the luminous body.

To calculate the shape of the reflector was used as an example of secondary optics Ledil Mirella- 50 -s-pin [9]. Using drawings provided by the manufacturer, the program was conducted Trace Pro simulation of light distribution of the reflector (Figure 2).

After optimizing the shape of the reflector, the form was made by paraboloidal with a focal length of 3.83 mm and a length of 24.8 mm and a diameter of 39 mm. The form received a reflector as close to drawing Ledil Mirella-50-s-pin.

For analytical calculation method selected reverse rays. This method is fast, accurate and easy to use. Since the shape of the reflector paraboloidal. This eliminates the possibility of multiple reverberations because the use of more sophisticated methods are not appropriate.

Using [10], a form reflecting surface is calculated as

$$\left.\begin{aligned} X^2 &= 4fZ; \\ r &= \frac{2f}{1+\cos\phi}, \end{aligned}\right\} \tag{3}$$

where X, Z - coordinates rectangular profile curve; f - focal length reflector.

The calculation of the return beam light distribution method was performed according to [10]. The equation of the surface in Cartesian coordinates

$$x^2 + y^2 = 4f(f - z) \,. \tag{4}$$

The equation of the normal to the surface

$$\hat{n} = [2x \quad 2y \quad 4f]^T / M \,,$$

where $M = 2\sqrt{x^2 + y^2 + 4f^2}$.

Feedback is given ray vector

$$\hat{a}_0 = [\sin\alpha \quad 0 \quad \cos\alpha]^T \,.$$

Internal beam described vector

$$\hat{a} = [2xQ_a - \sin\alpha \quad 2yQ_a \quad 4fQ_a - M^2 Q_a] / M^2 \,, \tag{5}$$

where $Q_a = x\sin\alpha + 2f\cos\alpha$.

$$I(\alpha) = 4\pi L_0 f^2 (R / \alpha f - 1) = 4\pi L_0 f^2 (\alpha_{\max} / \alpha - 1) \,, \tag{6}$$

where L_0 - source brightness, α_{max} = R / f, R - radius of the light source (take it as relatively small radius sphere).

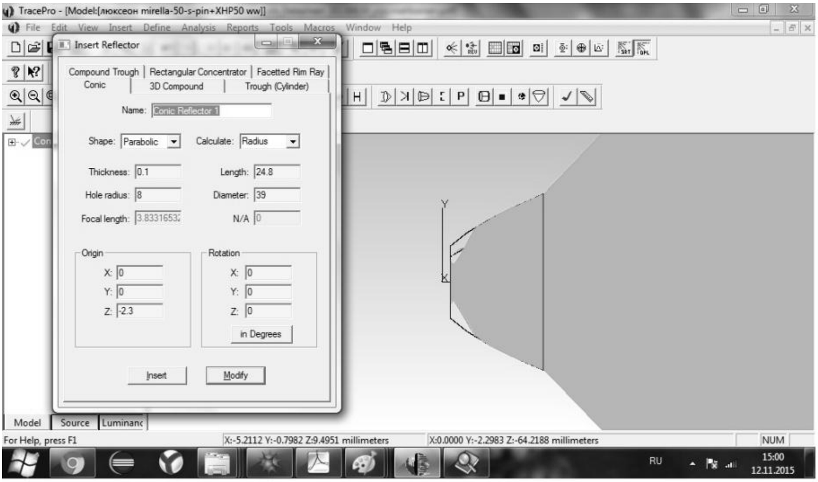

Fig.2. Computer modeling lights in the Trace Pro To compare the results, given intensity curves obtained Trace Pro program (Figure 3) and obtained analytically (Figure 4).

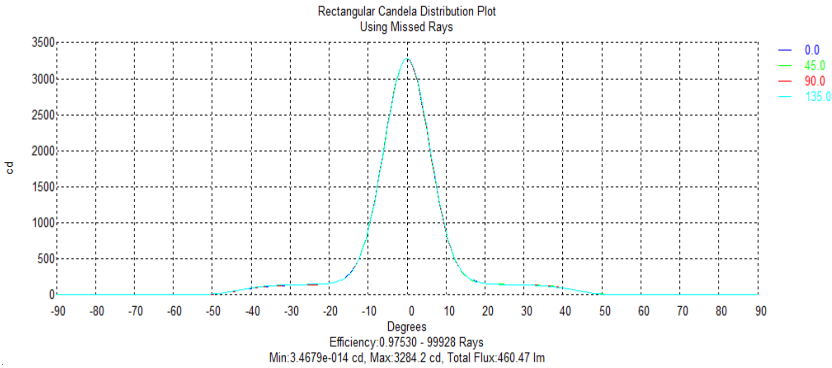

Fig. 3 intensity curve, obtained by computer simulation

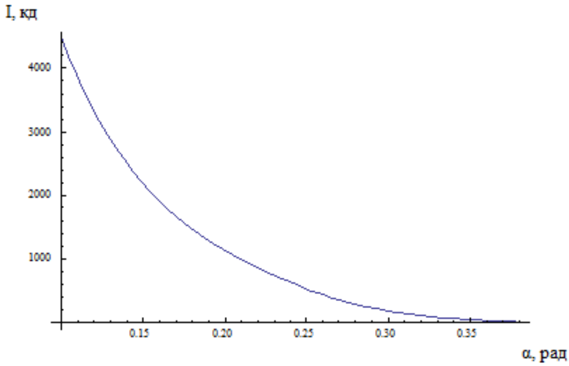

Fig. 4. The light distribution curve obtained from the mathematical modeling

Conclusions

The work was conducted computer simulations of industrial luminaire based on LED sources. During the optimization form reflector was installed form a profile curve. The method of calculation was chosen method of reverse -rays, which in this case is the best. The results of computer simulation and mathematical overlap by 98%.

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Features of measuring mechanical quantities into account water and heat

The analysis of prospects for the implementation of energy efficiency measures in the municipal sector and methods of calculation of consumed heat energy is done. The role, capabilities and motivation of the state and consumers to implement energy saving measures in the form of arranging individual metering of heat energy are showed.

The main purpose of modern European energy saving policy should be achieved to the rational scientific - reasonable consumption of hot and cold water and heat, reducing the volume of fuel and electricity for utilities.

Among the most important measures, aimed at energy saving is the devices implementation of water and heat accounting and regulation [1].

Accurate accounting of heat energy is becoming more urgent by the need to maximize saving of energy and water resources of countries are more expensive. Increasing demands for precision measurements in units of the commercial account need the replacement of obsolete equipments with modern intelligent instrument systems which have computer interface and are convenient for installation and operation.

Today, in Ukraine more than 30 % of buildings is not equipped with tools of energy account. The calculation of consumed heat energy conducts in accordance to the KTM 204 of Ukraine 244-94 "Norms and instructions of fuel and heat energy rationing for heating of residential and public buildings and domestic needs in Ukraine", due to which the amount of heat consumed energy is as following:

$$Q_i = k \cdot S_i, \tag{1}$$

Q_i – the amount of heat used by the *i*-consumer;

k – the rate of heat energy for 1m2 heating per reference period ;

S_i – floor space of *i*-consumer.

Standards of heat energy for heating of 1 m2 are set for individual regions based on calculations of heat in previous years. The annual demand of heat for heating is determined by specific formulas, the result of calculation depends on the outside temperature during the heating period, the duration of the heating period, the number of heating hours a day etc.

This method does not account for glazing areas, especially space-planning solution building thermal and other factors that significantly affect energy consumption of buildings. Also, the use of such accounting resulted in significant differences between the allowed and the actual consumption of heat consumption, the real need for consumption of heat is often overestimated and therefore it doesn’t promote energy saving technologies from the consumer [2].

In case of general - building heat metering an individual consumer pays proportionally according to parameters of heated area (or volume) apartment. So that the amount of consumed heat to individual consumers is as follows:

$$Q_i = Q_{буд} \cdot \frac{S_i}{S}, \qquad (2)$$

$Q_{буд}$ − the amount of heat energy according to general - building heat meter for a certain period of time;

S_i – floor space of the *i*-consumer;

S – the general area of the building.

Practice shows that it is through the general - building heat metering individual consumers pay on average 20% less than before the installation of metering. Payback period of metering arrangement for the 5-storey apartment buildings consists 2 seasons, and for 9 - storey apartment buildings is on average 1 season [3].

This method is more reliable for general - building use of heat energy than normalized method, but as individual consumers, it does not take into account individual thermal performance of each room and its heating equipment.

There are several ways to determine the cost of heat, the most advanced in the world is to determine the amount of heat by the formula:

$$Q_i = V_i \cdot K_T \cdot (T_{i\ пр} - T_{i\ зв}), \qquad (3)$$

K_T – heat coefficient (also known as factor Shtyuka), which depends on the properties of the coolant for the respective values of temperature and pressure, MJ / (m3 • ° C).

It is known that formula (3) is characterized by considerable methodological error [4]. Conventionally, the true value of thermal coefficient of water in case of using it as a carrier, expects to pressure 16 atmospheres (1600 kPa). The thermal coefficient takes into account the density of the carrier and its specific heat, by taking into consideration the specified pressure. Means of measuring thermal energy production European working on relevant European standards, but domestic heating systems are not designed to pressure 16 atmospheres. Because the features described above calculation should take into account when implementing foreign measuring devices in Ukraine.

To implement a general - building accounting method for determining the amount of heat consumption according to heat consumption in the heating system should also measure heat consumption V_i, temperature of coolant in the input and output (forward and reverse) pipelines $T_{i\ пр}$ and $T_{i\ зв}$, pressure coolant p (if value does not take constant). By the way almost all heat meters work that are present in

Ukraine (ST - 1 M, Multical, Sensonic, Ultraheat 2WR, Integral, UFEC 005 and others).

The problem of energy efficiency of houses and building with a vertical wiring intrahouse engineering heating systems is that with such a layout method for measuring and custody transfer is not always effective because, firstly, it does not allow correct heat measurement in a particular room, depending by equipping it with heat generating elements, and finally, it makes impossible to regulate the amount of thermal energy supplied in different rooms.

For more accurate and convenient commercial accounting of heat energy we offer to use the developed of us devices which measure the thermal energy on the basis of the coolant temperature difference in the supply (direct) and return the ambient temperature and the calculation of the measured parameters and submitted consumed quantity of thermal energy in the heat meter.

Measurement of the temperature difference in the supply and return pipelines, and the room temperature is carried out by means of temperature sensors.

Calculator heat meter using the brought in the configuration of the heater thermal performance (according to the manufacturer), uses the following method to determine the amount of heat energy consumed [5]:

$$P_{Ges.} = (P_{HK} + P_{Rohr}), \tag{4}$$

$$P_{Ges} = P_{Norm}\left[\frac{\dfrac{T_V - T_R}{\ln\dfrac{T_V - T_{Luft}}{T_R - T_{Luft}}}}{49{,}83}\right]^n + \left[C * A\left(\frac{T_V + T_R}{2} - T_{Luft}\right)\right], \tag{5}$$

T_V - the temperature of the supply line [° C];
T_R - the temperature of the return line [° C];
T_{Luft} - the indoor air temperature [° C];
P_{Ges} - the total consumed power [W];
P_{HK} - the heat flow of heater [W];
P_{Rohr} - the heat flow of piping [W];
P_{Norm} - the normalized heat flow of heater [W];
49,83 - an average logarithmic temperature in rated conditions;
C – the heat transfer coefficient $\left[\dfrac{W}{m^2K}\right]$;
A – the surface area of the piping [m^2];
n – an exponent of different types of heaters power curve, according to the manufacturer.

The total energy consumption is:

$$W_{Ges.} = \int_{1}^{n} P_{nGes.} * t_n \,, \qquad (6)$$

t – the measurement time;
n – a number of measurements.

In general - building accounting method ignores the individual characteristics of each thermal space and heating equipment, it is necessary to pay for heat in terms by individual heat meters each apartment. This approach is the most objective and one that encourages residents and owners of premises to the efficient and economical use of heat energy.

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Nano-Cluster Structure as Elements of the Optical System

The Parameterized Density Functional Theory (PDFT) was used to calculate the optic-electronic properties of a clusterize layer (CL) in Si-CL-Cu_2S(film) – optic sensitive hetero structure. The computational efficiency of the PDFT model provides improved scalability for large multi-atom simulations, such as of nanoelectronic devices that have experimental interest.

In this report, we have discussed in detail the theoretical results using local functional density method in parameterized modification of quantum-dimensional system like atomic nanoclusters. One of the main conclusions is that the comparison between theory and experiments shows the possibility of different radiative channels for the recombination in porous silicon.

Motivation of the study

Research into semiconductor clusters is focused on the properties of quantum dots (QD) - fragments of semiconductor (for example, Si) consisting of some to hundreds of atoms - with the bulk bonding geometry and with surface states eliminated by enclosure. QD exhibit strongly size-dependent optical and electrical properties [1-3]. Two peculiar characteristics of semiconductors influence the ways in which we think of an ideal semiconductor cluster, which is often called a QD. First, it is important to realize that in any material, substantial variation of fundamental electrical and optical properties with reduced size will be observed when the electronic energy level spacing exceeds the temperature. In semiconductors, this transition occurs for a given temperature at a relatively large size compared to metals, insulators, or molecular crystals.

The luminescence observed for por-Si raises an interesting problem related to the possibility of using Si in optoelectronics [2]. One likely explanation is *quantum confinement*, induced by the formation of nanocrystallites, whose effect is to break partially the optical selection rules and allow the material to luminesce.

The most striking property of semiconductor nanocrysials is the massive change in optical properties as a function of size. As size is reduced, the electronic excitations shift to higher energy, and the oscillator strength is concentrated into just a few transitions. These basic physical phenomena of *quantum confinement* arise as a result of changes in the density of electronic states and can be understood by considering the relation between position and momentum in free and confined particles. For a free particle, or a particle in the periodic potential of an extended solid, the energy and the crystal momentum can both be precisely defined, whereas the position cannot. For a localized particle, the energy may still be well defined, but the uncertainty in position decreases, so that momentum is no longer well defined.

For example, the kinetic stability of tetrasilatetrahedrane (Si_4H_4), hexasilaprismane (Si_6H_6) and octasilacubane (Si_8H_8) depends strongly on the steric bulkiness of the substituents (matrix). The silyl-substituted Si_nY_m (*Y=t-Bu*) is stable in an inert atmosphere, but is oxidized in air to give colourless solids. The 1,1,2-trimethylpropyl-substituted Si_nY_m ($Y=CMe_2CHMe_2$) is very stable even in air and survives for two weeks in the solid state. The prismanes with Si and Ge skeletons are yellow to orange. These prismanes have absorptions tailing into the visible region. So, Si_6H_6 has an absorption band with a maximum at 241 *nm* tailing to *ca* 500 *nm*. The absorption band of Ge_6Y_6 ($Y=2,6\text{-}i\text{-}Pr_2C_6H_3$) has a maximum at 261 *nm*, which is red-shifted compared to that of Ge_6Y_6 because of the higher-lying orbitals of the Ge-Ge bonds [4].

The discrete energy eigenfunctions of the particle may then be viewed as superpositions of bulk momentum states. Given the relation between energy and momentum in the bulk solid, one can see how a series of nearby transitions occurring at slightly different energies in the bulk be compressed by quantum confinement into a single, intense transition in a QD.

The experimental data reveal a more complex situation probably characteristic of several radiative channels.

Channels for the radiative recombination

We presents a compilation of data showing that observed luminescence energies on porous silicon or silicon nanocrystals in an oxide matrix are consistently lower that the predicted optical gaps [3].

On the other hand, recent luminescence measurements on silicon crystals obtained by silane decomposition are in good agreement with theory, but the luminescence is only observed for the largest crystallites.

The situation is thus complex, even if it seems that the degree of oxidation of the samples plays an important role in the recombination mechanisms. All these results suggest that other channels for the radiative recombination are possible. Large Stokes shifts might be consistent with the eventual existence of deep luminescent centers. The problem is that nothing is presently known regarding the nature and origin of these states.

We have found another interesting situation with very small crystals, containing less than about 50 silicon atoms, where we systematically obtain a large atomic relaxation in the excited state which induces an important reorganization of the bonds in the cluster. The consequence is a large Stokes shift between the absorption and the emission energies. Therefore, small nanocrystals could play a role in the luminescence of porous silicon.

We are presently investigating the possible existence of defect states in the band gap induced by the oxidation of the surface. Among different systems that we have studied, preliminary results show that an oxygen atom doubly bonded to a silicon atom (Si=O) at a nanocrystal surface is a good candidate to be involved in the luminescence of porous silicon. It gives rise to a deep level below the conduction band minimum which could explain the evolution with size of the luminescence peak [4].

Structural dependence of the band gap

We calculate the electronic structure of a-Si and a-Si:H spherical clusters using the ETB and PDFT model [5]. The interaction parameters are limited to first-nearest neighbors and the usual d^{-2} Harrison law can be used to calculate their variation with interatomic distance *d.* The starting structure for the a-Si or a-Si: H clusters is obtained by selecting the atoms belonging to the respective atoms unit cell. Due to the new boundary conditions the structure is no more in equilibrium and we have thus relaxed the atomic positions using a Keating potential.

A generally accepted picture of the electronic structure of a-Si is that it is still composed of valence and conduction bands separated by an energy gap but with band tails of defect or disorder-induced localized states extending into the gap. For what follows we find it useful to classify the electronic states into three categories: delocalized states, experiencing the full confinement effect as for c-Si; strongly localized states with extension in space much smaller than the cluster diameter and energies deep in the gap, insensitive to the confinement effect and showing no blue shift; weakly localized states with extension in space of the order of the cluster diameter and energies near the gap limits, subject to an intermediate blue shift.

Our results for the optical compounds of the intellectual robot's system are very important and actual. The accuracy of the method is illustrated by our results.

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Multi-pattern recognition technology in autonomous systems

A new method of forming a multi-layered system. Formation of hybrid layers containing several methods of image recognition.

Introduction

Detection and identification of objects is an integral part of human activity. It is not yet clear how the person manages so well and so quickly identify and learn the right things in the variety of environments. Attempts are made to find out physiology and psychology for over a hundred years. However, our goal here is not to understand the mechanism of human perception (and animals), as in the description of methods for automated recognition of objects in their images: the new information technologies, powerful, practical and in some sense a universal methodology for processing and evaluation of information and reveal hidden patterns.

Recognition of three-dimensional objects from their two-dimensional images has recently become one of the most important scenes tasks of analysis and computer vision. Initial recognition contain image information in different parts of the full spectrum of radiation (optical, infrared, ultrasonic, etc.) prepared by various methods (television, photographic, laser, radar, radiation, etc.), converted to digital form and represented as a numerical matrix. An object is defined not only (and not only) digital representation of a fragment of a two-dimensional local scene, and some of its approximate description, a set of characteristic properties (attributes). The main purpose of the descriptions (for objects) - is their use in the process of establishing compliance with the objects carried out by comparing (matching). Recognition problem is the definition of the "hidden" object supplies to a particular class by analyzing the vector of observed feature values. For information about the relationship between the values of attributes of the object and its belonging to a certain class recognition algorithm should learn from the training set of objects with known or values and attributes and classes, or only the values of their attributes.

In the process of mobile robots, or autonomous systems have to perform tasks such as recognizing objects around them. With that, the problem of determining the objects is not always the main. For example, there was a task to move to the specified point. In this case, the robot needs to know its location and be able to navigate the terrain.

Statement of the problem

Object of this study is technology analysis of images. The goal is a multi-layered system that will recognize the images on the input image and make decisions based only on data from images. This system is addition for multilevel hierarchical system of all mobile work. In the process of consolidating data from various sensors mobile robot will be able to adequately respond to changes in the environment and perform the task. For pattern recognition is proposed to use multiple algorithms. During the experiments tested algorithms are known and identified their strengths and weaknesses. To form the multilayer technology was chosen neural network with error back-propagation, support vector machine (SVM) and group method of data handling (GMDH).

Separating functions

We assume that there is a certain set of $\tilde{C} = \{C_i\}$ consisting of k mutually exclusive classes (images) of the objects. Each object represents a set of measurements of selected features $(x_1, x_2, \ldots, x_m)' = x$ called his description. Thus, the description - a point (vector) x in m - dimensional feature space $\Re^m$ The Euclidean distance between two points x and y in $\Re^m$

$$r(x, y) = \left(\sum_{i=1}^{m} (x_i - y_i)^2 \right)^{1/2} \quad (1)$$

Procedure for recognition of objects is a procedure to identify areas $\{R_i\}$ of space $\Re^m$ by examining the descriptions given set $X = \{x_1, x_2, \ldots, x_n\}$ of objecs, which are known to which classes they actually belong. In other words, X is a training sample, which runs the procedure of pattern recognition objects.

Procedure for the classification of objects is a procedure related to the class of the object C_i if and only if its description x enters the region R_i of the area corresponding to the class. This classification procedure is correct, and if the object is in fact belongs to the class C_i. Thus, the object recognition process involves pattern recognition process (the formation of classes of objects) and the procedure for classification of objects (usually referring to the objects of a particular class). Geometric concepts included in the recognition of objects, simple enough. For example, consider a two-dimensional feature space (Fig. 1).

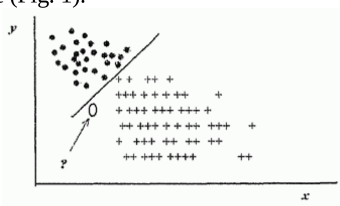

Fig. 1. The two-dimensional feature space with a training sample: dark points objects of class C_1 labeled crosses - class of objects C_2; ellipse - an unknown object

From the present example it shows that the two sets of objects turned out to be convenient to divide the line. Let $d(x) = w_1 x_1 + w_2 x_2 + w_3 = 0$ - the equation of separating line where w_i – arguments, x_i – attributes of objects. Function $d(x)$ it can be used as separating (discriminant) function because, considering the object x membership of which is unknown, it can be argued that it belongs to the class (image) C_1, when $d(x) > 0$ and membership of class C_2 when $d(x) < 0$. If the feature vector x lies on the dividing boundary, then there is the uncertainty: $d(x) = 0$. Obviously, this method can be extended to a larger number of classes and on the more general case of non-linear boundaries in any finite-dimensional Euclidean space signs.

In general, the feature space can be considered to consist of k regions $R_i, i = 1,\ldots,k$, each of which contains the points corresponding to the objects of the same class. This recognition task may be regarded as the construction of the boundaries of solutions that share class, based on the registered (training) of the set of vectors signs. Let these boundaries are determined, for example, sharing features $d_1(x), d_2(x),\ldots.,d_k(x)$. If $d_i(x) > d_j(x)$ for all $i \neq j$, then object x belongs to the class C_i. It becomes clear that the main problem arising after the definition of dividing functions, is to find the boundary surfaces. To determine them, and need training sample objects. Here, the learning process is considered complete when performed all dividing boundaries between sets of images (classes). It is usually possible to perform, provided the so-called compact when each group (cluster) vectors signs belonging to the same class, in the form describing compact space (locally limited) in a sense region. If the clusters corresponding to the various classes are spaced sufficiently far apart, it advantageously possible to use simple recognition patterns, for example such as the classification of the object by the distance from the center of gravity of the clusters or "average distance" to all elements of the training sample corresponding images and etc.

Formation of a multilayer system

Today proved efficient use of information technology for multi-data conversion system of the intelligent mobile robot. Figure 2 presents the hierarchical structure of the global functional dependence, which is obtained by converting multilevel data of a local model combines a layer. At the highest level are synthesized model based on the output signals of the previous execution.

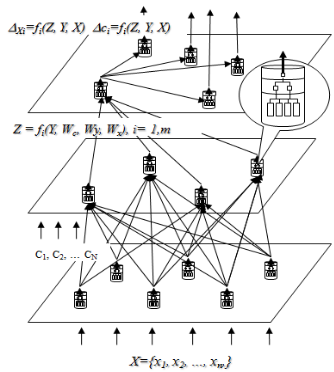

Fig. 2. Multi-hierarchical image analysis

It was found that for solving tasks Retrieve data informative system of mobile robot vision is not enough, while still not used to 27% performance. In this paper we propose a method to improve ascending synthesis of elements to model units database structure knowledge to use pattern recognition functions. In this case $X=\{x_1,x_2,\ldots,x_n\}$ – array of input (AOI), $C_1,\ldots,C_i$ – models from first level, where the model can be used neural network or support vector method, $Z_1,\ldots,Z_i$ – the upper layers of the model on which the final decision.

To test the system implemented training and finding people in images. For education system was given 30 thousand positive examples of images which are people and 40,000 negative examples. For training and retraining system used bootstraping. An example of learning sample shown in Figure 3.

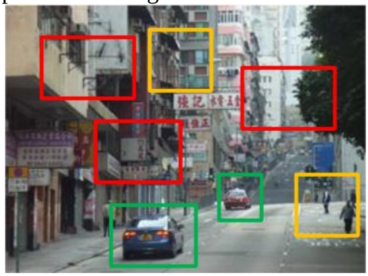

Fig. 3. Training Selection

After learning of the experiment was conducted. During the performance multilayer system was compared with the results of other algorithms. The experimental results are shown in picture 4.

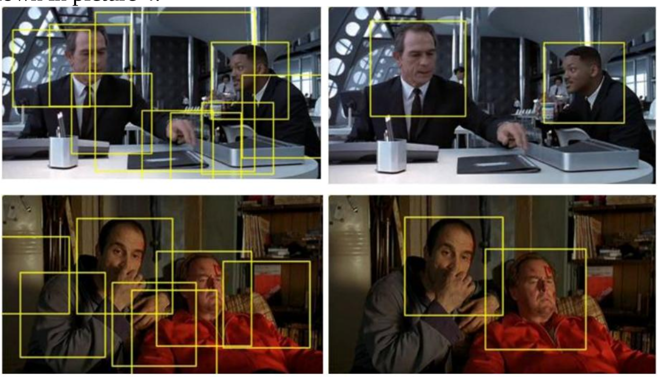

Image a *Image b*

Fig. 4. Test the trained systems. Image a - trained system based on support vector method. Image b - layered system using several algorithms.

Below is a graph of the result of the recognition algorithm support vector machine (Fig. 5) and a graph comparing the results of the system of support vector method (Fig. 6).

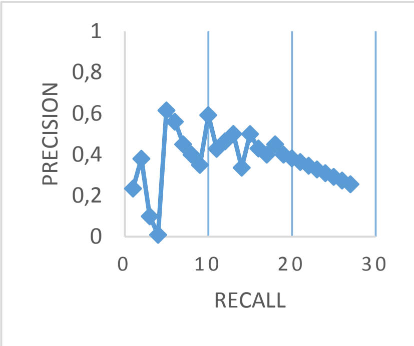

Fig. 5. Results from SVM

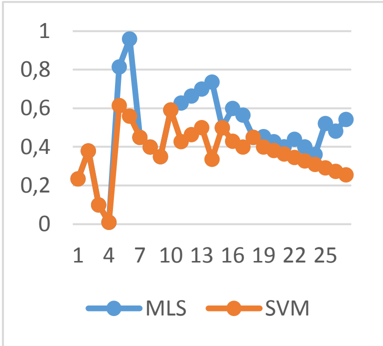

Fig. 6. Comparison of the algorithms

Conclusion

Was designed and tested multilayer system for image recognition. There have been comparisons of results showed that the system searches for objects in the image to 12% better than other algorithms.

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UDC 681.2

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Aviation gravimetric system with the vibrating string gravimeter

The aviation gravimetric systems (AGS) with the vibrating string gravimeter for gravimetric measurements and Earth's gravitational field information gathering were considered.

The information about the gravity *g* and its anomalies Δg is needed in aviation and space technique (correction of the systems of inertial navigation of rockets, planes), for realization of aims of engineering geology, archaeology, prognosis of earthquakes. To determine the characteristics of the Earth's gravity field the most useful is aviation gravimetric system (AGS) [1-5]. By means of the AGS it is possible to obtain the gravimetric information in the awkward-toreach zones of the globe much faster and at lower costs than doing this by means of groundmounted, seagoing and land-based gravimetric units.

Gravimeter is a sensitive element of AGS that measures the gravity and the accuracy of which, basically, determines the accuracy of all AGS [1]. Therefore, to improve the accuracy of existing and creation of new gravimeters is a very topical issue as of today

All known AGS gravimeters are inherent to both advantages and significant disadvantages, for which the main ones are the following [1]:

1) Low measurement accuracy (2-10 mGal);
2) The mandatory need to use the filtration procedure for AGS gravimeter output signal;
3) AGS gravimeter static gear coefficient volatility caused by changes in the properties of structural elements;
4) Low performance speed, the lack of operational data processing and others.

The articles [1,4] show that the vibrating string gravimeters own the highest precision of 2 mGal. Hence, they should be preferred.

Vibrating string gravimeters have high vibration and impact durability, reliability, frequency-modulated input signal, high-power output signal, small size and weight. The allow fast and accurate digital registration of *g*-force acceleration. The benefits also include the small time constant, which is vital for aircraft measurements and nearly unlimited input measurement range without reconfiguring the device.

Fig. 1 presents the functional scheme of vibrating string gravimeter in the AGS system [5]. Aviation gravimetric system for measuring *g*-force acceleration anomalies (fig.1.) contains system (1) of navigation parameters identification, the height meter (2) and vibrating string gravimeter mounted on girostabilized platform (3), the outputs of which are connected to OBC inputs (4).

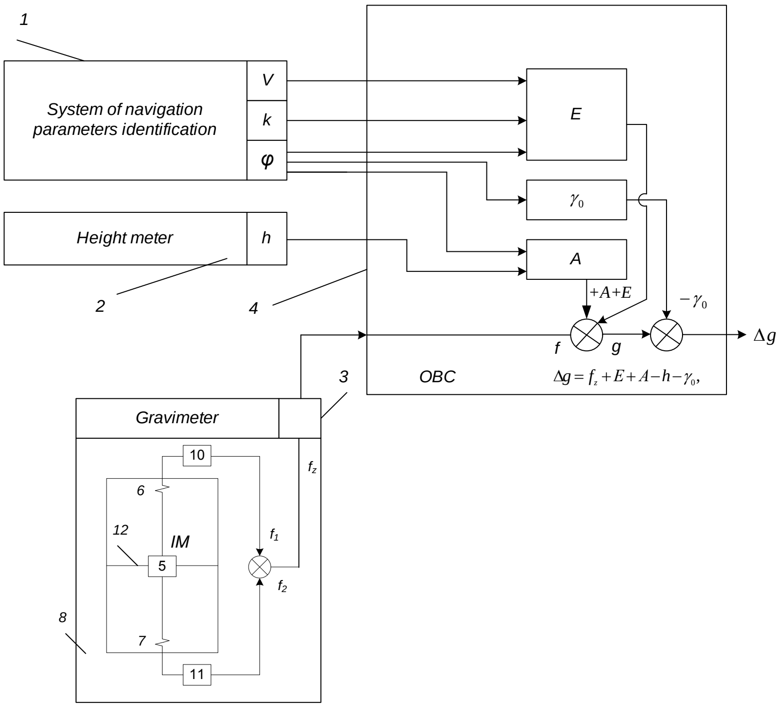

Fig.1. AGS vibrating string gravimeter [5]

The sensitive gravimeter element (3) (fig.1.) placed in the sealed vessel (8) and is designed as two identical vertical strings (6) and (7). They are attached to the top and bottom of the inertial mass (IM) (5) by one end, which is attached to the opposite wall sides of the sealed vessel (8) by the elastic element (12). The free ends of the vertical strings 6 and 7 are connected with string generators (10) and (11), which outputs are connected to the inputs of the adder (9) [5].

Aviation Gravimetric System for measuring *g*-force acceleration anomalies work in such a way.

The *g*-force acceleration *g*, aircraft vertical acceleration $\ddot{h}$ and the total instrumental errors Δi from the influence of residual non-identity of identical string structures, from the temperature, humidity and ambient pressure impacts the inertial mass (5) (fig.2.).

The force equation along the *Oz* axis for gravimeter sensitivity, directed along the vertical strings will look like:

$$f_z = f_1 + f_2 = mg + m\Delta\ddot{h} + \Delta i + mg_z - m\Delta\ddot{h} - \Delta i = 2mg_z \quad (1)$$

where f_1 – output signal from string generator 10; f_2 – output signal from string generator 11; f_z – output signal from adder 9; m – inertial mass.

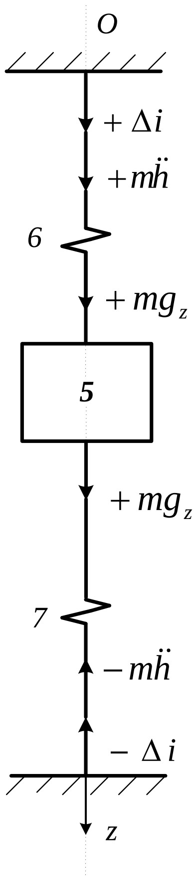

Fig.2. Operation principle of AGS vibrating string gravimeter

Equation (1) shows that output signal from 9 adder contains the doubled value of useful g-force acceleration signal and does not contain the vertical acceleration $\ddot{h}$ and the total instrumental errors Δi

The output signal f_z from adder 9 is passed to OBC 4, where output signals from navigation parameters identification system 1 and height meter 2 are also passed. OBC 4 calculates the value of g-force acceleration anomaly Δg using the formula [1]:

$$\Delta g = f_z + E + A - \gamma_0, \qquad (2)$$

where f_z – the output signal of vibrating string gravimeter 3; E – Etves correction; A – correction for height; γ_0 – reference value of g-force acceleration.

Equation (2) shows that it's missing the component of error $\ddot{h}$. All known gravimeters are measuring $\ddot{h}$ simultaneously with g. It leads to the large errors. The value $\ddot{h}$ is 10^3 larger than g. This ensures the significant increase in measurement accuracy using the new offered vibrating string gravimeter.

Conclusions

The expediency of using AGS with the vibrating string gravimeter [4,5] for gravimetric measurements and information gathering about Earth's gravitational field was proved.

It was shown that new AGS vibrating string gravimeter signal contains the doubled value of useful signal of g-force acceleration and does not contain the vertical aircraft acceleration $\ddot{h}$ and the total instrumental error Δi.

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Synthesis of window function to improve the estimation accuracy of the amplitude spectral component of periodic signals

The article was considered technique improve the accuracy by using window functions. Also, the technique of synthesis window functions for the discrete Fourier transform is developed.

The constant increase in the volume of information processed and expanding applications of digital signal processing (DSP) helps to create a completely new signal processing algorithms. To creating methods and technical means imposed more stringent requirements, both in speed and accuracy. The tasks associated with increased speed and accuracy, made both by taking into accounts the architectural features of the hardware, and through the improvement of DSP algorithms.

One of the most common problems of the DSP is to determine the spectral composition of the signal. In determining the amplitudes of the harmonic components is used: correlation analysis, approximation, the discrete Fourier transform (DFT). Widespread use of DFT found with the advent of the fast Fourier transform algorithm (Kuli-Tukey, Thomas Hood, Vinograda and others[1, 2]) and is used in fields such as acoustics, energy, physics and others.

In general, the DFT can be expressed by the following formula (1):

$$X(k) = \frac{1}{M}\sum_{m=0}^{M-1} x(m)\cdot e^{\left(-j\frac{2\pi}{M}mk\right)}, \quad m,k = 0 \ldots M-1, \tag{1}$$

where $x(m)$ – the samples of the real input signal, M – the size of the sample signal.

However, the feature of the DFT is the fact that if the period of the input analog signal is a multiple signal sampling step, the transformation provides a reasonably accurate assessment of the spectrum parameters.

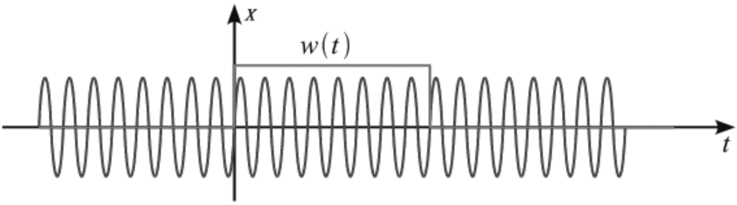
If the analog input signal period is not a multiple signal sampling step, the evaluation of amplitudes of harmonic spectral components can be obtained in accordance with the expression (2):

$$\widehat{X}(k) = \frac{1}{M}\sum_{m=0}^{M-1} X(m)\frac{\sin\left(\pi m\frac{f_c}{f_0} - \pi k\right)}{\sin\left(\frac{\pi m}{M}\frac{f_c}{f_0} - \frac{\pi k}{M}\right)}\cdot e^{-j(M-1)\left(\frac{\pi m}{M}\frac{f_c}{f_n} - \frac{\pi k}{M}\right)} \tag{2}$$

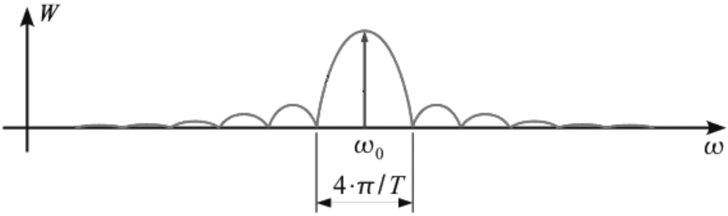
where f_c – the frequency of the real input signal, f_0 – the nominal frequency Rated frequency of the real input signal for which error estimates amplitude harmonic components has a minimum value.

The reason is that the actual signal is infinite, and when performing DFT conversion signal is limited in time. Time limit is an overlay window function $w(t)$ on the input signal (рис.1, a), therefore, according to the Fourier transform properties of the resulting spectrum will be equal to the convolution of the original signal spectrum and a rectangular window spectrum (рис.1, b), and therefore only for a periodic signal with frequency ω_0 spectrum will correspond to the actual signal.

To improve the accuracy of measurement of the amplitudes of the harmonic components, depending on the problem, are mainly used two approaches: selected window function $w(t)$, providing the required accuracy; introduced a feedback frequency for correcting the sampling step. Each option has its advantages and disadvantages.



a)



b)

Fig. 1 – a) the original signal; b) amplitude-frequency response of window

In this paper, we propose a different approach, the essence of which boils down to, that in accordance with the shape of the window to determine the value of the amplitude of the harmonic components, for example, in accordance with the formula (1). However, the disadvantage of this expression is that for determining the value of the amplitudes of the harmonic components is necessary to know the value of the frequency of the initial periodic signal f_c, that negates this approach. It is obvious that it is necessary to synthesize the window, invariant to frequency. The best option in this case is a function of the window, amplitude-frequency response which corresponds to Fig. 2, while the frequency resolution should be increased at least twice, reducing the sampling step. In this case, the value of the amplitudes of the harmonic components of initial signal will be the sum of the values of neighboring Fourier transform coefficients.

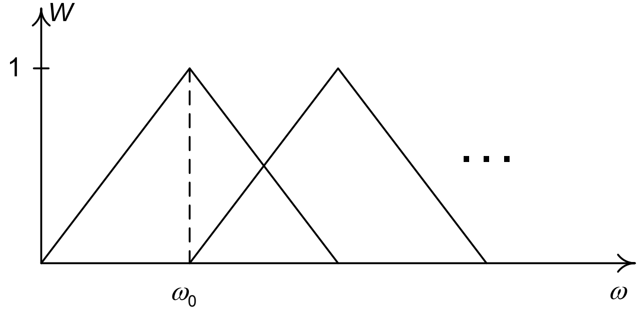


Fig. 2 –One possible amplitude-frequency response to improve the accuracy of estimates of the amplitudes of spectral components

Obviously, a frequency response is realized with certain accuracy.

The accuracy of this method can be improved if we pay attention to the fact that the amplitude-frequency response function window does not have to have a triangular shape and only requires that the sum of the left half and the right half was equal to some constant (units in our case), that necessary to synthesize a window in accordance with the expression (3):

$$\varepsilon = \min(1 - (W(\omega) + W(\omega + \omega_0))) \quad (3)$$

Synthesized several functions of windows for different numbers of points M in accordance with the expression (3) showed good results. Obviously, the larger the M, the better the result of evaluation of the amplitudes of harmonic components of the spectrum.

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Regulatory and technical control providing information security, that requiring protection under the law, based on the international standards of information security management

Authors have conducted theoretical research of regulatory and technical control providing security of information, that requiring protection under the law based on a series of based on the international standards of information security management.

Problem. The current status of the regulatory framework of Ukraine in the field of security of information allows to perform all major stages, that use for protection. However, nowadays, in the legal sphere, questions of the management of the organization works, and especially the establishment of a specific regulation of this activity, is not resolved in full.

Therefore, to improve the quality of work in the subject area should consider ordering and systematization of organizational procedures to ensure such works [1, 2, 3, 4].

The aim of the study is to improve information security system in the direction of the organization works to protect at information and telecommunication systems (further – ITS) and at the objects of information activities (further – OIA) in government agencies, enterprises, institutions and organizations.

The main part. There is no doubt, that the products of the industry (which are as a separate product of protection, and comprehensive systems of security of information in ITS [5, 6, 7], and complex of technical protection of information at OIA) to accomplish their objective function must be of high quality. Requirements for the quality of any products have set in ISO standards of 9000 (14000) series, which define the necessary conditions regarding composition, sequence of operations, distribution of activities, order of works at all stages of making to ensure, that these products would be qualitative [8].

The basis of quality at creation of comprehensive systems of security of information and complex of technical protection of information is the proper organization of work subject of creation. This approach is declared in ISO standards of 27000 series, that determine general organization works of information protection at the institutions, methods of classification of resources, direction of works planning, the responsibility of management and employees, task of services of information security and others.

Those standards describe a systematic approach to the management of protection of information, and are a tool, that allows to create at organization the system of organization process at all stages of making, which the most would be promote, to get quality final result.

ISO/IEC 27002 is a code of practice - a generic, advisory document, not a formal specification such as ISO/IEC 27001. It recommends information security controls addressing information security control objectives arising from risks to the confidentiality, integrity and availability of information. Organizations that adopt ISO/IEC 27002 must assess their own information risks, clarify their control objectives and apply suitable controls (or indeed other forms of risk treatment) using the standard for guidance.

For implementation regulatory framework in the field of protect of information, that would regulate the procedures of the organization works of protect at institutions, would define the conditions, when such procedures are mandatory, and when can be used by individual of his own choosing and, finally, would ensure harmony with international standards, is proposed to implement technical regulation of information security management system, that fully would repeat approaches, that used in ISO/IEC 27001, ISO/IEC 27002 [9, 10, 11].

Document should take into account all the requirements of current legislation of Ukraine in the field of technical protection of information, which directly are regulated requirements, composition of works and creation order of comprehensive systems of security of information in ITS, and complex of technical protection of information at OIA, and the mechanism used to achieve this aim, will not include amendments to the said regulations.

Instead, this document will increase the management's responsibility of institutions for the quality of such work.

Conclusions. Therefore, after the implementation of technical regulation, is expected to improve quality performance of works of security of information, that requiring protection under the law, increasing the responsibility of heads of companies for effectiveness of providing protect of information.

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Transformation of cybersecurity critical infrastructure and robot's security

Retrace stages and directions of transformation of the system for providing of information security in Ukraine. A new distributing of tasks of information is examined that cyber security critical infrastructure, systems with artificial intelligence and robotics. Substantial growth of human factor and social safety is shown. The list of actual threats of robotic security broadens. The mathematical model of dynamics of the process of providing information-psychological security offered.

For last twenty years the area of information security in Ukraine was repeatedly transformed and expanded. The aim of this work is to identify key issues and problems of information systems and cyber security today. Counting steps begin from the time when the problem of information security in the Soviet Union out of the shadows of secrecy. Then there were the published materials in the opened seal. They became widely available scientific and technical experts.

The main a feature of transformation areas of information protection choose the paradigm shift in information security. The concept of *paradigm* considered as a set of values, methods, approaches, technical skills and facilities, problem solving methods accepted in the scientific community of experts within the established scientific tradition in a certain period of time. The paradigm is undergoing changes depending on accumulated practical experience and research results. Terms separation stages determine the facts of the appearance of the relevant national legal documents. We consider the following stages of the transformation of national information security technologies and information resources. Let's start with "zero" stage:

Stage 0 (1980-1992) – is transformation in a period Soviet Ukraine;

Stage 1 (1992-1996) – is becoming of the own system of protection of information with the limited access in Ukraine and technical protection of information;

Stage 2 (1996-2000) – is creation and development of normatively-legal base and complex systems of protection of information in the automated systems;

Stage 3 (2000-2004) – is development of normatively-legal base of protection of state information resources and harmonization of her with international;

Stage 4 (in 2004-2008) – is development of information resources protection in all types of public, commercial and personal data in information and communication systems (ICS) and the information space Ukraine. Expanding the scope of information security (IS) for public information;

Stage 5 (2008-2012) – is development of the systems of information security on a background a foreign network-centric paradigm and systems of the information influencing. Expansion of sphere of information security on a commercial sphere;

Stage 6 (2012-2016) – is establishment of development of the systems of cyber security information space of the state cybernetic and. Expansion of sphere of information and cybernetic security on commercial and social spheres;

Stage 7 (modern) – update of the IS tasks as components of information opposition and information wars, the formation of the system of protection of individual and collective consciousness, comprehension of aspects of robotic security.

The high intensity of the transformation of information security has a good reason – the rapid introduction of modern information technology. In Ukraine, a paradigm shift, in contrast to developed countries, held at an accelerated pace. The sequence of transformations scope IS has an outstanding property. The principles set out at the beginning of information security remain almost intact to this day. The transformation of the sphere information security is maintaining and/or extension of the basic principles of all previous stages. Some previously identified problems and some important results are relevant today. For example, "time has shown that a general solution to the problem is the illusion of protection that many recommendations are extremely difficult to implement and that the problem of protecting computers generate entirely new links different fields [1, p. 6]." Consider the transformation of the directions IS areas.

Transformation of types of the systems which information and information resource are on the defensive in:

1) (stage) – in the technical systems of treatment of information;

2) – in single computers;

3) – in computer networks (automated systems);

4) – in the of informatively-communication and telecommunication systems;

5) – in information space of the state,

6) – in cyber space;

7) – a socio-technical (in information infrastructure) and social systems.

Transformation of basic paradigms:

1) (stage) – it is the classic paradigm of protection of information, based on the control of accesses;

2) – implementation of complex system of protection of information security;

3) – it is introduction of paradigm of around protection of objects of information activity (paradigm based on guaranteed secure core idea around which provided several lines of circular defense and demilitarized zone);

4) – it is construction of the echeloned complex system of protection of information resources;

5) – it is realization network-centric of paradigm of information and other security critically important the infrastructure states, in particular of informatively-communication networks as the most critical state resource;

6) – Paradigm increasing requirements for survivability of information systems, which are characterized by a high degree of resource allocation and decentralization of governance, enhancing the role of technical operation in terms of compliance to preserve a minimal set of critical functions to the vitality of information systems to the safety factor by the action of destabilizing factors external environment;

7) – Paradigm ensure cyber environment of enterprises, organizations and users (in progress); implementation of the "Strategy of Ukraine cyber security" [2].

Transformation technologies of information security:

1) – access control;

2) – a system of access mediation and access control; added antivirus technologies;

3) – added perimeter protection network using firewalls;

4) – added detection, response and handling information security incidents;

5) – added of automated search vulnerabilities in ICS;

6) – added audit system IS;

7) – created structures to ensure cyber security, to fight cybercrime and destructive informational influence.

Transforming innovation protective facility and measures in an attempt to reach functional completeness measures and facility:

1) and 2) (stages) – model "security threat –> Services Security –> Security mechanisms";

3) and 4) (stages) – model "security objective –> security profile –> security target";

5) – a model of network-centric and social-centric security paradigm in the information influencing [3];

6) and 7)) – model "technology and methods of cyber security –> cyber security technology categories –> cyber security technologies" [4].

Transformation properties protected:

1) (stage) – ensuring the confidentiality, integrity, availability and accountability (CIAA) information;

2) (phases) – providing CIAA in the automated system;

3) – added privacy (for compatibility with ISO/IEC 15408 in the commercial sphere);

4) – added ensuring the CIAA information resources;

5) – attached preparedness, sustainability (vitality) of networks and that repudiation users;

6) – added cyber security cyber environment, resources of any type and user;

7) – is added to protect behavior, individual and collective consciousness of people.

Transformation of terminology of the IS sphere:

1) (stage) – it is introduction by standards terms «cryptographic protection of secret information», «technical protection of secret information» and also «technical protection of information», «system of technical protection of information»;

2) – it is «complex of facilities of protection», «policy of security», «security service», «functional services of security», «mechanisms of security»;

3) – are they entered terms «information security of information technologies», «audit of security of the technological control systems»; the improved terms are «security of the information system», it is added in determination of the term «computer security»: «… to resist to the attempts … to introduction of information which results in destructive actions and imposing of vicious information»;

4) – it is the term «automated system» was transferable on the term of «informatively-communication system»;

5) – a term appeared «information space» and «information infrastructure», the term «personal information» is entered, first the term of «cyber security» is applied in normative documents;

6) – are they entered terms of «cyber security», «cyber environment», «cyber crime».

7) – the terms «information influencing» went out on the first plan, «information war», «socially-psychological security» of person, associations, states, terms are improved «information security of the state», «national security», intensive work after clarification of the concepts «critical information structure», «security of critical infrastructure» is conducted.

In fact, the transformation of the sphere of information security was introduced new activities to ensure information security and create new types of information security, cyber security and socio-psychological security. Older types of IS preserved, improved and occupy every niche in the system of national security. Table 1 shows how the changed significance solved security problems old and a new system IS.

Table 1.

Distributing of meaningfulness of facility of the information resource protection, (in percents, %)

Years	Organizational facility, legal norms	Cryptographic facility	Technical and physical facility	Programmatic-technical facility	Socially-psychological facility
2000	40	30	30	–	–
2005	30	30	30	10	–
2010	30	30	10	30	–
2015	20	10	10	20	40

The sheer volume of work to protect the IS increased significantly after increasing volumes of information technology. But the relative weight problems solved shifted towards the social, psychological, ethical and aesthetic aspects of information security. According to others the relative weight IS issues related to the human factor (in our case - organizational + psychosocial factors), reach 60-70%.

Today the actual task is of implementing the strategy of cyber security Ukraine. One of the main objectives is the protection of critical information infrastructures. During the critical information infrastructure understands of the information infrastructure of the state, disabling or destruction of objects which is detrimental to national security or harm its international image. The authors concentrate on the next task. "There are various areas in which information plays a decisive role.

The first sphere – is sphere of telecommunications, information which serves as a signal. The main processes here – transmission, processing and data storage. This aspect will be called IS *Network security*.

The second area – is information as content. Here senders and recipients are people. Information has the form of texts, videos, audio messages (mostly Internet and media). This aspect of IS will be called the *Content security*.

Third sphere – this is sphere human conduct. Here information is important not as signal and not as sense of report, and as reason of some practical actions. It is the world of acts, those, or other actions. This aspect IS we will name *behavioral security* [5]».

A fourth sphere is the sphere of robotics. The guided battle works are already used. There is development of autonomous battle robots on a turn. The process of complete robotics of industrial production and transport began. Robots will take the seat in a domestic sphere and sphere of service. This aspect of security can be named *robotical security*.

In the field of network security (telecommunications) warring parties seek to technically break the channels of information make it difficult or change processing algorithms, steal, damage or change information in the field of storage. In this area set up extensive system of protective measures. But today recognized that in the confrontation with cybercrime and offenders IS humanity loses so far. The authors proposed to introduce a system of determining the identity and identity management system defined in ICS systems [6]. It will monitor every transaction in the system. The effectiveness of these measures is due to the important role of the human factor. The system determining the identity aimed at identifying and promotes the inevitability of the next sentence offenders IS. In the field of content security and behavioral human factor is crucial.

To study the processes of information influence the group consciousness following authors propose a simple model. Group consciousness is seen as a system of group concepts, rules and image perception, which is well organized. It is known that the number of cyber security incidents (DOS-attacks, viruses, Trojans, password cracking and sites, etc.) is increasing. This means that the growing social group of supporters attacks on computer systems that do not consider it immoral to engage in cybercrime or pursue useful purposes. Develop a model of group consciousness on the opposite idea – the idea of the fight against cybercrime and create a safe information space. We will take advantage of method, laid out in the Kolesin's work and adopted «Model of formation of debatable group [7, part 2.1]».

It is assumed in this method that in the process of direct or mediated intercourse of the M people is idea a formed that unites them in a group. Lets N – is number of people which united in a group. We will use description of «brightness» of group self-expression that, lets V – is level of development of idea which unites people in a group. «An element which passed some border frequency is considered acknowledged by a group, accepted to everyday life, and such, that became the element of group consciousness. Let cabbage soup ω_i – frequency of displays of i-element, and $\Delta\omega_i$ – is increase of frequency in times of $\Delta t = 1$. Then the relation $\Delta\omega_i / \Delta t$ is *intensity* of forming of i-element of group consciousness. Lets n – is number of elements which passed the border of frequency to the moment of time of t, and Δn – is increase in times of Δt. Then $\Delta n / \Delta t$ is intensity of forming of group consciousness or *brightness* of group self-expression [7, c. 19]». We make balance equalizations for M and N, and to we fill up them by equalization for to the parameter of the order V:

$$\begin{cases} \dfrac{dM}{dt} = \alpha VM + \beta N, \\ \dfrac{dN}{dt} = \alpha VM - \beta N, M + N = const, \\ \dfrac{dV}{dt} = cM - mV, \end{cases} \tag{2}$$

where: αVM – is intensity of association of supporters of idea of fight against cyber crime, βN – is intensity of exit from him, «cM – is intensity of forming of idea («the more than the greater mass M, which she is formed in), mV – is intensity of disintegration ($m = 1/TV$), TV – is characteristic duration of storage of presentations which represent this idea) [see 6, c. 60]».

Suppositions can be initial conditions, that in an initial moment was not neither to the idea nor its transmitters: $V(0) = 0$, $N(0) = 0$. In this case the dynamic system (1) has the analytical decision. In this paper shown the research results of system properties.

Conclusions. Stages and directions of transformation of the IS sphere are classified in this work, the changes of relative meaningfulness of types of the IS systems are shown, the list of actual tasks of the IS sphere is complemented, application of the system assurance of the identity and by of identity management is offered, represented mathematical model of forming of collective consciousness round the idea of fight against cyber crime. They got results will allow to improve efficiency of management information systems, information-psychological and cyber security.

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The generalized classifications of threats on unmanned aircraft systems in un-segregated airspace/non-segregated airspace

Development of vulnerabilities tables for data channel the receiving / processing / transmission based on the analysis of international aviation standards and data operation of unmanned aircraft systems

For the safety of flights of unmanned aerial vehicles (UAVs) in un-segregated/non-segregated airspace including navigation specification and navaid infrastructure in accordance with ICAO requirements for the communication, navigation, surveillance it has previously been proposed the introduction of on-board equipment performance specifications. Developed base of specification characteristics for unmanned aircraft systems (UAS) and complexes (UAC) (including airborne and service system) can serve as a basis for identifying potential vulnerabilities and cyber threats in the design and creation of aeronautical information protection systems, taking into account international requirements for flight safety, types of systems UAV control and used class of airspace and its segregation (segregated airspace and un-segregated (non-segregated) airspace classes A, B, C).

The characteristics of the security of aeronautical information aren't developed for the integration UAVs, UAC, UAS to un-segregated (non segregated) airspace, at this point. Therefore, developments/groundworks of security features, classifications, models and risk assessment of potential vulnerabilities, threats and attacks on the UAV, the UAC, UAS to un segregated (non segregated) airspace are actual. Accordingly, the purpose of this work are the development of classifications threats of UAV, UAC, UAS for data channel "Air-Ground", "Board-on-Board" and "Ground-Ground".

On the analysis of available information (international aviation standards, data obtained during the flight of the UAVs and the work developed by the UACs), the possible scenarios and developed appropriate classification of threats on the UAV, the UAC, UAS data channel/link "Ground-on-Board", "Board-on-Board", "Ground-Ground" and board equipments of receiving/ processing/ data transmission. They presented on Table 1.

Table 1.

Classification threats of UAS

Threats	**Influence (After-effect)**	**Data link/channel*)**			**BE**)**
		G-G	**G-B**	**B-B**	
1. Distortion of the data (information)	1.1 modification information (data integrity scheme)	+	+	+	+
	1.2 damage/corruption to the system (technical resistance)	+	+	+	+

2. Unauthorized / unauthorized access	2.1 violation control (encrypted data set)	+	+	+	+
	2.2 damage to the system / can safely transmit / (team authentication without the use of open networks, authentication characters (such as a smart card), the control of management)	+	+	+	+
	2.3 theft of business data (characters authentication (such as a smart card))		+	+	+
	2.4 damage to the system / can safely transmit / (Team authentication without the use of open networks, authentication characters (such as a smart card), the control of management)		+	+	+
3. Interference	3.1 loss of control and telemetry link (upper multilevel communication, hopping, spread spectrum)	+	+	+	+
	3.2 loss of TT & C and / or network chains (multi-level upper link hopping, spread spectrum)		+	+	+
	3.3 commercial impact (multi-level upper link hopping, spread spectrum)		+	+	+
	3.4 impact on possible security (multi-level upper link hopping, spread spectrum)		+	+	+
4. Retransmission of data, information	4.1 damage to the system / can safely transmit / (accounting authentication (control) time stamp)	+	+	+	+
5. Software threats (viruses)	5.1 adverse events (adoption of (conduct) testing)	+	+	+	+
6. Computer hackers	6.1 system damage (independent certification (verification and validation) (IVV))	+			+
7. A software failure	7.1 system damage (Independent certification (verification and validation) (IVV), peer review, automated analysis codes Auditing (management control))		+	+	
	7.2 possibility of other threats to the use of software vulnerabilities /	+	+	+	+

	bug, bug, tab ... / unregistered modification or destruction of data, malicious programs such as viruses, worms, of DDOS agent, Trojan horse ...: (expert evaluation of the program, automated analysis codes Auditing (keeping control))				
8. A technical failure		+	+	+	+
9. Interception of data	9.1.1 loss of confidential data (assessment, protection of archival and distribution systems through encryption, the use of COTS products)		+	+	+
	9.1.2 loss of confidential data (data encryption, spread spectrum, frequency hopping)	+	+	+	+
	9.2 theft of commercial data (assessment, protection of archival and distribution systems through encryption, the use of COTS products, data encryption, spread spectrum, frequency hopping)		+	+	+
10. User substitution (masking)	10.1 management potential interruption / upper level / (strict upper and lower levels of data management authentication)	+	+	+	+
	10.2 potential receiving false information / lower level / (access control scheme)	+	+	+	+
	10.3 theft of business data (inspection staff do not use open networks)	+			
11. Ground-based physical attacks	11.1 loss of control, monitoring, data (protection, exits, access control, site provision)	+	+	+	+
12. Record on communication lines		+	+	+	
13. Analysis of the traffic		+			
14. The constant deception / dishonesty system / personnel		+	+	+	+
15. Unintentional actions of personnel		+	+	+	+

/ staff /					
16. Dissatisfaction with the state / staff /		+	+	+	+
17. Commercial competition		+	+	+	+
18. Terrorism and crime		+	+	+	+
19. Foreign Service / foreign intelligence services		+	+	+	+
20. Or subversive political activity		+	+	+	+
Data link/chanel[*)]: **G-G** – "Ground-Ground" and ground equipment; **G-B** – "Ground-on-Board" (radio channel); **B-B** – "Board-on-Board" (radio channel). **BE**[**)] – board equipment					

The proposed classifications can be used for the calculation of risk assessment and the development of models of vulnerability, threats and attacks for the UAVs in their safe integration in un segregated (non segregated) airspace (classes A, B, C) and segregated airspace for the protection of aeronautical information and flight safety, taking into account international requirements.

Data classifications threats of the UAV, the UAC, UAS can be used both in Ukraine and international aviation organizations, committees and groups.

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Infosec for civil aviation

At the moment, we are witnessing and, unfortunately, starting the increase of illegal actions in the world. One of the most bloody and cruel cases is the terrorist attack recently occurred in the International Airport "Ataturk" in Istanbul, that resulted to the deaths and injuries of many people. Definitely the number of victims could be significantly greater if terrorists managed to get into the waiting zone, where usually are large crowds of passengers.

The fact that the terrorists didn't get into the departure lounge is the result of measures taken by the authorities, for protection against acts of unlawful interference and protection of civil aviation against this kind of actions. In the Annex 17 "Security" to the Chicago Convention we can find an explanation the meaning of the act of unlawful interference. But there is a question: are these actions mentioned in definishion the only acts, that negatively affect the civil aviation security? The answer to this question is in another question.

What will happen if you purchased a ticket for a trip and, upon arrival at the airport, at the registration desk you are told that you don't have the ticket for the flight? But if the same thing happens with a larger number of people? Hundreds or thousands of passengers? And what will happen if in order to protect own rights they will submit claims to the court against the airlines, airports and ground services?

What will happen if an unauthorized person illegaly received the access to your personal data information from the online ticket booking companies and direct this information to persons with bad intentions?

But all these problems can have far secondary importance in comparison with the consequences of hacking the information system of the institution performing air traffic control (ATC). We can only imagine the consequences if the terrorists hack air traffic control information system and what can happen with an aircraft with, just for example, 120 passengers on board and full tanks of fuel. Or what can happen in case of interception of the aircraft in the air. Everything is possible. Unfortunately, the terrorist organizations have sufficient financial and human resources for the implementation of this kind of scenario.

Attacks on information networks are already a global reality and issue. Taking into account the growing dependence on IT-technologies and communications, this type of impact can be carried out in many different ways. This dependence on IT-technologies and communications reduces the level of safety and efficiency of civil aviation entities worldwide.

Terrorists or other people with criminal intentions may use the virtual space as a testing ground for the use of new tactics in order to achieve illegal purposes. They are often anonymous and hard to be identified so it's often quite difficult to give a quick and effective response, using a small amount of time, financial, technical and human resources. These factors can lead to disastrous consequences for manufacturers of aircraft, equipment, air transport security systems and generally for civil aviation.

Thus, there are many processes and steps which terrorists or hackers can strike in the civil aviation. Beginning from the of the aircraft designing and finish with to the equipment manufacturing. Another risk factor is the air operators. Impact on information networks can be realized not only by individuals and groups of individuals (terrorist, criminal or hacker groups), but entire corporations and, I will think in same situations, by any states as well.

Here I will focus on the certain features.

A possible target could be the aircraft, which consists of a complex system (hardware structures, electronic equipment and software).

Another target may be equipment and air traffic control systems, information systems, ground services, IT networks, computers and their components.

For example, hacker Hugo Tess, who in 2013 showed how easy is to take control over an aircraft using a simple program and equipment that can get everyone.

In the same year in DerbyCon was shown how is possible to make a total chaos in air traffic control system by displaying false aircrafts on the controllers' monitors, using equipment of $ 2,000 worth.

Taking into consideration the example of the interception and introduction of external control under air drone in the air space over the Crimea in 2015, performed by military units of the Russian Federation, we can assume that there is a possibility of interception of aircrafts. At least there is a sense that such technology already can exists.

In this context must be emphasized that there is a possibility of external influence on aircraft GPS - systems. Such a case was reported by the aliberty Newark International Airport authorities. Landing system signal was distorted by a device which was in a car parked at a distance of about 100 meters away from the runway. The driver of the car used the device for jamming GPS-system installed in the service car, but he did not realize that his actions violate operation of the airport. The good side of this case lies in the fact that no one was injured as a result of these actions, but there is a bad side - the terrorists can use the same device, too.

Regarding the MH370 flight there is still a lot of unknown. We know, this incident raises many questions, but, unfortunately, there are no answers for them, yet.

The above mentioned examples, unfortunately, are not unique. This is only the visible part of the iceberg. How many similar cases have occurred and have not been made public for different reasons? We do not know.

One of the methods to deal with such phenomenon was the adoption by ICAO of changes in SARPs, Chapter 4 of Annex 17 that has to do with cyber threats. It recommends that: Each Contracting State must develop measures in order to protect information and communication technology systems used for civil aviation purposes from interference that may jeopardize the safety of civil aviation, USAP program, and the Beijing Convention 2010 where was recognized that the use of aircraft as a weapon is a serious crime. Another step was the ICAO's closer cooperation with the FAA and EUROCONTROL.

In the near future, when more than 30,000 aircraft worldwide will use airspace and each company will use its own communication systems for data exchange, ICAO policy will have a key role. Each ICAO Member State has its own vision of the problem, realizing it by their own legislative or normative field. In this regard, the role of ICAO is to provide a common and synchronized vision. Otherwise there is a risk of creating total chaos.

Civil Aviation Field is the most important channel of passengers from different countries to travel fast over the big distances and not only big distances, cargo transportation, its importance, big financial implication, size and resonance of terrorist attacks consequences, as well as possible damages, makes civil aviation the most desired target. In the situation where the dependence on IT technology only increases, cyber attacks on the entire civil aviation system become inevitable.

In this context, I propose to consider the possibility of inclusion cyber attacks against any civil aviation object in the list of acts of unlawful interference and specify criminal punishment for committing this type of actions as the most dangerous, in the legislation of ICAO Member States.

Also I propose to create guidelines for operators of the airspace and ground facilities on the introduction of certification system of 27000 standard series, or other similar systems, in order to protect civil aviation objects from possible information systems attacks. Or, as an alternative, the creation of cyber attack operational response cells, which should include well-trained professionals.

LIST OF SOURCES

International Law / Treaties /Resolutions

- Cybercrime Convention, 2001
- United Nations Manual on the Prevention and Control of Computer Related Crime, International Review of Criminal Policy nos. 43 and 44 (1999).
- United Nations Resolution on Combating the Criminal Misuse of Information Technologies GA RES 55/63, UNGA 55th Session, 81st Plenary Meeting UN Doc. A/RES/55/63 (2001).
- European Treaty Series No. 185
- The Tokyo Convention On Offences And Certain Other Acts Committed On Board Aircraft, 1963
- The Hague Convention For The Suppression Of Unlawful Seizure Of Aircraft, 1970
- Montreal Convention For The Suppression Of Unlawful Acts Against The Safety Of Civil Aviation, 1971.

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A model developed for teaching an adaptive system of recognising cyberattacks in information systems

The study presents results aimed at further development of models for intelligent and self-educational systems of recognising abnormalities and cyberattacks in mission-critical information systems (MCIS).

A model of an intelligent recognition module for cyberattacks in information systems. The mathematical description of the module of systems of intellectual recognition of cyberattacks (SIRCA) is presented as follows:

$$\Delta = \left\langle IS \times T \times SS \times \Omega S \times KB, MX^{|2|}, MB^{|2|}, o_1, o_2 \right\rangle, \tag{1}$$

where IS is a set of input signals that determine the state of cybersecurity in corporate information systems (CIS) or mission-critical information systems (MCIS); T is a set of time points for the data on the state of information security (IS) of the object of protection; SS is a signature space for recognising a certain class of cyberattacks; ΩS is the space of the functional states of IS; KB is a knowledge base to identify cyberattacks; $MX^{|2|}$ is an instructional matrix (standard) that is stored in the repository of SIRCA; $MB^{|2|}$ is an instructional binary matrix; o_1 and o_2 are operators that form the instructional input and the binary matrices of SIRCA, respectively.

The SIRCA structure is shown in Fig. 1. The operator $O\Theta : MB^{|2|} \to MR^{|2|}$ is used to divide the space of cyberattack features into two classes of recognition. The parameter of the features (PF) is used to test the statistical hypothesis that the object of recognition belongs to a simulated class of cyberattacks. After evaluating the statistical hypotheses by using an *oy* operator, a plurality AR^Q is formed to contribute to the accuracy of recognising a cyberattack in SIRCA. It is assumed that q is the number of the statistical hypotheses, and $g = q^2$ is the quantity of SIRCA characteristics. The operator $o\mu$ generates an exploit kit (EK) plurality, which allows performing the procedure of evaluating the effectiveness of attack recognition within the class. The operator $o\beta$ is used to optimize the system of control deviations from the patterns of cyberattacks. The set SW is consistently closed by the operator $o\alpha_1 : EK \to SW$ and the operator $o\alpha_2 : SW \to MX$, which allow changing the implementation of various features of cyberattacks of different classes in the process of teaching SIRCA.

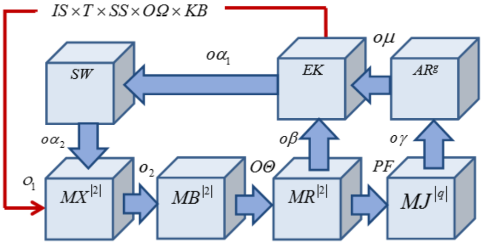

Fig. 1. A schematic diagram of SIRCA

The following feature of the matrix forming the objects used for training (OUT) was identified. The information content of the control set formed by the two features, characteristic for different classes of attacks, such as Dos/DDos, U2R, R2L, may describe the object of detection better than each of the features and the EC class separately. And the level of detection of cyber attacks, for which the training matrices of OUT were compiled, ranged from 25% to 30% for 2 features, 85–87% for 3–4 features, 92–98% for 5–9 features, Fig. 2.

Thus the OUT, described by a fragment of 2–3 features, belonging in different classes of objects, better described the studied class than each of the features separately. For example, in the tasks of assessing the impact of a cyber-attack on the systems of satellite navigation of MCCS of the transport, the most informative was the following group of features:

1) signal level (because the GPS signal at the Earth's surface is around 163 dB*Wt., at the same time the signals of simulators tend to be higher, which may indicate the attack);

2) the same level of signal from different satellites (signals of the different GPS satellites tend to differ significantly).

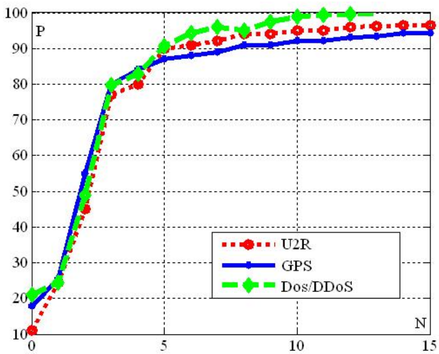

Fig. 2. Visualization of the accuracy of detection (***P*, %**) for attacks of classes U2R, DOS/ DDoS and attacks on satellite systems of GPS, depending on the number of features (***N***) in the OUT training matrix

As a result of the research:

– the model of detection of cyber attacks, anomalies and threats to mission critical computer systems was designed, which is based on the application of training samples in the form of feature matrices and elementary classifiers for each of the modeled class;

– the studies were carried out on minimizing the number of training samples from the informative features for the adaptive systems of detection and prevention of cyber-attacks (ASDCA) being developed. It was found that for detection in training matrices of OUT it was sufficient to use representative sets of 3–4 features long. The effectiveness of detection of anomalies and cyber-attacks reached 98%. The proposed model reduces the number of necessary rules for ASDCA by 2.5–12 times and reduces the time of detection of anomalies and cyber-attacks by 7–9 %.

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Software copyright protection using identification key

In this work, the task of developing software copyright rights protection strategy by creating a digital ID. Protection mechanism for digital identification from replication using the information about the components of the end-user computer system is developed. Processes of creation and verification the digital identification are described. Requirements to the final software system are concluded. Disadvantages of current implementation are detected and provided.

According to Art. 433 of the Civil Code and Art. 18 of the Law of Ukraine "On Copyright and Related Rights" [2], computer programs (software) are protected as literary works. Such protection applies to computer programs, whatever the mode or form of their expression. The basis for the classification of software to literary works is a certain commonality of display lines of the literary work and computer program: the line of literary works, and a string of computer software author fills characters, letters or symbols of operators. The identity of the creative process for the establishment of forms of copyright works of literature and computer programs was decisive for the choice of forms of software protection [1].

An analysis of the literature [3, 4, 5] concluded that one of the mechanisms of software copyright protection is a distribution of the license agreement to use the software. At the same time there are many different recommendations, technical, social, psychological and other areas for the effective use of this mechanism of protection, such as:

• an independent audit of the software;

• using a well-articulated policy with public address system;

• tools for backup;

• automation the process of using the tools of active detection, which would be allowed and unallowed installed programs.

Also recently in the scientific literature [3, 4] more attention is paid to the software protection using embedded digital watermarks, digital signatures and other marks, confirming authorship and simplifying the process of automatic software identification and verification.

Conducted research showed that one of the main shortcomings currently developed technical systems of identification and software licensing is the neglect of the formal data on the computer systems on which licensed software installed. This leads to the possibility of replicating a digital ID that is copyright infringement.

Based on the analysis of literature, the advantages and disadvantages of the existing mechanisms of verification and license key has been attempting to develop the software system, which will reduce the likelihood of malicious impact on the license key. On the basis of the benefits of the existing software systems in the first place, there was an attempt to protect the software system from malicious actions by obfuscating the code, designed to increase time of the analysis of malicious software algorithm and use a signature of the executable file in order to prevent modification.

The basic strategies of against license key replication protection are:

• usage the information about the components of the end-user computer system;

• license key core is a function (code), which executing on the end-user's computer system.

The process of a license key creation:

• end-user transmits information about the system to server through secure communication channel (for example, https protocol);

• selects the code server that will be executed on the client side, depending on the parameters passed (the operating system info, the type of license);

• server encodes the selected code including CRC32 sum;

• server sends to end-user license key over through the secure of communication channel;

• end-user client software saves a coded key, with decoding it at every executing.

The process of encoding the license key. Basing on the received information, server generates a function that depends on the client's OS, the term of the license, which will be executed on the end-user computer system.

Suppose, in machine code, this function is represented as a set of bytes:

0x60 0xA1 0x05 0x01 0xA3 0x61 0xC3

Data of the characteristics of the end-user computer system contains information about the processor, operating system, hard drive, RAM, motherboard. At the same time, each type of device has its own identifier (0-6). The identifier "7" is for the universal device, if the first 7 devices are not suitable. An example of device information:

0 – Processor: BFEBFBF000202B7

1 – OS: 00251-80443-12345-AA987

2 – HDD: WD5000AAKX-001CA0

When function is formed, received bytes are converting into a string of corresponding hex-codes:

60A10501A361C3

For each symbol in the received string:

• find an appropriate position in the input data. If no symbol - choose №7 (symbol leave unchanged). Create a pair of numbers "device number" - "position in the device number". In this case, the position should not exceed the value of 31 due to the limitation of 5 bits. If the specified character is not found for a particular end-user device information, the pair formed on the principle of "7" (reserved device identifier) - "symbol";

7-6 0-8 1-18 1-4 0-8 1-3 0-8 1-4 7-6 1-4 1-18 1-10 2-14 1-10

• convert each pair of numbers to one byte according to the principle: major 3 bits - number of the device in the input bytes (0-7), the other - position (0-31) or the number itself (0x0-0xF)

E6 08 32 24 08 23 08 24 32 2A E6 24 4E 2A

At the end, there the CRC32 sum is added. This type of hash is used only to verify that the transmission was successful. Protection against hacking is not used on this step as it is assumed that the contents of the key and the decoder algorithm is not known by another.

E6 08 32 24 08 23 08 24 32 2A E6 24 4E 2A AC 32 B7 5D

The process of license key verification:

• check the validity of the executable file (using signtool, certutil utilities) for its modification. If the validity has not been confirmed - display a message;

• CRC32 checks the integrity of the license key;

• decoding the license key;

• executing code represented by a license key. If the code is not correct, program crashes.

During development of a program part requirements were made to the final product – a system which generates a digital identifier (license key) for copyright protection:

• no modifications in registry. At the current stage of development of malicious technologies, find the software for the registry monitoring is not problematic. This can simplify the process of license key decoding;

• minimize the number of changes in the file system (create / modify / delete files);

• minimize the number of communication with server;

• usage of the secure communication channel with server (https protocol);

• protection the software from malicious actions. In the current implementation, a signature of the executable file and code obfuscation are used for complexity algorithm analysis and for preventing its modification;

• polymorphism encoding / decoding algorithm. Including, the order of the components of the system must be able to variation;

• cross-platform.

Of the nominated requirements arise disadvantages of the current implementation of the software system modules, which will be improved during further development:

• license key is stored in encrypted form in the file system of the end-user. This allows an attacker to get access to the encoded key and modify it with the aim hacking;

• mechanism of algorithm polymorphism encoding/decoding is not implemented;

• collection of end-user's computer system information is retrieved by Windows WMI service, which is Windows-specific feature.

Conclusions. Developed software system modules that demonstrate the ability of creation digital ID - the license key using the individual data of the end-user, which prevents replication of license key by malicious persons.

1. Formed license key is a software code which is executing on the side of the end-user, what gives additional protection from malicious actions.
2. Increasing protection software product from malicious actions by using the existing security mechanisms: digital signature of an executable file, obfuscation.

3. Suggested algorithm of the system functioning and generating a license key is adapted to the input data and probable terms of software verification.

4. A further objective of research is developing the imitation model and conducting practical experiments.

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Cryptographic system Gentry: basic concepts and mathematical aspects

Comparative analysis of homomorphic encryption methods of information resources by ensuring the integrity and confidentiality of modern information systems and networks. Material describes the further ways to improve the Gentry algorithm for full homomorphic encryption, as well as prospects for its use.

Introduction. The rapid increase in information flows in modern information and communication systems and networks, puts high demands on the technical characteristics of the networks and the using new modern methods of encryption to ensure confidentiality, integrity and availability of information resources and information systems in general. The use of encryption and decryption procedures on the condition of confidentiality is gaining popularity. One of these methods is homomorphic algorithms for encryption.

Problem research. Currently homomorphic cryptographic encryption algorithms are widely used in automated systems, cloud computing and implemented in the form of hardware, software and / or hardware and software techniques. The purpose of these material is the analysis of existing homomorphic encryption cryptosystems. Define criteria and requirements concerning the formation of modern homomorphic encryption systems. On the basis of these requirements to optimize cryptosystem Gentry, providing minimize the time for transactions software encryption/decryption and increase reliability by additional encryption session key [3, 4].

Analysis of existing methods of homomorphic encryption systems. The term homomorphic encryption will understand encryption model that allows you to perform certain mathematical operations on encrypted text and receive encrypted result that matches the results of similar operations carried out openly. Modern homomorphic encryption systems are divided into two classes: partly homomorphic system and fully homomorphic encryption. The term partially homomorphic system will understand these cryptosystems that are relatively homomorphic only one mathematical functions (addition or multiplication). By partly homomorphic system include RSA, El-Gamal, Peyia [1-4].

The term fully homomorphic system understand such a cryptosystem that allows operation «+» and «x» over the encrypted data so that the decryption result matches the result of the same operation on the unencrypted data. The most common – Gentry cryptosystem. Gentry cryptosystem is fully homomorphic encryption, it allows you to perform mathematical operations on encrypted text and receive encrypted result that matches the results of similar operations carried out openly. Undoubtedly, the mere possibility of such operations is the main advantage of the algorithm [3]. However the implementation of the mathematical algorithm has some shortcomings that could allow attackers based on the known key and ciphertext using known attacks on cryptanalysis algorithms and tools, receive plain text. Of course, if you do not consider the possibility of cryptoanalysis of malicious algorithm ideally be fitted to ensure privacy when using the "cloud" computing, but in a time when information protection from unauthorized access is one of the most pressing issues important task is identifying "weak "places in the algorithm and their possible elimination through the introduction of additional parameters and functions in the algorithm. One of the weaknesses of the algorithm is that encryption and decryption using the same session key. Therefore it is necessary to pay attention to the possibility of optimization algorithm to improve the reliability of the generated key.

Mathematical aspects of optimized of Gentry cryptosystem. Try to optimize the algorithm Gentry that its «strong» cryptography and reliability has been increased, and the speed is reduced to a negligible amount. As noted above, one of the weaknesses of the algorithm is that encryption and decryption using the same session key. Therefore it is necessary to pay attention to the possibility of optimization algorithm to improve the reliability of the generated key. Therefore, to improve the reliability of a given algorithm is proposed to use this encryption scheme in which the session key is encrypted in addition, with the help of my asymmetric RSA algorithm and transmitted in a communication channel encryption form. This will ensure «strong» cryptography and reliability algorithm, as for cryptanalysis and the decryption key the attacker will need to solve the problem of scheduling parameter *n* simple the factors *p* and *q*, and with the successful selection of the parameters (at least 1024 bits) such a problem to solve virtually impossible under current conditions.

For this algorithm is proposed to use a key pair (public and private) to encrypt secret session key. Encryption procedure consists in the following: For each *M* function is calculated: $C = z + x \cdot h$, where is h – an arbitrary number. Consequently the encryption function is as follows: $C = 2 \cdot r + m + (2 \cdot k + 1) \cdot h$

The procedure for encrypting the session key (secret parameter *x*) using asymmetric algorithm RSA $X = x^e \bmod n$, where is *(e,n)* – public key of cryptosystem RSA.

The procedure decrypt the session key (secret parameter *x*) using asymmetric algorithm RSA: $x = X^d \bmod n$, where is *(d,n)* – secret key of cryptosystem RSA.

Then the procedure of decryption cryptograms consists of the following mathematical procedures: $r = C \bmod x$; $m = r \bmod 2$.

Optimized Gentry cryptosystem is more reliable and "strong" compared with conventional algorithm, so as not to allow an attacker to decrypt the message based on the public key transmitted over a communication channel, as well as decrypt the session key is only possible by using the d, which is on the channel transmission and may be protected by additional means. In this case, given the right parameters p and *q* (length of at least 1024 bits) the attacker almost impossible based on the known n determine *p* and *q* (problem factorization composite number). Also, due to the modernization of the algorithm is reached that the attacker will not be able to effectively implement the attack on the known ciphertext, since the success of its implementation will need to obtain parameter *d*.

Evaluating the effectiveness of the optimized Gentry cryptosystem. Evaluating the effectiveness of encryption methods based on the international standard ISO 14756 «Information technology. Measurement and rating performance evaluation software systems». Comparative characteristics of the results of research programs, used algorithms RSA, Gentry and modified Gentry algorithm was provided on following parameters: the number of executable program features, overall bandwidth vector *B(M)*, the average time of program functions, the ratio of time that were spent to perform all functions of the program and additional options.

From the results obtained, the following conclusions: first, taking into account the rate of speed of the algorithm, namely the speed of operation encryption / decryption of data, the modified Gentry algorithm provides significantly "strong" due to additional encryption session key, but at the same time due to the complexity of mathematical computation speed of program functions increases. The quantitative value of the average execution time program features encryption / decryption for all experiments, much less in comparison with known methods (reduction in time is from 1.17 to 1.31 times, depending on the method used); secondly, there is the factor by which may significantly reduce execution speed encryption and decryption. This factor is an indicator e. Time of operations increases with the number of non-zero bits in the binary representation of open exponential e. To increase the speed encryption of e often be chosen equal to 17 257 or 65 537 - just numbers, binary representation containing only two units.

Conclusions

Comparative analysis of homomorphic algorithms for encryption information resources which provide integrity and privacy in modern information systems and networks. This material describes the current homomorphic algorithms, such as partially and fully homomorphic algorithms for encryption. Considered cryptosystem RSA, El- Gamal, Peyia and Gentry. As a result of the peculiarities of application homomorphic cryptographic algorithms, while ensuring the integrity and confidentiality of information resources, provided their classification, properties and compiled a comparative of the effectiveness of use of these algorithms. The ways of optimizing Gentry cryptographic algorithm, and the prospects for its use in modern information systems and networks. Evaluating the effectiveness of encryption methods based on the international standard ISO 14756 «Information technology. Measurement and rating performance evaluation software systems».

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Qualitativity of methods and models of navigation information security

Describes the expert assessment of the quality of navigation security scientific tools. Presents the results of qualitative indicators of methods and models of navigation information security. Shows the priority of new developments with probabilistic forecasting elements.

The information system existing on navigational sea routes has a targeted influence on the vessel's steering safety, in confined navigating conditions – on maneuvering and ship flows. In this context the methods, models and procedures of navigation information security are guarantee of supplying reliable, adequate and timely navigational data. Scientific tools must be subject to comparative analysis by method of determining criteria's weighted coefficients. While making a comparative assessment of qualitative indicators the **«Method of average»** was used. The essence of this method is in introduction the concept of weight expert assessments as a certain measure of recurrent procedure with pilots' expert answers. The form of filling in the pilot's expert answers is given in Table 1. The assessment criteria were the following five indices reflecting the qualitative side of the method / model – **prominence, data integrity, accuracy, intended purpose**. Each pilot-expert was offered to deliver a block of expert assessments by giving his/her answer-grade for each assessment criterion separately.

Table 1.

Fill-out form of the pilot's expert answers

Scientific foundation: Method; Model				
No.	Estimation criterion	EXPERT – Sea pilot		
		Expert assessments block		
		Grade, (point)	Weight indicator, pct	Final grade (point)
1.	Prominence	4	70	2.8
2.	Data integrity	3	50	1.5
3.	Accuracy	2	30	0.6
4.	Intended purpose	3	60	1.8
5.	Support reliability	2	30	0.6
Integral grade (point)				1.46

The first grade-answer **«Grade»** was given based on a general concept of the given method/model correspondence to the offered criterion критерию on five-point grading scale. The second grade-answer took into account the value of **«Weight indicator of criteria»** in percentage terms, that serves as determinant of importance recognition, of relative importance, of the given method/model «weight» as compared to others that influence the process of information security. The expert determined the third final grade by way of multiplying the numeric values of the first and the second grade thus presenting the **«Final grade»** in points. By the criteria's numeric values obtained as a result of arithmetical average of the **«Final grades»,** the expert determined the **«Integral grade»** for each method / model in points.

Under the conditions when conventions of the International Maritime Organization and the existing paradigm of safety at sea are in force, the aggregate of quality of the existing and suggested methods and notions, definitions, values and directives shared by scientific community, the importance of methods and models used as scientific tools of safe navigation is especially noticeable. This refers to design and instrument plotting method of navigating the vessel and its working fragmentations used by pilots-operators in ship-traffic control. This method includes simultaneous aggregate of constituents of cartographic method, special pilot chart method and absolute navigation method. **«The Model of vessels' automatic identification»** used is intended to support navigation safety by monitoring sea traffic. «**The Pilot method»** is not a direct-action instrument, it is aimed at using navigators' personal experience and it is spread wide enough in shipping practice.

Among top-priority scientific innovations there are **«The model of navigation information space»**, **«The method of vectorial fields of threats to vessels' traffic»,** «**The method of forming the traffic information field», «The model of navigational risks»**, «**The model of vessels' traffic information safety cluster», «The method of guaranteed navigational information safety»**. Collecting and governing content related to safe operating with on-board incoming and outgoing information document flow that serves for perfecting the general navigation safety system is presented in **«The model of «Vessel's information security passport»**.

The results of expert quality grades of new and suggested methods and models of navigational information security (NIS) are shown in Table. 2. Based on maximum numeric values of five points and 100 percent, the developed and suggested models and methods received an increased efficiency in «**Grade»**, **«Weight indicator»**, «**Final grade»** and «**Integral grade»**.

Increased level points are explained by a high dynamism of reflecting clearness and simplicity of impact on real-time perception. Their simultaneous presentation on board the vessel and at coastal vessel traffic control stations increases the guarantee of ensuring the vessel's information security and maritime traffic in general. A special priority and level of criterial assessments is attributed by the expert group to the definition model with the passport «**Vessel's Information Security**». The **«Integral grade»** index of newly developed methods/models exceeds the same of the instruments that make part of the known navigation method by almost 33%. A qualitative criterial assessment of each known and suggested method and model of knowing the level of ensuring navigational information security carried out by a group of pilots-experts was performed taking into account their interconnection, substantiation and completeness which increases the confidence of successful and reliable impact of the decisions made for increasing vessels' traffic safety.

Table 2.

Quality of NIS methods and models

SYMPTOM AND CHECK-UPS		NAME OF SCIENTIFIC BASIS	GRADE CRITERION					Integral grade (point)
			Clearness	Data completeness	Authenticity	Designated purpose	Support reliability	
			Block of expert grades					
			1. Grade (point). 2. Weight indicator (pct). 3. Final grade (point).					
SCIENTIFIC BASIS OF OPERATING NAVIGATIONAL INFORMATION SECURITY	EXISTING	Cartographic method	4	3	2	3	2	1,46
			70%	50%	30%	60%	30%	
			2.8	1.5	0.6	1.8	0.6	
		Special pilot chart method	4	4	3	4	4	2.20
			75%	60%	40%	60%	50%	
			3.0	2.4	1.2	2.4	2.0	
		Model of vessels' automatic identification	3	5	4	2	4	2.34
			60%	70%	80%	40%	60%	
			1.8	3.5	3.2	0.8	2.4	
		Absolute navigation method	5	4	4	3	5	2.98
			80%	55%	75%	90%	60%	
			4.0	2.2	3.0	2.7	3.0	
	SUGGESTED	Model of navigation information space	5	4	3	4	4	2.90
			70%	65%	60%	80%	85%	
			3.5	2.6	1.8	3.2	3.4	
		Method of vectorial fields of threats to vessels' traffic	5	4	4	5	4	2.96
			60%	50%	70%	80%	75%	
			3.0	2.0	2.8	4.0	3.0	
		Method of forming the traffic information field	4	4	4	5	4	2.97
			70%	55%	60%	85%	80%	
			2.8	2.2	2.4	4.25	3.2	
		Model of navigational risks	4	4	4	5	5	3.20
			65%	75%	54%	80%	85%	
			2.6	3.0	2.16	4.0	4.25	
		Model of vessels' traffic information safety cluster	5	3	4	5	5	3.34
			80%	70%	65%	85%	75%	
			4.0	2.1	2.6	4.25	3.75	
		Method of guaranteed navigational information safety	4	5	5	5	4	3.90
			80%	75%	85%	90%	95%	
			3.2	3.75	4.25	4.5	3.8	
		Model and passports «Vessel's information security»	5	4	4	5	5	4.10
			90%	85%	80%	98%	90%	
			4.5	3.4	3.2	4.9	4.5	

Conclusions. The expert assessment and the results of comparing qualitative indicators of methods and models that ensure navigational information security have been described. Qualimetry of the new instruments developed has an obvious advantage over the ones used in seamanship and their integral estimated figures by more than 1/3 exceed the ones in use today. The suggested methods and models enable to note basic invariant properties of various vessel types, to carry out processing, integrating and using of initial data to ensure navigational information security.

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Analytical basis of physical security determination

Researched theoretical background of physical risk assessment. Defined risks and aspects that have influence on physical system functioning A new approach for the assessment of the risk associated with a physical security system is presented.

Physical security determination. Twenty-four hours a day, 365 days of the year, an airplane takes off or lands every few seconds somewhere on the face of the earth. Every one of these flights is handled in the same, uniform manner, whether by air traffic control, airport authorities or pilots at the controls of their aircraft. Behind the scenes are millions of employees involved in manufacturing, maintenance and monitoring of the products and services required in the never-ending cycle of flights. In fact, modern aviation is one of the most complex systems of interaction between human beings and machines ever created.

Physical security is certainly not a new concept. The idea of protecting cities through the construction of fortifications dates back thousands of years. Significant threats were recognized to exist on global soil, and these threats affect civilians, military forces, and law enforcement agencies. Questions regarding the balance of civil liberties with security now arise. Key concerns in this debate are: 1) the cost of security, and 2) the value of inconvenience that people must tolerate. Physical security has emerged as a pressing social concern.

In response to this new emphasis on physical security, government agencies, industries, and businesses are dedicating considerable resources to improving security. In addition to the need for security systems, the need for security education and certification is growing.

The research reported here is focused on applying operations research methods to the analysis and evaluation of physical security systems. Before introducing an analytical approach for analyzing and evaluating physical security systems, we present an overview of the process of designing physical security systems. This provides the context for the evaluation problem. While these design principles may be applied to security in general, they have been drawn from sources whose focus is on physical security.

1. Asset identification.

The primary purpose of a physical security system is the protection of an asset or a set of assets. These assets can include resources, personnel, facilities, homes, locations, or other items of value. The identification of the assets to be protected and their value in turn reveals other items that must be considered such as the environment and threats.

2. Threats.

After identifying assets and environment, threats must be identified. Some considerations used to identify threats are motivations for attacking assets or goals to be achieved through an attack. Information about a potential threat should include the type of threat, capabilities of potential intruders, and tactics commonly used by intruders. Information about a threat should be specific so as to allow for both the assessment of potential damage and the identification of techniques to counter threats.

3.Threat evaluation.

Once threats are identified, the vulnerability of assets can be investigated through the performance of a threat evaluation or assessment. A threat evaluation requires the analysis of the potential threat actions. These threat actions are often characterized in terms of "consequences" and "likelihood."

4. Risk smoothing.

Once threats are identified, potential countermeasures can be identified to smooth risk.

5. Restrictions.

Certain restrictions will affect the development of alternative physical security systems; principal among them are resource constraints. Such constraints are typically financial and reflect the price that the decision maker is willing to pay for a security system.

6.Evaluation of alternatives.

After determining the constraints to which alternatives configurations must conform,feasible alternatives can be identified. Once alternatives are identified, they must be evaluated with respect to the protection they provide against the identified threats and how they mitigate risk. This evaluation should provide a criterio by which alternatives may be compared.

7. Decide, implement, and monitor.

Evaluation of the alternatives provides the basis for a decision to select a security system. Once a system is selected, it must be implemented in accordance with its design. This process is illustrated in fig.1.

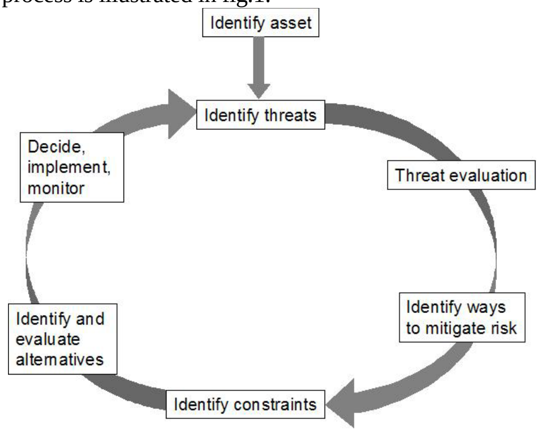

Fig. 1. Physical security design process

Hicks [2] presents a cost and performance analysis for physical protection systems at the design stage. Their system-level performance measure is risk which they define as follows.

$$R = P(A) \times [1 - P(E)] \times C, \quad (1)$$

where, P(A) is probability of attack, P(E) - probability of system effectiveness, C - consequence.

For each alternative configuration, an assessment is made of the probabilities of the occurrence of the attack types and of consequences of attacks, but these probability assessments do not result in a unique probability law on reward for each alternative. If a utility function u is given, the calculation of the expected utility for alternative is:

$$E_{\propto}(U) = \sum_{h=1}^{H} u(a + h\Delta)\left(\sum_{(n,k)\in N_h} p^{\alpha}(n,k)\right), \tag{2}$$

where

$$N^h = \{(n,k) : \|n\|_1 = -a-h\Delta,\ 1\le k\le M\}, \tag{3}$$

However, in the problem under consideration, no utility function is given. We consider two monotone, continuous functions $u_U : R \to R$ *and* $u_L : R \to R$ as boundaries on the utility function. That is, we require that

$$u_L(x) \le u(x) \le u_U,\ x \in R \tag{4}$$

An illustration of utility boundary functions is shown in fig. 2 where [a, b] is the support of the risk distribution for alternative. The plot of an acceptable utility function would fall within the shaded region.

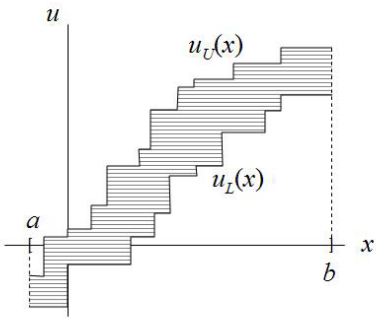

Fig. 2. Boundaries of utility function

Based on intelligence about enemy activity in the area, there are four attack types that the base might face. Let {A = k} be the event that an attack of type k occurs, where the attack corresponding to k is as shown below. Based on recent intelligence estimates, the probabilities of the different types of attacks are assessed as lying in the following ranges:

k1- Suicide car bomb via the road.

k2- Improvised explosive device or suicide bomb.

k3- Suicide car bomb.

k4- Dismounted attack.

$$0{,}15\le P(A=1)\le 0{,}25$$
$$0{,}2\le P(A=2)\le 0{,}3$$
$$0{,}05\le P(A=3)\le 0{,}2$$
$$0{,}1\le P(A=4)\le 0{,}35$$

This function is shown plotted over the possible loss values in fig. 3.

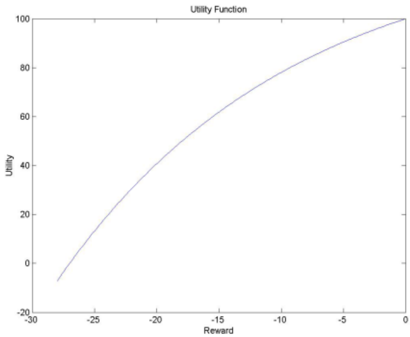

Fig. 3. Plot of utility function

Finally, a new approach for the assessment of the risk associated with a physical security system is presented. Demonstrated identification of a preferred alternative under incomplete characterization of probability law. Linear optimization problems to find the bounds on expected utility for two alternatives were formulated.

According to modern research in our country problems of physical security and risks become very important and the quick and effective improvement of old methods of system state assessment will provide desirable level of security in every sphere of activity from aviation till government functioning.

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Matrix exchange encryption keys protocol on open communication channels

The solution of the problem of synthesis of keys assumes calculation of unilateral functions and is based on use of the generalized similar matrixes of Galois. Options of creation of operative change of keys of enciphering in each communication session of land points of management are discussed with unmanned aerial vehicles.

One of the most urgent problems of modern cryptography is the formation of secret legalized subscriber's encryption keys open computer networks or other public information channels. Particularly acute becomes the problem in the control systems of *unmanned aerial vehicles* (UAV), because, for example, unauthorized access to the radio reception and transmission of command and telemetry data is associated with the risk of loss of the device or it can lead to other serious consequences [1].

To exchange encrypted messages between two subscribers of the cryptosystem is necessary that both parties exchange delivered stored in a secret encryption keys. Open channels of communication secret key transport technology are called the *Key Distribution Protocol* [2].

The report discusses the method of forming a *one-way function* (OWF), based on the so-called *generalized matrix Galois* (GMG), and are offered based on these algorithms for constructing GMG-oriented applications in the operational change the encryption key systems in every communication session between the *ground control station* and board equipment of the UAV. Under the communication session refers to the transmission of information by radio single packet in the direction of ground control station – board of UAV.

Galois matrix terms borrowed from the error-correcting coding theory and cryptography, which are widely used generators binary *pseudo-random sequence* (PRS) in the Galois configurations built on linear shift registers with linear feedback [3]. It is known that in order for the linear shift registers is the generator of the PRS maximum period corresponding feedback polynomial must be a *primitive polynomial* (PrP). Example eighth order Galois generator forming pseudo-random sequence maximum period as shown in Fig. 1.

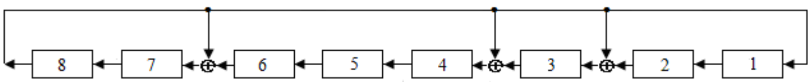

Fig. 1. Structural generator Galois scheme over PrP 101001101

Each linear generator PRS may be represented by the corresponding Galois matrix $G_f^{(n)}$, where $n-$ the order of the matrix and $f-$ PrP forming the same sequence as the generator of the PRS. Below is an example of a classical matrix Galois $G_f^{(8)}$, forming the same PRS as the generator shown in Fig. 1.

$$G_f^{(8)} = \begin{array}{c|c} \begin{bmatrix} 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} & \begin{matrix} 8 \\ 7 \\ 6 \\ 5 \\ 4 \\ 3 \\ 2 \\ 1 \end{matrix} \\ \begin{matrix} 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 \end{matrix} & \end{array} .$$

Synthesis of generalized Galois matrix $G_{f,\omega}^{(n)}$ made by the method of diagonal fill, the essence of which is as follows. The bottom line is synthesized GMG recorded images of her element $\omega \geq 10$, which is an element of the field $GF(p^n)$ over the irreducible polynomial (IP) f_n, where $n-$ the degree of the polynomial. Bits line to the left of ω, filled with zeros. The subsequent rows of the matrix formed of the previous line shift by one bit to the left and right in the releasing entered digit 0. When the shear line senior nonzero digit beyond the matrix, the vectors corresponding to such lines are provided to the residue modulo f_n and thus line again becomes a $n-$bit.

From the theory of polynomials in one variable x is known, that the multiplication of an arbitrary polynomial $\omega_k(x)$ of degree k on x equivalent to his shift by one bit to the left and, respectively, an increase of 1 degree polynomial [4]. In other words,

$$x \cdot \omega_k(x) \to \omega_{k+1}(x) . \qquad (1)$$

Using (1), as well as the method of filling the diagonal GMG $G_{f,\omega}^{(n)}$, we write the chain of transformations:

$$G_{f,\omega}^{(n)} \Rightarrow \begin{pmatrix} x^{n-1} \cdot \omega \\ x^{n-2} \cdot \omega \\ \vdots \\ x \cdot \omega \\ \omega \end{pmatrix} \bmod f_n = \omega \cdot \begin{pmatrix} x^{n-1} \\ x^{n-2} \\ \vdots \\ x \\ 1 \end{pmatrix} \bmod f_n . \qquad (2)$$

The elements of the right column vector in (2) are monomials, which, being represented in binary form, pay a column vector into a single matrix E, that allows us to formulate the following assertion.

Statement. *Generalized matrix Galois* $G_{f,\omega}^{(n)}$ *order* n *over IP* f_n *is isomorphic to its image of an element* ω*, which is a characteristic* p *element of the field* $GF(p^n)$*, i.e.*

$$G_{f,\omega}^{(n)} \leftrightarrow \omega. \qquad (3)$$

In other words, between the GMG $G_{f,\omega}^{(n)}$ and its constitutive element ω of one correspondence (*isomorphism*), the ratio of the display (3). In addition, it is easy to establish that the isomorphism (3) leads to the investigation.

Corollary. *Matrix Galois* $G_{f,\omega_1}^{(n)}$ *and* $G_{f,\omega_2}^{(n)}$, $\omega_1 \neq \omega_2$*, commute, because they are members of the same order of the maximum multiplicative group* GF^**, composed of a matrix of degrees arbitrarily primitive element* θ *which belongs to the field of the IP* f_n.

Multiple Galois arrays can be expanded by the introduction of such a Galois arrays ${}^*G_{f,\omega}^{(n)}$, defined by the relation

$${}^*G_{f,\omega}^{(n)} = P^{-1} \cdot G_{f,\omega}^{(n)} \cdot P.$$

where $P-$ the similarity transformation matrix. The template selected permutation matrix of order n, for which $P^{-1} = P^T$.

Unlike the original GMG $G_{f,\omega}^{(n)}$ such generalized Galois matrix ${}^*G_{f,\omega}^{(n)}$ lose isomorphism property. This feature is similar Galois arrays and provides just the opportunity to build OWF used in the formation of the proposed system of secret key encryption subscriber's open channels of communication.

Definition. *The function* $f : X -> Y$ *is called unilateral (one-way) that* $f(x)$ *it can be easily computed for each* $x \in X$*, whereas almost all* $y = Y$ *the calculation such that* $f(x) = y$ *(with the proviso that at least one such exists), is a complex* [5].

Below is a brief description of the GMG-OWF and discusses how the formation of secret encryption keys. The proposed method belongs to the class of asymmetric cryptography, which is known to use two keys: public and private.

The adopted as a public key: the initialization vector V, which is a $n-$bit vector; irreducible binary polynomial f_n of degree n and a permutation matrix P of order n. Each of the subscribers A and B generates $n-$bit secret keys ω_α and ω_β respectively. The shared secret key K is determined as a result of such conversion step:

1. Subscriber A generates a casual vector ω_α, finds at first GMG $G^{(n)}_{f,\,\omega_\alpha}$, then similar matrix ${}^*G^{(n)}_{f,\,\omega_\alpha}$, calculates a vector $V_\alpha = V \cdot {}^*G^{(n)}_{f,\,\omega_\alpha}$ also sends it to the subscriber B. Similar operations are carried out by the subscriber B, defining a vector $V_\beta = V \cdot {}^*G^{(n)}_{f,\,\omega_\beta}$, which sends to the subscriber A. Vectors V_α and V_β just also are unilateral functions which are constructed on the basis of similar GMG.

2.Subscriber A multiplies accepted from the subscriber B vector V_β the confidential matrix ${}^*G^{(n)}_{f,\,\omega_\alpha}$, forming a key

$$K_\alpha = V_\beta \cdot {}^*G^{(n)}_{f,\,\omega_\alpha} = V \cdot {}^*G^{(n)}_{f,\,\omega_\beta} \cdot {}^*G^{(n)}_{f,\,\omega_\alpha} =$$
$$= V \cdot (P^{-1} \cdot G^{(n)}_{f,\,\omega_\beta} \cdot P) \cdot (P^{-1} \cdot G^{(n)}_{f,\,\omega_\alpha} \cdot P) = (P^{-1} \cdot G^{(n)}_{f,\,\omega_\beta} \cdot G^{(n)}_{f,\,\omega_\alpha} \cdot P).$$

Just the same calculations are carried out by the subscriber, taking a vector

$$K_\beta = V \cdot (P^{-1} \cdot G^{(n)}_{f,\,\omega_\alpha} \cdot G^{(n)}_{f,\,\omega_\beta} \cdot P).$$

As GMG $G^{(n)}_{f,\,\omega_\alpha}$ and $G^{(n)}_{f,\,\omega_\beta}$ it appears, that $K_\alpha = K_\beta = K$ and, therefore, both subscribers of a network receive an identical confidential key of enciphering K. If instead of similar matrixes ${}^*G^{(n)}_{f,\,\omega}$ to use usual OMG $G^{(n)}_{f,\,\omega}$, that owing to their isomorphism (3) opponent, having intercepted vectors V_α and V_β, can calculate confidential keys ω_α and ω_β, as generally

$$V_\gamma = V \cdot G^{(n)}_{f,\,\omega_\gamma} = V \cdot \omega_\gamma (\text{mod } f_n), \quad \gamma = \alpha \text{ or } \beta. \tag{4}$$

Since V and f_n - both known quantities, the opponent, allowing the equation (4) with respect to ω_γ, and calculates a secret key ω_α and ω_β, which leads to the breaking of the shared secret K.

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Development of antivirus security system

The work considers the construction of the anti-virus software system, which contains the basic operating system and monitors the changes in the data, generates statistics and analyzes incoming and outgoing data in the network. This system is based on a mathematical model of different security systems to form a self-learning principle to detect and remove virus threat, the system integrates into the collaboration horizontally scalable systems and forms an integral organism. The system takes into account the possibility of loss of data and mechanisms of leveling system failures, it is achieved at the expense of memory and branching capabilities based on the recovery of the changes in the system. Through hardware virtualization and a dedicated anti-virus kernel is possible to avoid internal and external influence on the contained operating system. The result of the system is the formation of a cloud database behavior and reproduction of the virus activity of the entire system in order to prevent further attacks to plug units.

One of the most common threats to security of modern computer systems are malicious software that is created to steal personal data, spy on the user, which in turn can lead to negative consequences [1].

To protect information using a number of specialized antivirus software that can not only detect but also prevent unauthorized access. But antivirus software does not provide absolute protection, because it depends on the update installed directly into the operating system and is a part that does not guarantee the integrity of the security module. In addition, creating signature database takes time, allowing the virus attack to execute malicious actions on the system without the possibility of data recovery and system performance. Behavioral (heuristic) analysis also has a high percentage of false positives, this is offset by the possibility of recovering data [1-5].

For memory protection privileged components, such as the VMM and VMkernel, vSphere uses certain well-known techniques. Address space layout randomization (ASLR) randomizes where core kernel modules are loaded into memory. The NX/XD CPU features enable the VMkernel to mark writeable areas of memory as nonexecutable. Both methods protect the system from buffer overflow attacks in running code. NX/XD CPU features also are exposed to guest virtual machines by default. [6]

Each virtual machine is isolated from other virtual machines running on the same hardware. Virtual machines share physical resources such as CPU, memory, and I/O devices; a guest OS in an individual virtual machine cannot detect any device other than the virtual devices made available to it. To further clarify, a virtual machine can detect only the virtual (or physical) devices assigned to it by the systems administrator, such as the following examples:

• A virtual SCSI disk mapped to a file on a disk;
• An actual disk or LUN connected to a physical host or array;

• A virtual network controller connected to a virtual switch;

• An actual network controller connected to a physical network A virtual machine cannot map to a device that has not been preassigned. A virtual machine is incapable of mounting another virtual machine's disk unless the disk has been explicitly assigned to both virtual machines in the management console; for example, VMware vCenter™ or ESXi [6].

At the hardware level, all direct memory access (DMA) transfers and device-generated interrupts are virtualized and isolated from other virtual machines. This prevents one virtual machine from accessing the memory space controlled by another virtual machine. If such an attempt is made by a virtual machine, the guest OS will receive a fault from the CPU. Because the VMkernel and VMM mediate access to the physical resources, and all physical hardware access takes place through the VMkernel, virtual machines cannot circumvent this level of isolation [6].

Modern processors feature an I/O memory management unit that remaps I/O DMA transfers and device interrupts. This enables virtual machines to have direct access to hardware I/O devices, such as network cards, storage controllers (HBAs), and GPUs. In AMD processors, this feature is called AMD I/O Virtualization (AMD-Vi) or I/O memory management unit (IOMMU); in Intel processors, the feature is called Intel Virtualization Technology for Directed I/O (VT-d). Within ESXi, use of this capability is called DirectPath I/O. DirectPath I/O does not impact the security properties in any way. For example, a virtual machine configured to use VT-d or AMD-Vi to directly access a device cannot influence or access the I/O of another virtual machine [6].

The report proposed the development of an autonomous operational antivirus systems to protect data from potential disruptions or attacks or identity theft. Using virtualization and selected core antivirus system avoids external and internal impact on the operating system.

Developed antivirus system, through the analytical system evaluates the state of the computer system and the detection of failures suspicious activity or malicious software creates copies of system components without shutting down the system and stores this event and with the possibility of data recovery or integration of data after overcoming threat. Multimodal and multi-layer system allows a safe execution of operating system, control the execution of processes in the system and modify the operating system components, perform low-level tracking of changes and restore data, generate reports for creating signatures. This approach allows full control of all activities and if necessary block them. The system interface provides the ability to change the operational files or build hardware clones or copies of all hardware storage devices.

The result is the formation of cloud database system behavior, which keeps statistics packages for analyzing memory, copies of system files infected operating systems, network management of users, cluster computing and analyzing incoming data. This can increase the level of protection directly antivirus system and prevent data loss.

The standalone antivirus operating system allows you to playback analysis assessment data protection for different algorithms that improves the accuracy and reliability of performance. Using the .NET allows migration of current projects on different operating systems and integration of new technologies accelerate the implementation process.

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Information protection in automated information systems. Definition, threats, approaches and measures to protect information

The basic issue of information security in automated information systems are definitions of key terms regarding data protection and information security. The basic potential threats to information security in information systems. The basic approaches to problem-solving information security of corporate information systems, measures to protect information in information systems, the main approaches to the management of IT infrastructure as part of ensuring a high level of reliability and security of information systems.

Definitions of key terms regarding data protection and information security. According to the Law of Ukraine "On information" [1] "On protection of information in automated systems" [2] "On protection of information in telecommunication systems" [3] "Terminology in the field of information security in computer systems from unauthorized access Sun Heat 1.1-003-99 "[4] defines the main terms of data protection and information security, namely, protection of information systems, information (automated) system, information and telecommunication systems, complex systems of information protection, Technical information security, information security in automated systems (information protection, information security, computer system security), information space, information infrastructure, information security, integrity of information, privacy information, the reliability of information, the importance of legal information, access to information, etc.

Potential threats to information security in information systems. How urgent problem of information protection from various threats can be seen in the data published by the Computer Security Institute [5] (San Francisco, CA, USA), according to which the security breach computer systems is for the following reasons:

• Unauthorized Access – 2%;
• rooting viruses – 3%;
• technical failure network equipment – 20%;
• purposeful actions of staff – 20%;
• human error (insufficient training) – 55%.

Thus, one of the potential threats to information in information systems should be considered accidental or deliberate destructive actions of personnel (human factor) as they constitute 75% of all cases.

Basic approaches to solve the information security of corporate information systems. At present, formed the theoretical and practical basis for the development of theoretical positions and practical use of information security, electronic documents and electronic document information technology.

In scientific studies in the field of information security are two qualitatively different directions.

The first – is the protection of information in the form of information on traditional media (paper, magnetic, optical).

Second – defense transformation processes information - technology invariant to the content of protected information.

In practice, most institutions, business organizations, there are two basic approaches to creating secure corporate information systems, namely **fragmented and complex** [6, 7, 8].

Fragmented approach is clearly aimed at countering specific threats in the given conditions. As examples of this approach can set individual access controls, encryption independent specialized anti-virus software and more.

The advantage of this approach is the high selectivity to a specific threat. The main drawback is its lack of a single secure environment processing.

As protection subsystem, based on fragmented approach is not an essential component of the information system, if you disable individual security features as a result of unauthorized acts user-attacker, the other elements of the information system continues to work normally, which further reduces the reliability of protection.

A comprehensive approach is aimed at creating a secure environment in the information processing system that brings together disparate measures against threats.

When integrated approach protective functions implemented in the corporate information system during its development and deployment, and is an integral part of, and the information is protected not only in the form of information to the media, but also conversion processes information. Despite its advantages integrated approach has a significant disadvantage - it does not provide full and adequate protection of information systems against new and advanced threats.

Measures for the protection of information in information systems.

Measures of information protection in information systems will be considered from the perspective of development and creation of complex information security systems, as a set of organizational and technical measures aimed at protecting information from unauthorized access, disclosure, diversion, change of information, etc. [7.8, 9].

Arrangements are obligatory part of building any corporate information system primarily involve and include the creation of the concept of information security of the institution and corporate information systems, as well as:

• contain a set of actions for the selection and testing personnel involved in the preparation and maintenance of hardware and software;

• clearly regulate the development and operation of information systems, administration thereof, recording, storage, reproduction, the carriers of information, user identification;

• decide whether to draw up job descriptions for users and staff;

• create regulations and action plans in case of attempts of unauthorized access to information resources system failure remedies of an emergency;

• Provide training information security rules users.

Engineering measures – a set of specific technical measures designed to protect information in information systems.

The choice of technical measures depends on the level of information security that should provide.

Engineering activities carried out to protect the information infrastructure of the organization, may include using secure connections, firewalls, separation of information flows between network segments, the use of encryption and protection against unauthorized access.

Engineering and technical measures to protect corporate information systems can be divided into hardware, software, defense transformation, etc., are carried out in the required quantities.

The main groups of information security. With some fate probability it can be argued that the creation and implementation of computer security in Ukraine is not the result of purposeful work, and is more intuitive expression of interest in companies and institutions on how to protect their data.

As a result - only large corporate customers can pursue expensive projects with information protection and keep staff engaged in the development and support of defense systems.

It is very important that customers understand that it is necessary to protect and means that problems will arise in the organization of work and so on.

Management of IT infrastructure as part of ensuring a high level of reliability and security of information systems. As a result of intensive development of information technology, information networks increase in size and a lot of application and system software, it became apparent that the use of only certain remedies does not significantly effect. You must use complex systems, remedies that would ensure comprehensive protection of information systems monitored networks, analysis of information flow, ensure safe storage and more.

Therefore, one of the activities to ensure a high level of reliability and security of information systems is to improve infrastructure.

In general, the solution of complex information security infrastructure solutions, networks and telecommunications engaged the following major companies, world leaders: IBM, CISCO, Check Point, McAfee, TREND MICRO, Symantec.

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The methodology of information technical protection complex design.

The methodology of design given within this study is alternative to well-known methods for simple and complex technical protection of information (CTPI) systems. Methodology given below ensures quantitative evaluation of CTPI by probabilistic reliability measurement and based on such input parameters like CTPI system's cost, effectiveness, minimal hacking attempt and timing of such attempt.

In most documents and methodologies for CTPI systems design only qualitative evaluation of information protection is used. The alternative methodology that ensures quantitative evaluation of CTPI by probabilistic reliability measurement that is based on such input parameters like CTPI system's cost, effectiveness, minimal hacking attempt and timing of such attempt is given in references [1-3].

The goal of this study is theoretical explanation and research of alternative CTPI system design methodology based on existing input data and quantitative evaluation of designed system.

Expression of CTPI hacking maximums distribution obtained in Boris Zhurilenko researches [1-3], can be presented as following:

$$P_{hack\_CTPI} = \prod_{i=1}^{n} [P_{hack\_i}(X_i) \cdot P_{hack\_i}(m,t)]^{\alpha_i} . \qquad (1)$$

Where $P_{hack\_i}(X_i)$ – is expression of CTPI hacking probability maximums dependence from financial investments brought to possible financial losses in case of lack of security

$$P_{hack\_i}(X_i) = \frac{X_i^{X_i}}{(1+X_i)^{1+X_i}}, \text{ and } X_i = \frac{x_i}{H_i} = (m_c\text{-}1) , \qquad (2)$$

x_i – financial investments into single technical protection of information (STPI); H_i – initial financial loses in case of hacking of non-protected system; m_c – chosen hacking attempt for financial investments [3]. $P_{hack\_i}(m, t)$ – hacking probability maximums' spread considering hacking attempts m and hacking attempts time t for STPI; α_i – effectiveness coefficient of i protection (ECP); n – number of protection systems; i – current single protection parameter's index.

Hacking probability maximums' spread considering hacking attempts and hacking attempts time for STPI according to [2], can be expressed as:

$$P_{hack\_i}(m,t) = \left(\frac{f_i(m,t)}{f_i(m,t)+t}\right)^{\frac{f_i(m,t)}{t}} \cdot \left(\frac{t}{f_i(m,t)+t}\right), \qquad (3)$$

and

$$f_i(m,t)=[t_1+\frac{t_2-t_1}{m_2-m_1}\cdot(m-m_1)]\cdot(m-1), \tag{4}$$

where $f_i(m,t)$ – inherent function of i protection system, defining the direction of hacking and its protective properties; m_1, t_1, m_2, t_2 – parameters chosen for hacking and correspond to designed, real or simulated hacking attempts; m, t – current value of attempt and time of hacking; $m_1=1$, $t_1=0$ – trivial starting initial conditions of hacking process.

Hacking with m – attempt makes possible definition of technical protection of information (TPI) system.

Hacking probability of any system (STPI or CTPI) with m – attempt is defined as

$$P(m)=\frac{1}{m}. \tag{5}$$

During the first stage of design process according to technical requirements for protection the direction of hacking is chosen, for example: $m_1=1$, $t_1=0$, $m_2=3$, $t_2=2$ and financial investments in TPI x_i or powered financial investments $X_i=1$.

Then the number of STPI – n – is defined, as well as financial investments X_i in every single protection system.

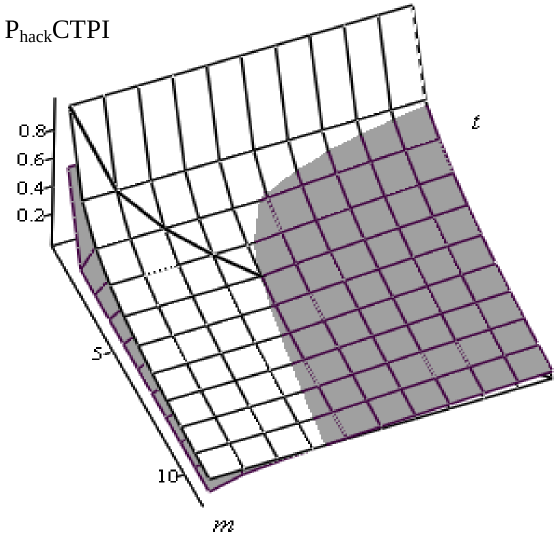
On third stage the effectiveness coefficient α_i of every STPI is defined according to formula (6), if financial investments for every STPI vary. If those do not vary then α_i is defined only once. In case of using n equal by its efficiency systems, final efficiency is defined by production of α_i and n. In example reviewed lets define $n=1$.

After choosing a point of hacking of STPI in same direction with parameters $m_{hack}=5$, $t_{hack}=4$ and substituting in formula (4) instead of m and t, and then in (3), (1) and with formula (5), (6) effectiveness coefficient of protection is defined (ECP), giving us a value of $\alpha_i=0,414$.

$$\alpha_i=\frac{ln[P(m)]}{ln[P_{hack\_i}(X_i)\cdot P_{hack\_i}(m_{hack},t_{hack})]}. \tag{6}$$

Considering formulas (3), (4), (6) by means of formulas (1), (5) the hacking probability maximums' surfaces are built (1) and (5), and then by the interception of built surfaces a line of designed CTPI hacking line can be defined. If necessary, a line of hacking direction is built. If the design of CTPI is correct the point of projected hacking coincides with point of lines' interception.

Picture 1 shows the calculations of hacking probability maximums' surfaces (grey surface) and hacking probability (white surface) with selected designed parameters. On Picture 1 the direction of hacking is represented by solid line. As far as chosen hacking point coincides with hacking direction, the interception of surfaces and a line defines point $m_{взл}=5$, $t_{взл}=4$. If the direction of hacking for this particular TPI with ECP $\alpha_i=0,414$ would go in other directions, then hacking points of TPI would be positioned on a line of grey and white surfaces interception.



Picture 1. Hacking probability (white surface) and system hacking probability (grey surface) maximums surfaces calculations. The line defines the direction of projected hacking. For calculation the following parameters were used: $m_1=1$, $t_1=0$, $m_2=3$, $t_2=2$; $X=1$; $\alpha_i=0{,}414$; $n=1$; $m_{hack}=5$, $t_{hack}=4$.

Using graphs for CTPI design allows visualization of hacking and protection processes, as well as performing a comparative analysis of different types of CTPI designed or continuous protection complex analysis during its lifetime.

Thus, as a result of current work the theoretically reasonable alternative information protection design methodology with probable reliability is represented.

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Sound generation by vortex flow – helicopter's rotor blade interaction

A mathematical setting of problem of the BVI- noise generation has been presented. Algorithm and method of the problem solving are given. As an example of the problem realization two particular cases of the problem are concerned: influence of changing angle of attack (a) and rounding of the blade tip (b) on generating noise.

Mathematical setting of the problem

1. Aerodynamic part

Let consider helicopter's rotor blade of swept R in Cartesian coordinates (fig.1) The blade is interacting with vortex flow next: the leading edge interacts with Taylor's vortexes (1) but tip of the blade Generates Scully's vortex (2).

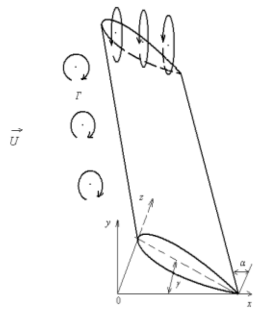


Fig.1 Blade -vortexes interaction

$$V_\theta = V_{\theta\max}\frac{r}{r_c}\exp(1-\frac{r}{r_c})^2 \qquad \text{(Taylor's vortex)} \tag{1}$$

$$\gamma = \Gamma\cdot\frac{r^2}{r^2+r_c^2} \quad \text{(Scully's vortex)} \tag{2}$$

The Scully's bound vortex generates additional (to main) inductive flow along the blade with distribution of velocity components (3) [1]:

$$v=\frac{\Gamma}{2\pi}\cdot\frac{h}{(R-y)^2+h^2+r_c^2},\ w=\frac{\Gamma}{2\pi}\cdot\frac{R-y}{(R-y)^2+h^2+r_c^2} \tag{3}$$

The flow around blade is described by the next system of equations [2]:

$$\frac{\partial u'}{\partial \tau}+u'\frac{\partial u'}{\partial \xi}+\lambda c v'\frac{\partial u'}{\partial \eta}+\frac{c}{AR}w'\frac{\partial u'}{\partial \zeta}=-\frac{1}{M^2\rho'}\frac{\partial \rho'}{\partial \xi}$$

$$\frac{\partial v'}{\partial \tau}+u'\frac{\partial v'}{\partial \xi}+\lambda c v'\frac{\partial v'}{\partial \eta}+\frac{1}{AR}w'\frac{\partial u'}{\partial \zeta}=-\frac{\lambda c}{M^2\rho'}\frac{\partial \rho'}{\partial \eta}$$

$$\frac{\partial w'}{\partial \tau}+u'\frac{\partial w'}{\partial \xi}+\lambda c v'\frac{\partial w'}{\partial \eta}+\frac{1}{AR}w'\frac{\partial w'}{\partial \zeta}=-\frac{1}{M^2 AR\rho'}\frac{\partial \rho'}{\partial \zeta} \qquad (4)$$

$$\frac{\partial \rho'}{\partial \tau}+\frac{\partial(\rho' u')}{\partial \xi}+\lambda c\frac{\partial(\rho' v')}{\partial \eta}+\frac{1}{AR}\frac{\partial(\rho' w')}{\partial \zeta}=0\,.$$

The incoming flux velocity is $U_\infty = 0$. As far as blade shape B is rigid normal velocity of flow equals zero:

$$\bar{V}_{n,B}=\bar{0}\,. \qquad (5)$$

Equations (4) together with boundary conditions (1),(2),(5) form boundary problem for velocity components $\bar{V}$ and density ρ.

2. Acoustical part

Aerodynamic problem setting allows formulating next acoustical problem: to define sound field generated by vortex flow – rotor's blade interaction.

System of equations for sound field components near blade is [2]:

$$\frac{\partial^2\bar{\rho}'}{\partial \tau^2}-\frac{1}{M_\infty^2}\frac{\partial^2\bar{\rho}'}{\partial \xi^2}-a^2(\lambda^2c^2\frac{\partial^2\bar{\rho}'}{\partial \eta^2}+\frac{1}{AR^2}\frac{\partial^2\bar{\rho}'}{\partial \zeta^2})+\Re=Q\,, \qquad (6)$$

$$\bar{\rho}(\frac{\partial^2\bar{\phi}}{\partial \xi^2}-\lambda^2c^2\frac{\partial^2\bar{\phi}}{\partial \xi^2}+\frac{1}{AR^2}\frac{\partial^2\bar{\phi}}{\partial \zeta^2})+c\frac{\partial\bar{\rho}}{\partial \xi}\frac{\partial\bar{\phi}}{\partial \xi}+\lambda^2c^2\frac{\partial\bar{\rho}}{\partial \eta}\frac{\partial\bar{\phi}}{\partial \eta}+\frac{1}{AR^2}\frac{\partial\bar{\rho}}{\partial \zeta}\frac{\partial\bar{\phi}}{\partial \zeta}=$$

$$=-[c\frac{\partial\bar{\rho}'}{\partial \tau}+\bar{\rho}'(c\frac{\partial\bar{u}}{\partial \xi}+\lambda c^2\frac{\partial\bar{v}}{\partial \eta}+\frac{c^2}{R}\frac{\partial\bar{w}}{\partial \zeta})+c\bar{u}\frac{\partial\bar{\rho}'}{\partial \xi}+\lambda c^2\bar{v}\frac{\partial\bar{\rho}'}{\partial \eta}+\frac{c^2}{R}\bar{w}\frac{\partial\bar{\rho}'}{\partial \zeta}]\,. \qquad (7)$$

Here in (6),(7) variables $\bar{\rho}',\bar{\phi}$ - dimensionless density fluctuation and sound potential.

$\Re = \Re(\bar{\rho}', \frac{\partial \bar{\rho}'}{\partial \xi}, \frac{\partial \bar{\rho}'}{\partial \eta}, \frac{\partial \bar{\rho}'}{\partial \zeta}, \frac{\partial^2 \bar{\rho}'}{\partial \xi^2}, \frac{\partial^2 \bar{\rho}'}{\partial \xi \partial \eta}, ..., \frac{\partial^2 \bar{\rho}'}{\partial \zeta^2})$ - the operator takes part in the process of sound generation , $Q = Q(\rho \frac{\partial \bar{\phi}}{\partial \xi}, \frac{\partial \bar{\phi}}{\partial \eta}, \frac{\partial \bar{\phi}}{\partial \zeta}, \frac{\partial^2 \bar{\phi}}{\partial \xi^2}, \frac{\partial^2 \bar{\phi}}{\partial \xi \partial \eta}, ..., \frac{\partial^3 \bar{\phi}}{\partial \zeta^3})$ - is a source term operator. Boundary conditions for $\bar{\rho}', \bar{\phi}$ are included inside whole aerodynamic field variables.

Far sound field

When we know near field of $\bar{\rho}', \bar{\phi}$ we can calculates far noise field:

$$-M_1^2 \int_S [\frac{F}{R}]_{t}^{*} dS_x - \int_S [\frac{1}{R}\frac{\partial \phi}{\partial n} + \frac{1}{Ra_\infty}\frac{\partial R}{\partial n}\frac{\partial \phi}{\partial t} - \phi \frac{\partial (1/R)}{\partial n}]_{t}^{*} dS = 4\pi \phi(x, t_1) , \qquad (8)$$

where $F = \rho[(\nabla \phi \cdot \nabla)\bar{v} + (\bar{v} \cdot \nabla) \cdot \nabla \phi] + \rho^{'}(\bar{v} \cdot \nabla)\bar{v} + \bar{v} \cdot div(\rho \nabla \phi + \rho^{'} \bar{v}) + \nabla \phi div(\rho \bar{v})$. Thus the through aero-acoustics problem has been formulated above.

Method of the problem solving

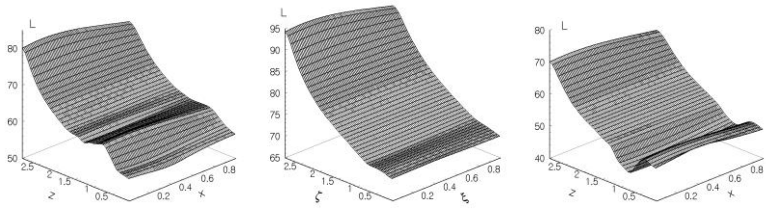
For solving aerodynamic and aero-acoustic problem the numerically-analytical method is used [3]. According the idea of the method resolving system consists of 15 equations. The calculating process is conducting along the flow by march scheme. Computational grid along ξ -coordinate has 85 nods, but along ζ - coordinate it has not more then 55 nods. This grid is suitable for stable calculation.

Examples of BVI-noise calculation

(a) Influence of angle of attack on sound generation process

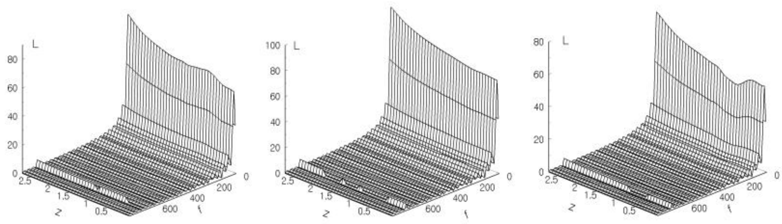
Let we return to fig.1: angle γ – is angle of attack of the blade; angle α – is angle of position the blade in the plane of rotation. Incoming flow has $\bar{U}$ velocity.

The analysis of calculation data (fig.2,fig.3: a) $\gamma = 5^\circ$,b) $\gamma = 10^\circ$,c) $\gamma = 15^\circ$) shows next regularities. At low angles of attack the level of generated noise increases pro rata γ . Reaching $\gamma = 15^\circ$, however, the sharp reduction of generated noise is observed. This fact says that vortex flow captures part of the kinetic energy of the flux and spends it for vortex noise generation. It type of noise has low level then the rotational noise. The generated noise is the noise of mixed type: it includes both vortex and rotational noises.



a) b) c)

Fig.2 Noise pressure level, $M = 0.2, \bar{r} = 1.0, \alpha = 30^\circ$



a) b) c)

Fig.3 Noise frequency spectrum $M = 0.2, \bar{r} = 1.0, \alpha = 30^\circ$

(b) Noise generation by tip rounded blade

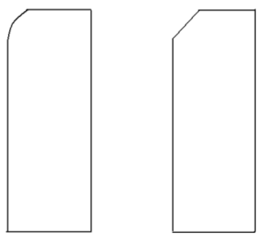
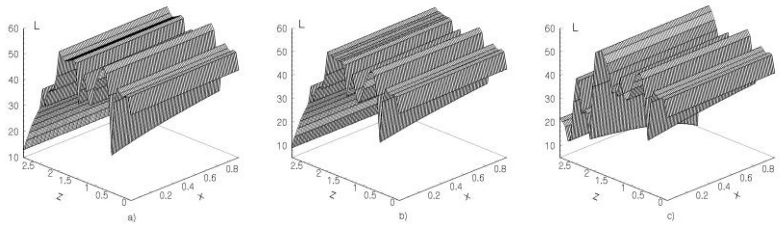


Fig.4 Rounded and truncated blades

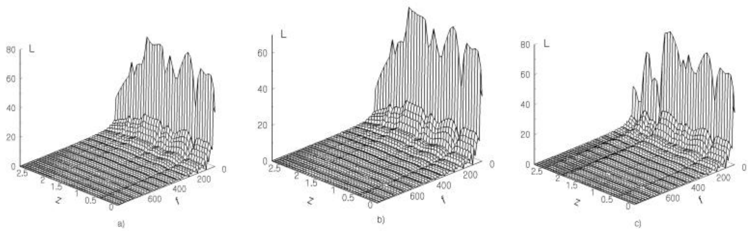
At fig.4 rounded and truncated blades are depicted. The noise of such blades has next particularities (see fig.5,6 $a)\alpha = 90^\circ, b)\alpha = 60^\circ, c)\alpha = 45^\circ$). In case of rounded blade decreased at 10-15dB level noise is obtained in comparison with non rounded blade. Noise energy is distributed along blade swept smooth then for non rounded blade. Thus blade rounding is effective means for BVI noise reduction.

Blade truncation doesn't give desirable results of noise reduction. Moreover, there are several calculation cases where flow at truncated area becomes irregular in vicinity of corner points. The fact violates hypotheses of "small" noise perturbations.



a) b) c)

Fig.5. Noise pressure level $M = 0.2, \bar{r} = 1.0, \alpha = 30^{\circ}$ $M = 0.2, \gamma = 5^{\circ}$



a) b) c)

Fig.6 Noise frequency spectrum $M = 0.2, \bar{r} = 1.0, \alpha = 30^{\circ}$ $M = 0.2, \gamma = 5^{\circ}$

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Vortex description for non-compressible fluid and compact vortex models

A new approach for non-compressible fluid motion description is proposed. The theorem on compact vortex flows is accompanied by a number of compensated vortex flow models.

1.Vortex description for non-compressible fluid motion.

Theorem 1 *Arbitrary motion of non-compressible fluid parcel consist of transport (macroscopic) rotation and relative (microscopic, spin-like) rotation.*

The physical insight into essence of fluid flow shows the existence of two rotations instead of only one. The pole's rotates within transport motion and fluid parcel rotates due to it's deformation (relative motion) [1].

$$\vec{V}_a = \vec{V}_e + \vec{V}_r \to \vec{V}_e, \quad P \to M.$$

Whence for angular velocity one can write

$$\vec{\omega}_a = \vec{\omega}_e + \vec{\omega}_r.$$

The subtitles *a,e,r* are correspond to absolute, transport and relative motion respectively.

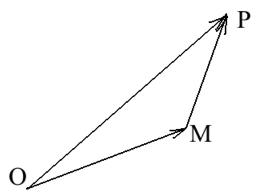


Fig. 1. The representation of the radius-vector parts of arbitrary point P. Point M corresponds to fluid parcel pole.

2. Vorticity compensation as a mechanism for compact vortex existence

Theorem 2. *The existence of compact revolving fluid areas (cylindrical vortexes) is provided by their vertical vorticity filed compensation.*

$$V_\theta = \frac{1}{r}\int_0^r r\omega_z dr.$$

Vortex is compensated if $V_\theta(r) = 0, \;\; r \ge R.$ Here, V_θ, ω_z are azimuthal velocity and vertical component of vorticity respectively [2].

3. Non-viscous compact vortex flows' models

3.1 Quasi--point vortex model as the compact analog of point vortex one.

For many years scientists all over the world use simplest model for describing revolving fluid. When $\omega_e = -\omega_r$ that means $\omega_a = 0$. So one has called non-rotational (or potential) fluid motion. In all cases where point vortex model is used for description of free vortexes they (vortexes), nevertheless, have finite radial scales. In order to meet this fact as well as to agree with vortex's finite energy one it was created quasi-point vortex model . Meet it:

$$V_\theta = \frac{\Gamma}{2\pi r}\left(1-\left(\frac{r}{R}\right)^2\right)$$

The details of the solution's obtaining one can find in [3]. The point vortex and quasi-point one curves of azimutal velocity presented at figure 2.

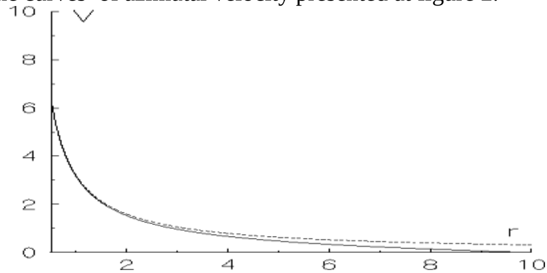


Fig. 2. The example of velocity distribution in quasi-compact vortex in comparison with point vortex analog (dotted curve).

3.2 Compact analog of Rankin vortex and it's using for more complicated vortex flows .

Rankin vortex model is still frequently used for study of different vortex flows. Many years ago a particular compact analog Rankin vortex was used in ocean flow modeling [4]. Recently, independently of [4], by using theorem 2 approach, was obtained compact compensated vortex model as a response to infinite size and energy unphysical Rankin vortex model. The distributions of azimutal velocity and vertical vorticity in the model are [5]:

$$V_\theta = \begin{cases} \dfrac{V}{a}r, & 0 \le r \le a, \\ \dfrac{Va}{r}\left(\dfrac{R^2-r^2}{R^2-a^2}\right), & a \le r \le R, \\ 0, & r \ge R. \end{cases} \qquad \omega_z = \begin{cases} \dfrac{2V}{a}, & 0 \le r \le a, \\ -\dfrac{2Va}{R^2-a^2}, & r \ge R, \\ 0, & r \ge R. \end{cases}$$

The using of the model for vortexes that have three and more domains with constant vorticity is given in [2].

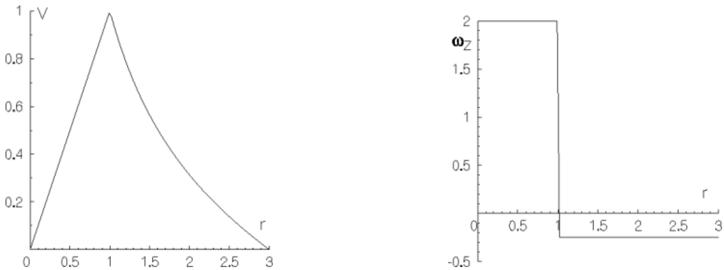


Fig. 3 Velocity and vorticity of compact compensated vortex model

3.3 Compact helical vortex models.

There is class of vortices whose velocity and vorticity vectors are parallel. They are called as helical vortices. Compact helical vortex models were elaborated in [6].

$$-\frac{\partial V_z}{\partial r} = \lambda V_\theta, \quad \frac{1}{r}\frac{\partial V_\theta}{\partial r} = \lambda V_z \ , \qquad \Rightarrow \ -\frac{\partial V_z^2}{2\partial r} = V_\theta \omega_z$$

Compact helical vortex.

$$\frac{V_Z^2}{2} = \begin{cases} \frac{V_0^2}{2} - \int\limits_0^r 2\left(\frac{V_0}{a}\right) r dr = \frac{V_0^2}{2} - V^2\left(\frac{r}{a}\right)^2, \ 0 \le r \le a, \\ \frac{V_0^2}{2} - V_0^2 + \left(R^2 \ln\frac{r}{a} - \frac{1}{2}\left(r^2 - a^2\right)\right), \ a \le r \le R, \\ 0, \ r \ge R. \end{cases}$$

3.4 Compact vortex with helical symmetry models.

Vortices with helical symmetry is determined by following correlation between azimutal and axial velocity components:

$V_z = V_z^0 - \frac{r}{l} V_\theta$,   here l is helical symmetry constant.

There are five solutions based on different compact vortex models given in [7].

4. Viscous compact vortex flows' models

4.1 Spherical compact vortex molecular diffusion

There are many cylinder vortex model that conclude only one independent variable that is radial coordinate. As it turned out, in spherical coordinates frame one can derive a simple model of vortex flow that only depend on radial coordinate. This flow is also helical one. The solution below must be used, through analogy, in electromagnetism and other fields of physics. In spherical coordinates r, θ, φ [8]:

$$\frac{\partial U_{\vartheta}}{\partial t} = \nu\left(\frac{\partial^2 U_{\vartheta}}{\partial r^2} + \frac{2}{r}\frac{\partial U_{\vartheta}}{\partial r}\right), \quad \frac{\partial U_{\varphi}}{\partial t} = \nu\left(\frac{\partial^2 U_{\varphi}}{\partial r^2} + \frac{2}{r}\frac{\partial U_{\varphi}}{\partial r}\right).$$

$$U = U(\eta), \quad \eta = r/t^b. \qquad \text{For } b = 0.5 \ \frac{d^2U}{d\eta^2} + \left(\frac{2}{\eta} + \frac{\mathrm{Re}}{2}\eta\right)\frac{dU}{d\eta} = 0.$$

$$U(\eta) = -\frac{\exp\left[-\frac{\mathrm{Re}}{4}\eta^2\right]}{\eta} + \frac{1}{2}\sqrt{\pi\,\mathrm{Re}}\left(\frac{2}{\sqrt{\mathrm{Re}}} - erf\left(\frac{\sqrt{\mathrm{Re}}}{2}\eta\right)\right).$$

$$\omega_{\vartheta} = -\omega_{\varphi} = \frac{1}{\sqrt{t}\eta}\left(\sqrt{\pi}\left[\frac{\sqrt{\mathrm{Re}}}{2}erf\left(\frac{\sqrt{\mathrm{Re}}}{2}\eta\right) - 1\right] + \left(\frac{\mathrm{Re}}{2}\eta + \sqrt{\mathrm{Re}}\right)\exp\left(-\frac{\mathrm{Re}}{4}\eta^2\right)\right)$$

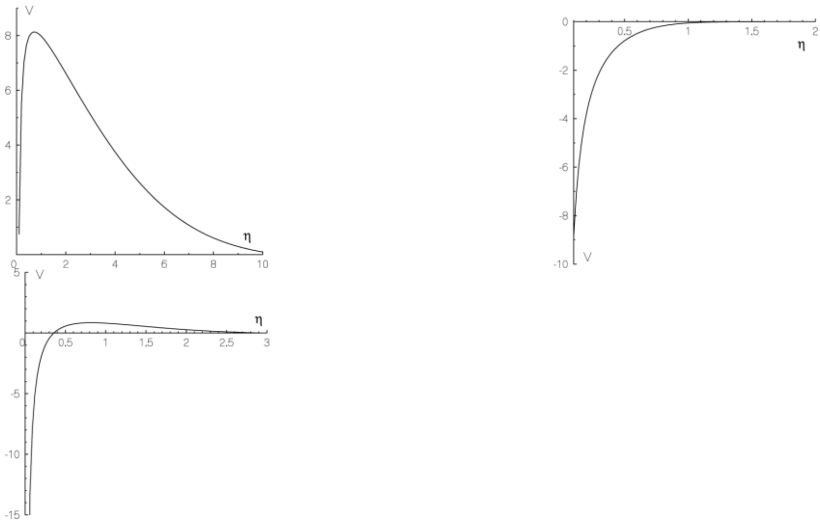


Fig.4 Velocity distributions for Re 0.1 (a), 10(b) and 1(c) respectively.

4.2 Compact turbulent vortex generation approximate model for relatively large time moments

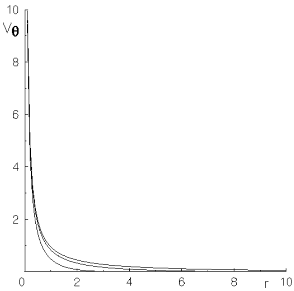
Here, by using approximation of eddy viscosity as constant one within the flow, a simple model that describes growing in time cylinder vortex is given [9].

$$\frac{\partial\overline{V_\theta}}{\partial t}=\frac{1}{\mathrm{Re}}\left(\frac{\partial^2\overline{V_\theta}}{\partial r^2}+\frac{2}{r}\frac{\partial^2\overline{V_\theta}}{\partial r}\right),\ \overline{V_\theta}(r,0)=0,\quad 0<r<+\infty,$$

$$\overline{V_\theta}(R_i,t)=\Gamma/2\pi,\quad t>0,\quad \overline{V_\theta}(\infty,t)=0,\quad 0<t<+\infty.$$

$$U=\overline{V_\theta}\cdot r\quad \frac{\partial U}{\partial t}=\frac{1}{\mathrm{Re}}\frac{\partial^2 U}{\partial r'^2},\ U(0,t)=\Gamma/2\pi,\quad 0<t\le T_g,$$

$$U_s(\eta)=\frac{\Gamma}{2\pi}\left(1-erf\left(\frac{\sqrt{\mathrm{Re}}}{2}\eta\right)\right).\ V_\theta(r,t)=\frac{\Gamma}{2\pi r}\left(1-erf\left(\sqrt{\frac{\mathrm{Re}}{t}}\frac{(r-R_i)}{2}\right)\right).$$



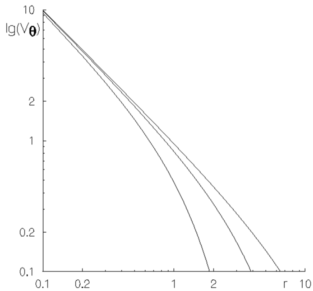


Fig.5 Azimutal velocity distribution and it's logarithm respectevly.

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UDK 532.526

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Triangulation method of bearing surfaces of aircraft systems

For the purpose of the numerical realization of the numerical solution on the basis of the method of boundary integral equations developed algorithmic process coordinate surfaces of arbitrary spatial form for further triangulation of that ensures the implementation of correct definition of distributed computing experiment aerodynamic characteristics.

Introduction

Due to multi parameter nature and nonlinearity of the main tasks concerning continuum mechanics [1], the computational experiment along with the physical one obtained a considerable development. Currently, the development of computer technologies has reached such a level that it makes no sense any longer to demonstrate computer simulation or numerical experiment advantages in aerohydrodynamics compared to traditional physical modeling methods [2]. It should be emphasized that current research of problematic and sought continuum mechanics tasks and, in particular, aerodynamics, are based on advanced machines of functional vector and tensor analysis [1], and contributes to the development of numerical methods for the solution of the entire spectrum concerning demanded mechanics tasks.

The aerodynamics of complex bearing surfaces (Fig. 1, 2) based on the systematic use of boundary integral equation method and numerical embodiment options the distributed and total nonlinear aerodynamic characteristics of bearing forms, planar and spatial ones are obtained

Problem formulation

Recently, the aircraft with additional airfoils (AAF) (see. Fig. 1, 2) is studied actively. These AAF prevent the overflow of the air flow and equalizes the pressure on the upper and lower wing surfaces, weakening a powerful end vortex by separating it into several vortices of smaller intensity.

Fig. 1. Bearing and control aerodynamic surfaces of modern aircraft

Fig. 2. Prospective aircraft with advanced aerodynamic mechanization systems

AAF application designed with the prediction of the necessary aerodynamic characteristics, allows to reduce the induced resistance of an aircarft, to increase an effective elongation of a wing and the lifting force at its end, to develop a course stability, to decrease the specific fuel consumption, to reduce the length of running start and run during an aircraft (AC) take-off and landing, that also has a considerable economic significance.

The experience of recent years showed that along with the universal packages of application programs, the possibilities of which are often declared, you must continue to create, correct algorithms and software products from a mathematical point of view. The combination of numerical and analytical approaches based on the boundary integral equations in the calculations of aerohydrodynamic characteristics of aircraft, vehicles and their parts in different flight or movement modes, providing a sufficient economic benefit seems to be a very topical one. Now we are talking about the efficiency and the reliability of numerical simulation and numerical experiment improvement, because, despite all its advantages, it became apparent that a numerical experiment can not replace field tests completely for now. It is necessary to increase the speed, the volume and the accuracy of calculations. One way to improve the speed and accuracy of calculations is to increase the efficiency of geometric modeling in full compliance with certain differential-topological properties of curves and surfaces within the spaces of a given dimension.

Geometric modeling results

According to developed tradition, the long period of preliminary design phase was associated with the need for successive stage implementation: the preparation of a project, the creation of a model, the testing in a wind tunnel and the drawing up of an adjusted project. The creation of a model is often the slowest and the most expensive stage of this process. The use of a well-established computer program according to the method of calculation aerodynamics allows the testing of alternative project series (e.g., with different geometric configuration) in a wide range of parameter value change, such as the Reynolds number, Mach number, the angle of flow deflection.

Based on the ideology of boundary integral equation method, an integrated computer technology seems to be especially promising. This method was the most effective one in the cases of internal and external problems concerning continuum mechanics for unbounded domains with compact internal borders and allows, in particular, to determine directly the distribution and total aerohydrodynamic characteristics of aircrafts and their parts.

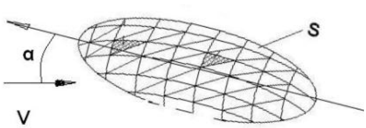

Fig. 3. Canonical triangulated surface in a natural coordinate system

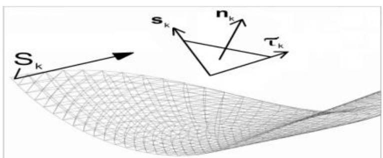

Fig. 4. The elements of triangulated bearing surface in a natural coordinate system

During the study of these characteristics for aircraft carriers and their bearing and control systems on the basis of the boundary integral equation method with the help of computer technology with its correct numerical implementation the triangulation method of an object surface in orthogonal curvilinear coordinate system is used (Fig. 3, 4) [3]. In modern systems of geometric modeling objects are represented as the combination of simple elements (primitives). The process of a complex configuration polygon area splitting in a set of triangles is called triangulation and performed, depending on a surface class - a plane, section surface, the surface given by an array of points and interpolating functions, etc. Also there are different subclasses of surfaces - conical, spherical, cylindrical, ellipsoidal, and others. During the analysis or the synthesis of complex surfaces they are approximated by the mesh of triangles, and subsequently they operate with simple polygonal regions, i.e. with each of the triangles.

Triangulation (from Latin triangulum - triangular) - was one of the methods for basic geodetic network development and currently it is a powerful method for for three-dimensional object construction using software in computer graphics. Triangulation algorithm is applicable to a surface of any shape in a plane and in a spatial cases [4]. This approach, along with the subsequent quadrature-interpolation process of integral calculation like potentials leads to a linear system of algebraic equations for the desired kinematic and dynamic parameters of a task.

The development of computer graphics for the tasks of this class requires powerful hardware and intellectually provided algorithms for the purpose of coordinate system development based on three-dimensional models of an arbitrary spatial shape, followed by the decomposition of images into the simplest elements-triangles.

Any surface may be approximated with a desired accuracy by a grid of triangles. The approximation accuracy is determined by the number of triangles and the method of their choice. A high-quality object imaging that is close to an observation point, requires to take into account much more triangles than in the situation when the same object is located at a distance. Even a fairly coarse mesh is useful in practice, since the smoothing methods used in the display process may significantly improve a surface curvature image.

Triangulation, the splitting of a surface into simple elements makes it possible to control the accuracy during the calculation of aerodynamic characteristics. Depending on the requirements of a task and a computer configuration a number of triangles is selected in order to clarify the convergence of computing process and achieve an acceptable accuracy.

Mathematical model

The algorithm of such an approach implementation is developed in the case of an integral representation concerning the problem solutions in respect of flowing around an arbitrary spatial bearing system of by a real fluid flow [5]:

$$\mathbf{V} = \iiint\limits_{(S+\Sigma)} \left\{ \left(\left(\left(\frac{\partial \mathbf{V}}{\partial n} + \left[\mathbf{n}, [\nabla, \mathbf{V}] \right] \right), \mathbf{\Gamma} \right) \right) - \left(\mathbf{V}, \left(\frac{\partial \mathbf{\Gamma}}{\partial n} + \left[\mathbf{n}, [\nabla, \mathbf{\Gamma}] \right] \right) \right) \right\} dS \qquad (1)$$

of the fundamental boundary value problem of hydrodynamics as a conservative form of momentum conservation law in the simplest case of a steady motion concerning an incompressible viscous fluid taking into account the natural boundary conditions of the bearing system S flowing inside the control area Σ:

$$\left(\nabla, \left[\mathbf{V}\otimes\mathbf{V} + \mathbf{I}\frac{p}{\rho} - \nu\nabla\mathbf{V}\right]\right) = 0, \qquad (2)$$

where the tensor $\mathbf{\Gamma}$ is the fundamental solution of vector analysis basic problem [1]: $\nabla(\nabla,\mathbf{\Gamma}) = \mathbf{I}\delta(|\mathbf{x}-\mathbf{y}|)$, $\otimes$ - the symbol of the tensor product, and **I** is a single tensor.

In order to calculate the aerodynamic characteristics of an object under study on the basis of the established system of boundary integral equations equivalent to set boundary value problem (1), using a graphical triangulation process, followed by an analytical calculation of the necessary integrals of potential type on flat triangular surface elements, the algorithm of this system transformation into the system of linear algebraic equations is created with a single guaranteed solution.

The procedure of illustration concerning the flow of three-dimensional bearing system or its component with the use of computer graphics to determine the aerodynamic characteristics, the programming interface is applied with an open graphics library OpenGL (Open Graphics Library) with the C ++ programming language and other software, confirmed by relevant documents, is presented on Fig.5.

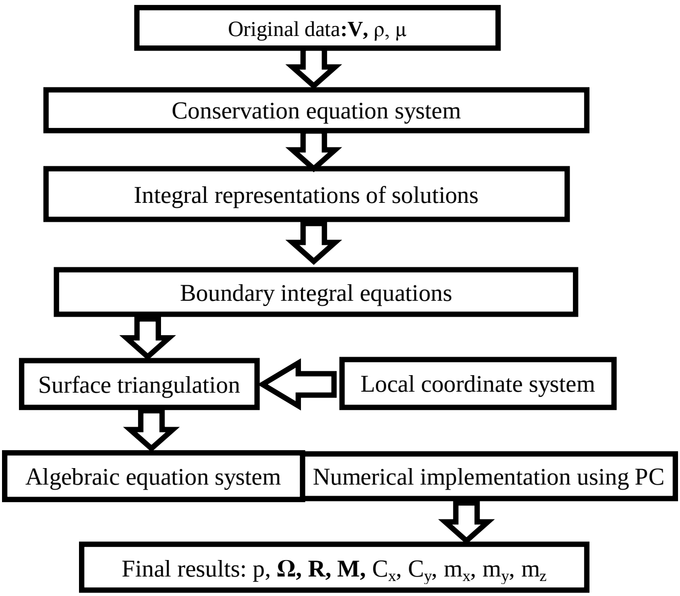

Fig.5. Calculation procedure of total distributed aerohydrodynamic characteristics

Conclusion

Currently, the most promising method to solve a wide range of boundary value problems concerning continuum mechanics is the method of boundary integral equations, which allows:

- to reduce the dimension of a problem and consider more complex classes of problems than those that are solved by other methods;

- to determine unknown values on the boundaries of an area; the solutions in the interior points of an area are obtained by integration;

- nonlinear boundary problems for the systems of differential equations concerning basic conservation laws of mechanics lead to the system of linear boundary integral equations concerning unknown boundary values of the sought problem parameters or its wanted features;

- to perform the correct algorithms and implement some computational process to determine the kinematic and dynamic characteristics of the environment and a streamlined object interaction.

During the study of these aircraft characteristics on the basis of boundary integral equation method using the modern software products and computer technologies the author developed an object surface triangulation method in a curvilinear orthogonal coordinate system. Triangulation algorithm is applicable to the surfaces of any shape in a plane and in a spatial cases. The article shows the results of geometric modeling with the subsequent triangulation of an aircraft wing surface with additional aerodynamic surfaces, which allow to reduce the induced resistance of an aircraft, increase an effective extension of a wing and the lifting force at its end, to improve the course stability, reduce specific fuel consumption, reduce the length of running start and run during an aircraft takeoff and landing, which has also a significant economic effect.

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Statistical research and simulation of MEMS gyros measurements

This article provides results of the statistical analysis and numerical evaluation of noise level components in the MEMS gyroscopes measurements. The Simulink-model of measurement errors for the ADIS16250 angular rate sensors was build, and test data and simulation results were analyzed.

Introduction

Strapdown inertial navigation is based on the use of inertial modules that produce the data used by the associated algorithms to get an idea about the current position of the object, its speed and orientation. The accuracy of above parameters directly depends on the accuracy of the sensors in use.

Traditional applications for inertial navigation in the Aerospace and Marine industry utilize the high precision sensors that are quite expensive to develop and produce. It is a trend of today to select the module components that include more energy efficient, more compact and inexpensive to produce sensors. These requirements correspond to the sensors built on micro-electro-mechanical systems (MEMS).

Design and production of sensors of this type have achieved great success, as evidenced by the mass production and variety of models. However, the miniaturization of MEMS sensors and production volumes do not allow them to achieve high precision in measurements. Their use often requires algorithmic additions to improve the accuracy of the data. This applies particularly to MEMS-gyros. In this paper, we study the statistical properties of the measurements of the Analog Devices' MEMS gyroscopes ADSI16250. Technical documentation, which is available on the website of the Analog Devices, does not provide complete information about individual characteristics of a single sensor. This creates the need for additional research.

Objective.

The aim of this work is to identify the noise from each MEMS-gyro included into assembly. This task includes processing of the measurements, getting coefficients for Allan variance and computer simulation. Hereafter, the information about the noise level makes it possible to adjust the obtained measurements.

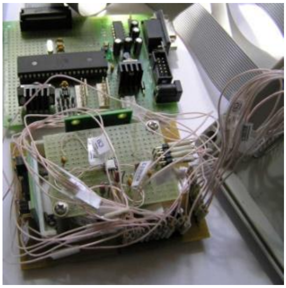
Mathematical error model including both systematic and random components is needed for algorithmic data correction. At all, components of the error model can be divided into additive (zero offset, drift, casual care zero) and multiplicative (the error of scale factor linearity, asymmetry). The additive error of the gyro zero signal ω_0 makes the greatest contribution into the final error of gyro; it is represented in the form of several components

$$\omega_0 = \omega_{сист} + \omega_{зав} + \omega_{случ}, \qquad (1)$$

where $\omega_{сист}$ is the systematic component that does not depend of external factors and keeps its value within the service life; $\omega_{зав}$ – gyro drift component depending on the temperature, storage time, overload, current time in operation and other factors; $\omega_{случ}$ - random noise component of the zero signal.

Working model of the system is an inertial measurement unit on a fixed base with a control and computer interface PCB (Fig. 1). It includes three integrated MEMS-gyro ADIS 16250.

During of the experiment, records were made under static conditions and constant temperature. Data recording occurred with a frequency of 50 Hz, the duration of the session – 25 minutes. The signal of the gyroscope, taken at a static position shown in Fig. 2.

a  b

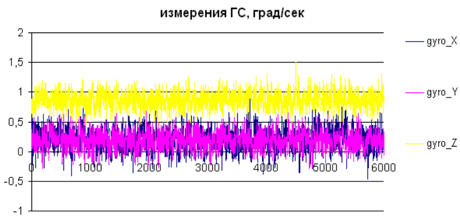
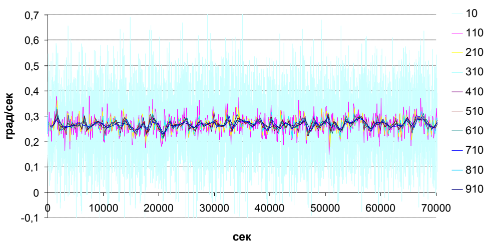


Fig. 1. a – Inertial measurement unit built on MEMS-sensors; b – measurements from 3 MEMS-gyros.

The most of theoretical conclusions and practical results is carried out in the literature for stationary series; so of course, the first task is to study the stationarity of the available data.

First, the conclusion about the stationarity of the measurements can be based on the variation of the average value and dispersion value within a time period. The moving average method is selected for averaging. See Fig. 2 that shows plots of the velocity along the X-axis at various parameters of the averaging. The relationship between the average value and time indicates the presence of zero drift and trend. Stationary time series were obtained with the help of the linear regression and subsequent data filtering. The mean value and variance value of the time series do not change over time and therefore, the process can be considered stationary.

Another approach to the stationarity study is based on the comparison between the values of distribution density function for samples obtained by splitting a primary time series into equal sequential intervals. Analysis of the density distribution functions obtained for samples from one implementation, and different implementations, shows comparable values (Fig. 2 b). Thus, stationarity of the time series registered in the experiment is determined.



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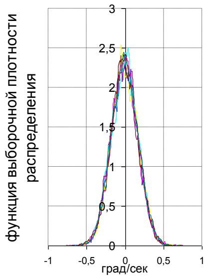


b

Fig. 2 – Stationarity of the samples: a - measurement of average value after averaging, b) selective distribution.

Thus, the values of the zero offsets of the sensors are (grad./sec.): 0,0104009 for the X axis - 0,000995936 the Y-axis 0,00746764 axis Z. These values define the first component in (1).

The second component $\omega_{зав}$ can be defined as formula connection of the gyro error from design features and external factors obtained from the physical principles of device operation.

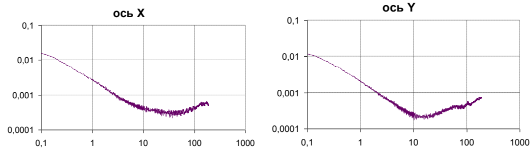
Regarding the third component in (1), traditional methods of spectral analysis did not answer the question about the structure of the noise available in the measurements and their intensity. Currently, Allan variation [1] starts to find a wide use as a method for estimating the noise component.

$$\sigma_A^2(\tau) \approx R^2 \frac{\tau^2}{2} + K^2 \frac{\tau}{3} + B^2 \frac{2}{\pi} \ln 2 + N^2 \frac{1}{\tau} + Q^2 \frac{3}{\tau^2}, \qquad (2)$$

where R, K, B, N, Q – typical noise components coefficients [2]. Namely, the R – linear change of the angular velocity, K is a random deviation of the angular velocity, B is the coefficient of instability of the zero signal, N is the coefficient of random angle deviation, Q – quantization noise factor.

Fig. 3 a, b, C shows the curves of Allan variation, based on the measurements for the three MEMS gyroscopes.

Comparing the figures, we note the following types of noise in the measurements: angle increment noise (N), instability of the zero offset (B) and angular velocity deviation noise (K). See Table 1 for the calculated values of the coefficients (2) for each sensitivity axis.



a b c

Fig. 3 –Allan variance graph: a) for the sensitivity axis 0X, b) for axis 0Y, c) for axis 0Z.

Table 1

Coefficients of Allan variation curves

The direction of sensitivity axis in the assembly	Coefficients of polynomial (2)				
	$\|R^2\|$, $\times 10^{-8}$ м/с^3	$\|K^2\|$, $\times 10^{-5}$ м/с^2/√с	$\|B^2\|$, $\times 10^{-4}$ м/с^2	$\|N^2\|$, $\times 10^{-3}$ м/с/√с	$\|Q^2\|$, $\times 10^{-5}$ м/с
X	1,336	1,176	2,074	2,662	3,65
Y	2,352	1,754	0,0106	2,115	3,116
Z	5,839	6,607	5,135	1,59	1,962

Based on this analysis, errors model for ADIS 16250 MEMS gyro is as follows:

$$\omega_g = \omega + b + n_a, \dot{b} = n_b \qquad (3)$$

where ω_g - simulated output signal of the sensor; ω - true angular velocity; b - zero drift of the gyro (rad/s) imposed by the random drift of the angular velocity n_b; n_a - white noise, distorting the signal of the angular velocity measured by the gyroscope, which determines the random drift when measuring angle as per the gyroscope data.

Simulink model (Fig. 4) was compiled with the help of the error model specified in (3) and simulation exercise was conducted with the results provided in Fig. 5. Comparison of the real signal graph (Fig. 5a) and simulated signal graph (Fig. 5 b) confirms that the approach specified in this article can be used to identify noise of MEMS sensors.

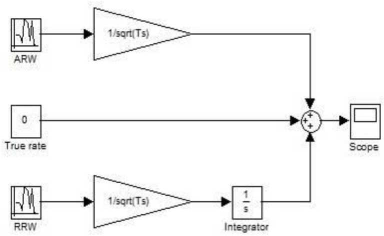


Fig. 4. Simulink model of ADIS16250 angular rate sensor measurement errors

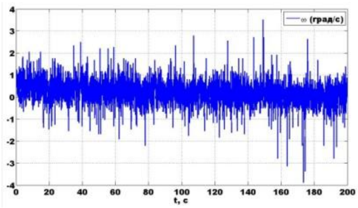
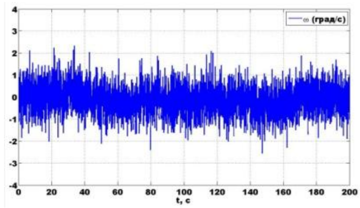
а  б 

Fig. 5. Gyro signal: (a) experimental; b) simulated

Conclusions.

This paper presents the results of the statistical analysis for MEMS gyroscopes measurements. Evidences for the stationarity of the time series realizations and numerical estimates of the level of the inertial measurements noise components were obtained. The obtained noise component estimates were compared to the claimed characteristics from the manufacturer. The Simulink model of angular rate measurement errors, which allows to recover the real signal, was built for the ADIS16250 sensors that are included into the inertial measurement unit.

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UDC 629.7.05

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Multiplicative three-frequency models of a rigid body rotation in error analysis for algorithms of determination of orientation

The new reference models of a rigid body rotation based on multiplicative representation of a quaternion of orientation are offered. For several sets of parameters numerical realization of models is received. The offered models are used for error analysis for algorithms of determination of orientation.

The problem of determination of orientation in the strapdown inertial navigation systems (SINS) is considered. Recently large number of algorithms of determination of orientation in SINS are developed, which are oriented to use primary information on rotation of object in the form of quasicoordinates [1]. At the same time error analysis for algorithms at a design stage of SINS and the choice of the best algorithm for specific object is an actual practical task.

The reference models of rotation of a rigid body (discrete and continuous) are used for algorithms error estimation establishing connection between a quaternion of orientation and quasicoordinates which are formed as the output of measuring instruments of angular velocity on a step $[t_{n-1}, t_n]$:

$$\theta^*_{ni} = \int_{t_{n-1}}^{t_n} \omega_i dt, \qquad i = 1,2,3, \tag{1}$$

where ω_i, $i = 1,2,3$ – projections of a vector of absolute angular velocity of object on axes of the related system of coordinates.

The continuous reference models based on exact solutions of the equations of rotation of a rigid body (conical motion model [4] and a regular precession [5]) are widely used in practical applications. Extension of a class of the continuous reference models other than existing is an actual task of the precision analysis of algorithms.

The continuous model of rotation is defined completely by the accepted analytical representation of a quaternion of orientation $\Lambda(t)$. Projections of model angular velocity are obtained analytically from the inverted kinematic equation

$$\omega(t) = 2\tilde{\Lambda}(t) \circ \dot{\Lambda}(t) . \tag{2}$$

Model values of quasicoordinates (1) will be defined from a formula:

$$\theta^*_{ni} = \theta_i(t_n) - \theta_i(t_{n-1}) , \; i = 1,2,3, \tag{3}$$

where $\theta_i(t_n) = \int_0^{t_n} \omega_i(t) dt$, $\theta_i(t_{n-1}) = \int_0^{t_{n-1}} \omega_i(t) dt$, $i = 1,2,3$ – the components of a vector of the seeming turn calculated in timepoints t_n and t_{n-1} respectively.

The continuous reference models of rotation of a rigid body other than a case of a classical regular precession are presented in works [6, 7, 8]. In this work three new types of asymmetrical three-frequency multiplicative models of rotation of a rigid body are offered.

Components of a quaternion are represented for model of the first type as:

$\lambda_0(t) = \cos(k_1 t)\cdot$; $\lambda_1(t) = \sin(k_1 t)\cdot \sin(k_2 t)$;

$$\lambda_2(t) = \sin(k_1 t)\cdot \cos(k_2 t)\cdot \sin(k_3 t)\,;\ \lambda_3(t) = \sin(k_1 t)\cdot \cos(k_2 t)\cdot \cos(k_3 t)\,. \tag{4}$$

The orientation quaternion in model of the second type is presented in the form:

$\lambda_0(t) = \cos(k_1 t)\cdot \cos(k_2 t)$; $\lambda_1(t) = \sin(k_1 t)$;

$$\lambda_2(t) = \cos(k_1 t)\cdot \sin(k_2 t)\cdot \cos(k_3 t)\,;\ \lambda_3(t) = \cos(k_1 t)\cdot \sin(k_2 t)\cdot \sin(k_3 t)\,. \tag{5}$$

For model of the third type the quaternion of orientation reads like:

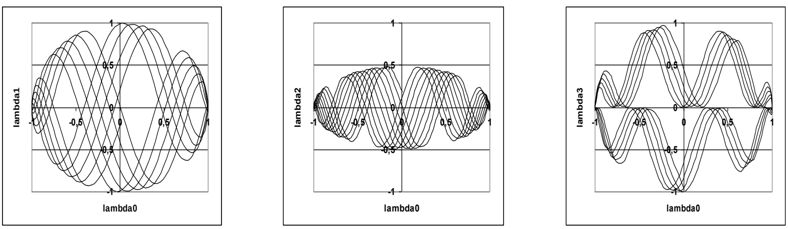
$\lambda_0(t) = \cos(k_1 t)\cdot \cos(k_2 t)\cdot \cos(k_3 t)$; $\lambda_1(t) = \sin(k_1 t)$;

$$\lambda_2(t) = \cos(k_1 t)\cdot \sin(k_2 t)\,;\ \lambda_3(t) = \cos(k_1 t)\cdot \cos(k_2 t)\cdot \sin(k_3 t)\,. \tag{6}$$

Analytical expressions for the components of the angular velocity and quasicoordinates corresponding to quaternions (4) - (6), could be easily found from the formulas (2) and (3). Values of the frequencies k_1, k_2, k_3 in reference model result from the existing restrictions on the angular velocity of the object or from approximations of the real motion of the object.

We construct multiplicative reference models for several values of parameters k_1, k_2, k_3, a computation step $\Delta t = 0{,}1$ sec. on time interval 2000 sec. Fig. 1,2,3 demonstrate results of realization of model of the first type for values of parameters $k_1 = 0{,}015$, $k_2 = k_3 = 0{,}052$ of model of the second type at $k_1 = 0{,}02$, $k_2 = k_3 = 0{,}04$ and of model of the third type at $k_1 = 0{,}015$, $k_2 = 0{,}025$, $k_3 = 0{,}005$ in the form of trajectories in configuration space of parameters of orientation.

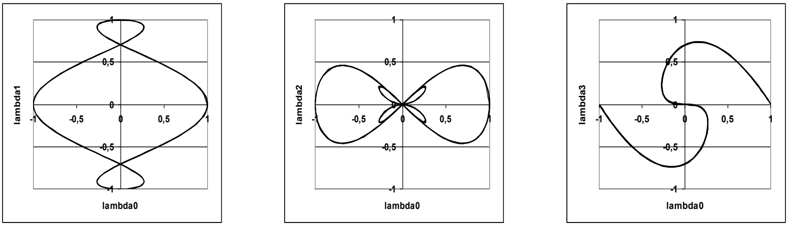
Results of realization of reference model of a regular precession are given in work [6] and the constructed trajectories in configuration space are presented. The significant difference between of the proposed multiplicative models and model of a regular precession has been shown. Moreover multiplicative models cover other, more difficult rotations of a rigid body.



a b c

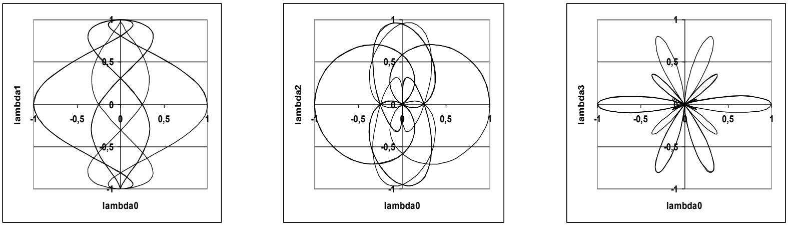
Fig. 1 – Trajectories in configuration space for model of the first type:

$a - \lambda_1(\lambda_0)$; $b - \lambda_2(\lambda_0)$; $c - \lambda_3(\lambda_0)$



a b c

Fig. 2 – Trajectories in configuration space for model of the second type:
$a - \lambda_1(\lambda_0)$; $b - \lambda_2(\lambda_0)$; $c - \lambda_3(\lambda_0)$



a b c

Fig. 3 – Trajectories in configuration space for model of the third type:
$a - \lambda_1(\lambda_0)$; $б - \lambda_2(\lambda_0)$; $в - \lambda_3(\lambda_0)$

We apply the constructed reference models to the precision analysis of two algorithms of determination of orientation of the third order. As the first algorithm we will consider difference algorithm with a turn quaternion [2]:

$$\Delta\lambda_{n0}^* = 1 - \frac{1}{8}\theta_n^{*2}, \quad \Delta\vec{\lambda}_n^* = \frac{1}{2}\vec{\theta}_n^*(1 - \frac{1}{24}\theta_n^{*2}) + \frac{1}{24}(\vec{\theta}_{n-1}^* \times \vec{\theta}_n^*), \qquad (7)$$

where $\theta_n^{*2} = \theta_{n1}^{*2} + \theta_{n2}^{*2} + \theta_{n3}^{*2}$.

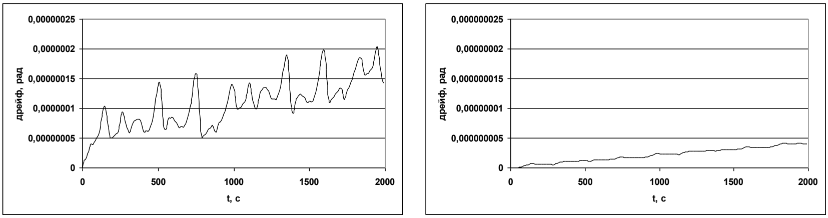
As the second algorithm we take power algorithm with a turn quaternion [3]:

$$\Delta\lambda_{n0}^* = 1 - \frac{1}{8}\theta_n^{*2}, \quad \Delta\vec{\lambda}_n^* = \frac{1}{2}\vec{\theta}_n^*(1 - \frac{1}{24}\theta_n^{*2}) + \frac{1}{3}(\vec{\theta}_{n-1/2}^* \times \vec{\theta}_n^*), \qquad (8)$$

where $\vec{\theta}_{n-1/2}^* = \vec{\theta}^*(t_n + 0{,}5\Delta t)$.

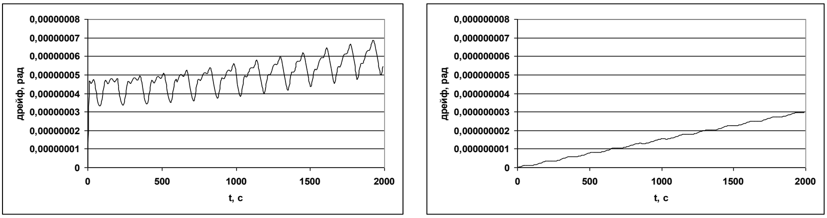
As estimates of errors of algorithms we define an ineradicable error of definition of orientation – the cumulative small angle of rotation (drift) of the calculated basis concerning its true situation. For this purpose we use the drift definition technique proposed in [2].

In fig. 4,5,6 the dependences of errors of drift on time for the above-stated algorithms obtained on realization of reference model of the first type at $k_1 = 0{,}015$, $k_2 = k_3 = 0{,}052$, of model of the second type at $k_1 = 0{,}02$, $k_2 = k_3 = 0{,}04$ and of model of the third type at $k_1 = 0{,}015$, $k_2 = 0{,}025$, $k_3 = 0{,}005$.



a b

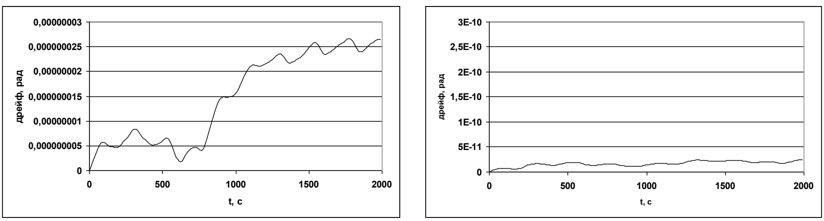
Fig. 4 – Dependence of an error of drift on time for models of the first type:
a – for difference algorithm; b – for power algorithm



a b

Fig. 5 – Dependence of an error of drift on time for models of the second type:
a – for difference algorithm; b – for power algorithm

Based on results of numerical experiment we conclude that on all considered realization of reference models according to an error of drift the power algorithm of determination of orientation is more preferable in comparison with the difference algorithm of determination of orientation.



a b

Fig. 4 – Dependence of an error of drift on time for models of the third type:
a – for difference algorithm; b – for power algorithm

Conclusions:

We propose three new types of three-frequency continuous models of rotation of a rigid body based on multiplicative representation of a quaternion of orientation in terms of trigonometric functions of the angles which are simultaneously changing in time. Models include analytical dependencies for components of a vector of the seeming turn which are used to obtain the corresponding analytical expressions for quasicoordinates. The performed numerical experiment has shown that at the appropriate choice of parameters of models it is possible to receive rather wide set of motions of object as rigid body which differ from a classical case of a regular precession. Results of realization of models are presented in the form of trajectories in configuration space of parameters of orientation. On several realizations of models the error analysis of two chosen algorithms of determination of orientation is carried out.

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Numerical simulation of supersonic chemically reacting combustion products jets under parabolic Navier-Stokes equations

Numerical simulation of the parameters of supersonic turbulent nonisobaric jet of combustion products is carried out with using the marching calculation method, solutions regularization in the subsonic area and the algorithm for determination the asymptotic jet bound. Influence of combustion products afterburning in the air oxygen on jet parameters is shown by using equilibrium and nonequilibrium thermodynamic models.

Jet flows of combustion products are characterized by shock-wave structure in the jet core, turbulent mixing of the jet with the surrounding area air, afterburning of combustion products in the air oxygen, large extent of the computational area along the jet axis. In this connection, the use of full averaged Navier-Stokes equations or direct numerical simulation methods for carrying out parametric calculations of termogasdynamic parameters of non-isobaric turbulent multicomponent chemically reacting combustion products jets requires large computational efforts. A model of parabolic Navier-Stokes equations (viscous layer stationary equations model) for viscous multicomponent chemically reacting gas [1, 2] using regularization solutions in subsonic flow regions [3] allows to carry out calculations of nonisobaric supersonic turbulent combustion products jet during its outflowing to subsonic cocurrent stream or surrounding area using efficient marching methods.

Turbulent nonisobaric jet outflow is accompanied by the significant increase in the cross-jet size. The accuracy of determination calculations of the flow field in the jet depends on the accuracy of jet bound. The algorithm for determining the asymptotic jet bound is used to reduce the computational efforts during calculations parameters of turbulent flows in multicomponent chemically reacting jets. The algorithm is based on the requirement of a smooth velocity coupling both in the jet and in the cocurrent stream [4].

Afterburning of combustion products in the jet under the influence of temperature and pressure increase during supersonic jet stagnation, and the afterburning of combustion products in the air oxygen may significantly influence the thermogasdynamic jet parameters, especially the jet temperature. The following cases of the components thermodynamic state are considered to study the influence of chemical interaction on the parameters of turbulent supersonic combustion products jet:

a) frozen components mixture (chemical interaction between the jet components and the air is absent);

b) nonequilibrium state (with accounting chemical reactions between the jet components and the air oxygen at a finite velocity);

c) equilibrium state (the jet components and the air are in the thermodynamic equilibrium).

Kinetic model is proposed to determine the parameters of the combustion products jet, taking into account afterburning in the air at a finite velocity of the chemical reaction. It includes two elementary reversible reactions involving gaseous carbon and eight elementary reversible reactions for the gas mixture involving O-H components. This model testing was carried out during simulation of kerosene combustion products afterburning at volumetric average approach. Results of the testing have shown that the model allows to get a good agreement with the equilibrium parameter values after thermodynamic system reaches to equilibrium state.

The algorithm based on the fundamental principle of maximum entropy [5] is used for the jet parameters determination in the assumption of equilibrium composition. This method allows to describe any high-temperature state of a thermodynamic system with the help of the fundamental laws of thermodynamics, regardless of the conditions and ways to achieve equilibrium. Calculations of composition and equilibrium characteristics are cared out using the individual substances properties database.

Numerical simulation of the flow termogasdynamic parameters in axisymmetric supersonic overexpanded turbulent combustion products jet with consideration components afterburning is carried out with the following parameters at the nozzle exit section: static pressure is $P = 0{,}73 \cdot 10^5$ Pa; Mach number is M =3,24; stagnation temperature is T_0 =2850°K; mass concentrations of the components are c_{H_2} =0,01; c_{CO} =0,29; c_{H_2O} =0,3; c_{CO_2} =0,4. Differential one parameter turbulence model « $\nu_t - 90$ » [6] is used to determine the characteristics of turbulence.

Distribution of static temperature and mass concentration of hydrogen on the jet axis, obtained by the calculation of the flow field under frozen, equilibrium and nonequilibrium composition conditions are shown in Fig. 1 and 2.

Chemical interaction most significantly effects the temperature and jet component composition. A significant increase of temperature is observed in the calculation of flow parameters in the equilibrium approximation. The maximum value of the temperature is achieved in the mixing area at the expense of afterburning of the combustion products with air oxygen. A slight increase in temperature near the axis of the jet at the expense of stagnation occurs for the frozen composition.

The values of all thermogasdynamic parameters, except for the mass concentration, for all the three considered thermodynamic states almost coincide at the initial part of the jet for $x / R_a < 25$ (R_a is the radius of the nozzle). Differences in the mass composition for the conditions of equilibrium flow are explained by fluctuations in temperature and pressure due to stagnation of the supersonic flow.

Considering the influence of afterburning in the air in the main part of jet leads to increasing in the temperature in the axis in the final section, compared with the frozen composition is about 1.25 times for the non-equilibrium composition and 1.9 times for the equilibrium composition.

The best agreement with the experimental data on the stagnation temperature was obtained in a non-equilibrium approximation, the equilibrium values of the stagnation temperature is considerably higher than the experimental values. It is worth noting that the value of the temperature and components concentration are largely determined by the used chemical kinetics model, which is used in the calculation of parameters in non-equilibrium approach.

On the main part of jet considering of the chemical interaction leads to a slight increase in velocity (in the equilibrium state it is greater than in the non-equilibrium) and reducing the number of Mach (due to an increasing of the sound velocity with increasing temperature), pressure does not differ for all three considered thermodynamic states practically.

Conclusions

As a result of the study of influence of the chemical interaction on the termogasdynamic parameters of turbulent supersonic nonisobaric chemically reacting combustion products jet is established that combustion products afterburning in the air oxygen leads to a significant increase temperature, noticeable increase of combustion products concentrations, a slight increase in velocity and a slight decrease in the number of Mach. Influence of chemical interaction in the jet pressure is practically absent. Influence of chemical interaction in equilibrium approximation leads to increasing thermal effects, in comparison with non-equilibrium approach. Influence of chemical interaction on the flow parameters in the jet leads to deceleration mixing of combustion products with the air. Mixing with the air in equilibrium approximation is less intensive than in the non-equilibrium approximation.

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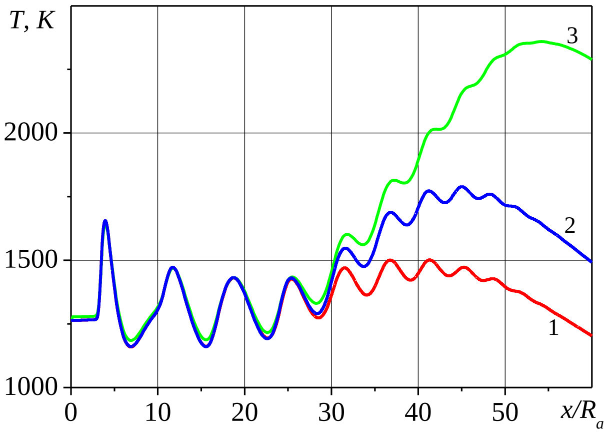

Fig. 1. Distribution of static temperature along the axis of combustion products jet: 1 – frozen mixture; 2 – nonequilibrium mixture; 3 – equilibrium mixture

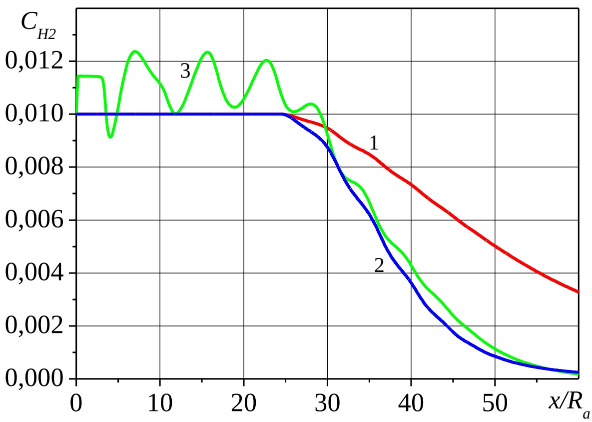

Fig. 2. Distribution of mass concentration of hydrogen along the axis of combustion products jet: 1 – frozen mixture; 2 – nonequilibrium mixture; 3 – equilibrium mixture

UDC 532.526

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Modeling of the Aerophysical characteristics of supersonic aerodynamic objects along the flight trajectory

The work presents the efficient methodoligy of calculating the friction and heat transfer of the aerodynamic object such as rocket/missile in the presence of a supersonic flow near the shell compressibility effects, non-isothermal, laminar-turbulent transition, and relaminarization in the solid fuel engine operating conditions.

In the present time, there are some methods of calculating of friction and heat transfer in supersonic flow near the shell, such as numerical methods based on the integration of differential Boundary layer equations and the Navier–Stokes equations, for example [1,2], the integral calculation methods [3,4], which are used to create different supersonic and hypersonic objects. When choosing the concept of such objects, the integral economical methods for calculating the friction and heat are heavily considered; and the compressibility of the flow, non-isothermal, pressure gradient, laminar-turbulent transition, relaminarization effect (reverse transition) in a turbulent flow near the shell in the conditions of running engines SRM and LRE are taken into account. One of such methods is presented in [5,6]. It was tested for flight conditions of the flow around warheads of the Aerophysical missile complexes such as the *"Cloud"* [5] and the *M-100* [6]. The data of the temperature of the warhead portion of the missile shell was obtained from the flight experiments. For the *"Cloud"*, for the Mach number $M_\infty \le 2{,}0$, the Reynolds number is $Re_{L,\infty} \le 2\cdot 10^7$, and the acceleration is a $\le$ 12g. For the *M-100*, for the Mach number $M_\infty \le 4{,}5$, the Reynolds number is $Re_{L,\infty} \le 2\cdot 10^8$, and the acceleration is a $\le$ 32g [7].

The calculated data of the temperature of the warhead portion of the shell was compered to the data obtained from the the flight experiments. For the Aerophysical complexes *"Cloud"*, the presence of time-laminar and transitional flow regimes was found, the effectiveness of the Emmons' spot theory in lamanarno-turbulent transition was confirmed, and the Reynolds number at the beginning of the transition was determined. For the Aerophysical complexes *M-100*, it was found that in one (1) second of the movement along the trajectory after the start, the turbulent boundary layer was formed, and then the relaminarization of the turbulent boundary layer was advancing (reverse transfer) [6].

The asymptotic theory of the turbulent boundary layer was also tested under the flight conditions using the flight experiments. Base on the test results, the theory was deemed to be valid for the arbitrarily large Reynolds numbers [3], and the Reynolds number for the beginning of the relaminarization was defined [6].

For calculation of the temperature of the missile shell in the laminar-turbulent transition zone for the intermittency factor γ in accordance with the Emmons' turbulent spot theory, for the Aerophysical complexes *"Cloud"*, the modified time ratio from [5] was utilized. In the time ratio provided in [5], the Reynolds number for beginning of the laminar-turbulent transition obtained from the flight experiments was used:

$$\boldsymbol{\gamma = 1,0 - \exp\left[-\frac{3,507}{A^2} \cdot Re_{tr}^{-1,34} \frac{U_e^2 \cdot \rho_e^2}{\mu_e^2} \times \left(\frac{\mu_{e,tr}}{U_{e,tr} \cdot \rho_{e,tr}}\right) \cdot \left(Re_{x,e}(\tau) - Re_{tr}\right)^2\right]} \tag{1}$$

where: $\mathbf{A = 60 + 4,68 \cdot M_e^{1,92}}$; $\mathbf{Re_{tr} = Re_{x,e}(\tau_{tr})}$; τ_{tr} – time corresponding to the beginning of the laminar-turbulent transition; tr - index refers to the parameters of the flow, fixed at the beginning of the transition to turbulent flow regime; $\mathbf{Re_{tr}}$ – Reynolds number at the beginning of the transition; τ– time of flight by trajectory.

The values of the Reynolds number for the transition to turbulent flow regime, measured in the supersonic wind tunnel, in sereval times differ from those obtained from the flight experiments [8], primarily due to the acoustic field that is present in the test section of the wind tunnel. The acoustic field stimulates the loss of stability of the laminar boundary layer and results to a more rapid transition to the turbulent regime.

Since the Biot number Bi ≤ 0,01, the differential equation for the thin wall of the missile shell was used for the calculation of the temperature of the warhead portion of the shell in the laminar and turbulent flow regimes for the Aerophysical complexes *"Cloud"* and *M-100*:

$$\boldsymbol{\rho_w \cdot c_w \cdot \delta_w \cdot \frac{dT_w}{d\tau} = \alpha \cdot \left(T_{r,e} - T_w\right) - \varepsilon_w \cdot \sigma_0 \cdot T_w^4} \tag{2}$$

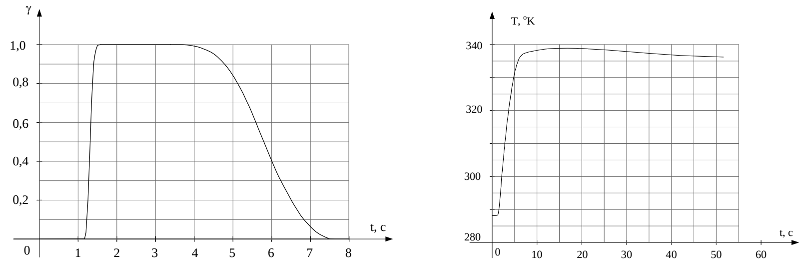
The differential equation for determining the temperature of the shell for the transient flow around the warhead of the *"Cloud"* is:

$$\boldsymbol{\rho_w \cdot c_w \cdot \delta_w \cdot \frac{dT_w}{d\tau} = [\alpha_{л} \cdot (1 - \gamma) + \alpha_{т} \cdot \gamma] \cdot \left(T_{r,e} - T_w\right) - \varepsilon_w \cdot \sigma_0 \cdot T_w^4} \tag{3}$$

In the equations (2) and (3) ρ – density (kg/м^3); $\boldsymbol{c_w}$ – the heat capacity of the material of the shell in [J/(kg·K)]; $\boldsymbol{T_w}$ – the temperature of the shell (°K); δ – the thickness of the shell wall (м); τ– time (sec.); $\mathbf{T_{r,e}}$ – the equilibrium temperature calculated for the outer edge of the boundary layer (°K); $\boldsymbol{\alpha_{л}}$ – heat transfer coefficient for the laminar flow; $\boldsymbol{\alpha_{т}}$ – heat transfer coefficient for the turbulent regime in [W/(м^2·K)]; $\boldsymbol{\varepsilon_w}$ – the emissivity of the surface of the shell; $\boldsymbol{\sigma_0}$ – the Stefan-Boltzmann constant; γ – coefficient in a transitional flow regime (intermittency factor).

The heat transfer coefficient $\boldsymbol{\alpha_{л}}$ in the equation (3) is determined by the relations for the laminar regime; $\boldsymbol{\alpha_{т}}$ is calculated by the asymptotic theory [3]; γ is etermined by the equation (1), which includes the Reynolds number at the beginning of the transition.

Equations (2), (3) were used for the calculation of the temperature of the shell of the missile *ОФ-21*, having the Mach number of the flow $M_\infty \leq 2,0$ and known trajectory data of the Reynolds number for the length of the warhead portion. Since the maximum Mach number for the *ОФ-21* and the *"Cloud"* are the same, the flight data of the Reynolds number at the beginning of the laminar-turbulent transition is in relation to the intermittency factor γ in the equation (2). The values of the Reynolds number for the trajectory of the *ОФ-21* indicate the presence of laminar-turbulent transition in the flow.



a) б)

Fig. 1. The results of calculations of the aerodynamic heating of the surface of the missile type *ОФ-21* depending on the time of flight in point 1 – X = 0,25 м; δ_w = 4 mm; material 1X18H9T: a) change of the intermittency factor along the flight trajectory at $\tau \leq 8$ s.; b) change the temperature of the missile shell along the flight trajectory.

The Figure 1,a shows the data for calculating the intermittency factor γ for the equation (1); the Figure 1.b shows the estimated temperature of the shell $\boldsymbol{T_w}$ for the missile *ОФ-21* taking into account the different flow regimes. From the Figure 1.a, the dependence of γ from the time τ during the fligt along the trajectory indicates that the laminar flow regime exists at $\tau \leq 1{,}2$; the transition mode is at $1{,}2 \leq \tau \leq 1{,}35$; a turbulent regime is at $1{,}35 \leq \tau \leq 4{,}0$; and the reverse transition to laminar flow regime is at $4{,}0 \leq \tau \leq 7{,}35$. Local friction coefficient was calculated using the formula:

$$\mathbf{c_f/2 = c_{f\text{л}}/2 \cdot (1-\boldsymbol{\gamma}) + c_{f\text{т}}/2 \cdot \boldsymbol{\gamma}}\ , \qquad (4)$$

where $\mathbf{c_{f\text{л}}/2}$ – local friction factor for the laminar regime, $\mathbf{c_{f\text{т}}/2}$ – local coefficient of friction for the turbulent regime [3].

Conclusion

Utilization of flight data for the beginning of laminar-turbulent transition for the Aerophysical complexes *"Cloud"* for Mach numbers $M_\infty \leq 2{,}0$ with the running engine, and the use of the proven theory of Kutateladze and Leontiev, with the consideration of the non-isothermal compressibility and flow, allowed on the example of the warhead of the missile *ОФ-21* to obtain reliable data on the intermittency factor, the temperature of the shell, and the local coefficient of resistance of the friction.

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Analysis of ventilation systems of aircraft electrical generators taking into account changes the aircraft flight parameters

Considered by the one of the possible approaches to the construction of digital control systems by autonomous electric power supply systems, taking into account the "technological" the unity of the processes of production, distribution and consumption of electrical energy and provides an effective solution to the complex tasks entrusted to the digital control system.

In most methods [I] of ventilation calculation aviation generators required air consumption is determined only losses and medium heating in an electric car. And the final result of the calculation is a calculation of the required pressure of the cooling air, which depends actually on the flight conditions of the aircraft.. Thus it is not take into account the particularities of location of the generator and the air intake on the plane [2,3]. Therefore, not counted changes in air parameters at the input into a generator, depending on height and speed of flight, and the calculation is performed only for one or two fixed heights.

However, research distribution pattern of air flows between separate ventilation channels are associated with more serious difficulties, which are due to the complexity of the changes for this measurement and do not allow, of course, explore the ventilation system with wide range of variation inlet air parameters, caused by changes of height, speed, density, and temperature partially of hindered of air flow at the inlet of the air intake, varying throughout the entire flight time. Analysis of the results of experimental research shows [3] that the ventilation circuit of the generator has areas with split and merge airflows. For machines with a relatively simple ventilation scheme by the presence of such areas can be neglected, and considered that air expense through the generator is determined by the sum of expenditure in the parallel channels. In modern electric generators, consisting of two or three cars in the same housing, well as having the built-in rectifier, and consequently the complicated ventilation circuit, such areas significantly affect the distribution of the total air flow between separate channels. This circumstance significantly affects the intensity of the cooling of the individual active surfaces of the electric machine and to neglect it, in our view, is inadmissible. The presence of such areas greatly complicates the calculation of due to the need transfiguration schemes of the compound aerodynamic resistance [2,3].

It is proposed that the task of analyzing of the generator ventilation system must include: the definition of the expense of air in separate channels, depending on the speed and flight altitude at constant parameters of the ventilation circuit; identification of "narrow" places the cooling system from the point of view of minimum air consumption [2,3].

The solution to this problem in the general form obtained by using known methods of matrix graph theory as applied to electrical circuits direct current linearized equation previously dynamic pressures of individual sections of substitution ventilation system scheme of the generator [2,3]. It was assumed that in the ventilation circuit electric current is similar to the consumption of air, and the voltage (EMF) is similar to the full air pressure. Moreover equivalent circuit of the generator ventilation system has a number of features which are considered in the calculation: depending on the design of the generator replacement scheme may be a number of contours and knots, which there is a splitting and merging flows; usually the number of nodes greater than the number of independent loops, that is the determining factor for selecting mesh analysis for solving the problem; the circuit has only one branch comprising a pressure source (EMF), which is a drop total pressure on the generator, the magnitude of this pressure is different from the total pressure values at the inlet of the generator, found from the flight conditions because the air of the generator output has a speed which is an unknown quantity; EMF should be refined by successive approximations on each linearization interval.

Equivalent circuit corresponds directed connected graph with conventionally branches selected positive directions the currents. The numbers correspond to the branches of the resistance equivalent circuit. Vertices of the graph correspond to nodes of the equivalent circuit [2,3].

Given this matrix equation of air consumption of on plots of the generator ventilation system takes the form:

$$[G_k] = [H_k] \cdot \left\{ [B_f] \cdot 2[G_{j\,k-1}\delta_{j\tau}]_1^{\mathrm{p}} \cdot [Z_j\delta_{j\tau}]_1^{P} \cdot [B_f]^T \right\}^{-1} [B_f],$$

where $[G_k] = [G_{1k} \ldots G_{jk} \ldots G_{pk}]$ − is the vector of total air flow (voltage) of the ventilation channels;

$[H_k]$ – the vector sum of pressures (EDS) the contours of the scheme, expressed through the matrix of aerodynamic resistances;

$[B_f]$ − matrix of basic circuits of a graph (matrix match):

$[B_f] = [B_{ij}]$, here i = 1,..., m is the number of the loop (line number);

j = 1,… p – the number of branches (number of columns). Here Bij = 1 if j-th branch includes the i-th contour, and the direction of traversal of a path coincides with the positive direction of the current j-th branches; Bij = -1 if the branch is included in the circuit, but the direction of the bypass current and the opposite; Bij = 0 if j-th branch is not included in the i-th circuit;

$Z_{j\,k-1} = 2Z_jG_{j\,k-1}$ – a linearized resistance, the value of which is determined by the value of consumption $G_{j\,k-1}$ at the end of the previous interval linearization;

G_{jk-1} – the air flow at the i-th phase of the ventilation system at the end of the previous interval linearization;

k − the index of the corresponding interval linearization of the ventilation characteristics of individual channels;

$\delta_{ij} = \begin{Bmatrix} 1, & j = \tau \\ 0, & i \neq \tau \end{Bmatrix}$ – the symbol of Kronecker;

p – the number of graph branches.

Ventilation calculation results allow to produce the heat calculation of the generator for all phases of flight and thereby have the information about a change in its temperature field a result of change flight conditions and load.

Thus, the above method of analysis of air ventilation schemes generators cooling systems (air-blowing of outboard) allows to solve the problem of the ventilating calculation various generators in the design phase, taking into account changes in altitude and speed of flight for a single algorithm using a digital computer. This makes it possible to identify the most narrow place of the ventilation system, and remove them, if possible, even at the design stage.

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Problems the universality of the computational schemes for the processes approximation

A uniform calculation scheme for approximation of arbitrary discrete sets initial data. This automation computing speeds and simplifies preparation of the desired results, including the results of operations differentiation and integration (*including re*).

Traditional methods [1], [2], a smooth approximation of a discrete set of dependencies, assume familiarity with various computing concepts. Wanted to understand the capabilities and limitations of different methods of calculation, have some experience with proven programs.

As a result, many researchers and graduate students to spend more time on the design of suitable schemes of calculations than the calculations themselves. Hence the need for improved circuits and calculations approximating the automation process, wherein the original digital data would be processed by a single algorithm.

A uniform computer system makes it possible to expand the range of types of methods developed by mathematicians for generations approximation processes and automate them. In the process of sketching software implementation of the declared computational scheme has been produced volume programmer work on the implementation of the universal library functions. To distinguish it from the documented, proven and well–known scientific communities libraries and software packages, is optionally acquaintance with numerous details the implementation of interpolation methods, least squares, calculations quadratures and derivatives on an arbitrary discrete set .

A smooth approach of a set of points $\{x_i, y_i\}$, ($i = 0, 1, \dots m$), derived from some measurements difficult or cumbersome experiments calculations made on the basis of traditional [1] [2] a linear combination of basis functions computed analytically $\varphi_j(x)$, (for example, members of the Power series or Chebyshev series, Fourier series, ...), multiplied by some coefficients C_j, ($j = 0, 1, \dots n$).

$$y(x) = C_0 \cdot \varphi_0(x) + C_1 \cdot \varphi_1(x) + \ldots + C_n \cdot \varphi_n(x) \qquad (1)$$

Substitution of discrete values $\{x_i, y_i\}$ in (1), leads to a system of linear equations with strings:

$y(x_i) = y_i$,

If for some points (x_i) are the measured values of the slopes of tangents y'_i and/or calculated values Y_i integrated areas on some intervals $[x_k, x_i]$, these equations can be supplemented by more rows:

$y'(x_i) = y'_i$ and/or $Y(x_k, x_i) = Y_i$.

Then each point x_i may correspond to three rows (equations) as shown in the following expanded matrix form on one of these points:

$$\begin{pmatrix} \vdots & \vdots & \vdots & \vdots \\ \varphi_0(x_i) & \varphi_1(x_i) & \cdots & \varphi_n(x_i) \\ \varphi_0'(x_i) & \varphi_1'(x_i) & \cdots & \varphi_n'(x_i) \\ \int_{x_k}^{x_i} \varphi_0(x_i)dx & \int_{x_k}^{x_i} \varphi_1(x_i)dx & \cdots & \int_{x_k}^{x_i} \varphi_n(x_i)dx \\ \vdots & \vdots & \vdots & \vdots \end{pmatrix} \cdot \begin{pmatrix} C_0 \\ C_1 \\ \vdots \\ C_n \end{pmatrix} = \begin{pmatrix} \vdots \\ y_i \\ y_i' \\ Y_i \\ \vdots \end{pmatrix} \qquad (2)$$

Or in matrix notation **P c = v**

Where **P** is square plan–matrix this system of linear equations
v is the values on the right side of system equations

Precise execution of linear equations (2) at the points x_i, it is a condition for the *interpolation* (with square matrices of size up $m \times m$ to $3 \cdot m \times 3 \cdot m$).·

Minimizing the square length of the error vector Δ**v** left and right sides of the system (2) leads to the *smoothing* approximation of a given system of points $\{x_i, y_i\}$ (for example, the method of least squares). If you use a well–known analytical approach, a necessary condition for the minimum vector Δ**v** is become zero of its gradient, i.e. all its partial derivatives with respect to the vector argument (in this case, the vector **c**). Having done the appropriate vector–matrix calculations [1], you can come to the following relationship:

$$\mathbf{P}^{\mathrm{T}}\mathbf{P}\,\mathbf{c} = \mathbf{P}^{\mathrm{T}}\mathbf{v}$$

The last condition, a system of linear equations, too as a result of the product of matrices is also a matrix (with $n \times n$ size).

System of linear equations derived from the conditions or smoothing interpolation approximation a given set of points $\{x_i, y_i\}$, processed under uniform algorithm. As shown in [4], [5], [6], [7] resulting system of equations leads to expansion of the uniform mean (3), the transfer of the right side of the column and adding the bottom line (4), which can also be analytically (algorithmically) differentiated or is integrated (since the operations of differentiation and integration a linear row of (4), it does not violate the linearity):

$$\left(\begin{array}{cccc:c} h_{00} & h_{01} & \cdots & h_{0k} & h_0 \\ h_{10} & h_{11} & \cdots & h_{1k} & h_1 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h_{k0} & h_{k1} & \cdots & h_{kk} & h_k \\ \hdashline h_0(x) & h_1(x) & \cdots & h_k(x) & 0 \end{array}\right) \cdot \begin{pmatrix} C_0 \\ C_1 \\ \vdots \\ C_n \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \vdots \\ 0 \\ 0 \end{pmatrix} \qquad (3)$$

Or in matrix notation **H c = 0**

$$C_0 \cdot \varphi_0(x) + C_1 \cdot \varphi_1(x) + \ldots + C_n \cdot \varphi_n(x) = 0 \qquad (4)$$

Then use a single algorithm for obtaining the results of such an algorithm derived from the conditions of existence of nonzero solutions of a homogeneous system with a square matrix **H**, that is, from the condition *det* **H** = 0.

After the LU–decomposition [3] of the matrix **H** (without the bottom row permutations), in its lower–right element accumulates sought result. Replacing the bottom line of the derivative / the integral from (4), you can get the results, except for the corresponding values of $y\,(x)$, differentiation $y'(x)$ or integration $Y(x_{-1},\, x)$, as well as their subsequent repetitions.

It is possible to get the results back in the form of these two species (instead of using the last cell block matrices):

– as a linear combination of basis functions $\varphi_j\,(x)$ taken:

$$C_0 \cdot \varphi_0(x) + C_1 \cdot \varphi_1(x) + \ldots + C_n \cdot \varphi_n(x)$$

– or a linear combination of the initial values y_i :

$$w_0(x) \cdot y_1 + w_1(x) \cdot y_2 + \ldots + w_m(x) \cdot y_m$$

While the original digital data will not change, re LU–decomposition of a homogeneous matrix **H,** to calculate results at other intermediate points (x) is not required.

Conclusions

The versatility of the above computation scheme provides the ability to easily and quickly get the results you want in the "push of a button – get the result," no restrictions on the location of the nodes, the choice of basis functions and the method of approximation (interpolation or the least squares method). Traditional computational methods [1], [2], a smooth approximation of one–dimensional discrete data, are only some of the special cases of the proposed scheme.

All the variety of the results determined by the capacities of the analytical (algorithmic) calculation basis functions $\varphi_j\,(x)$ and the operations of their analytical differentiation or integration.

You can continue to spread this approach to two–dimensional and multi–dimensional discrete set dependencies. If a dependent variable, such an approach allows you to use it and to calculate partial derivatives, and thus a multi-dimensional gradient of a scalar depending on what is important in optimization problems (gradient descent on a discrete set). If more than one dependent variable, then a calculating the partial derivatives can define the elements of the Jacobi–matrix of a multidimensional vector based.

Another area of application of such a calculation scheme can serve the task of improving and/or developing methods for constructing approximate solutions of the equations – functional, differential, integral. In traditional methods of solving equations is used mainly polynomial interpolation unit that restrict the variety of options calculation equations. It may be added that the proposed universalisation of computing can be used in mathematical packages.

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The Methods of Change Point Detection and Statistical Estimating of Dynamic of the Noise Stochastic Signals Characteristics

General vector model of the noise stochastic signals with piece-stationary and piece-periodic stochastic processes is presented. Using statistical estimation of the time change points of the indicated components on the well-known detection methods gives the opportunity to use powerful statistical analysis of the stationary and periodic stochastic processes.

Introduction. Stochastic processes are the mathematical model of the numerous informational signals. They are explored in the theory and practice of the technical system functioning in different industrial, scientific and technical fields. Noise stochastic processes are the subset of the general stochastic process set. Recently they take important place in the statistical exploration of the phenomena, processes and signals. Physical noise processes formed by numerous sources of the oscillations and waves of the different physical nature are accumulated and transmitted in time and space by noise signals.

These signals are stochastic but their statistical characteristics contain versatile information about explored object. Noise stochastic signals (NSS) show broad physical processes spectrum in the different objective fields. Recently they are actual objects of the exploration in the theoretical and applied directions. The increased quantify of the scientific publications confirms it.

NSS exploration is particularly actual and important for the mechanical, power and thermal engineering. The technical system parts of these branches (about 60-90%) have worked out their technical recourses. The results of the NSS characteristics measuring, diagnostics and forecasting formed in the functioning system could determine the further operating of the worked-out technical system.

Setting objectives. To approve the NSS mathematical model, make an analysis of the known NSS change point detection methods and determine a further statistical processing methodology of the explored NSS.

Exploration results. Based on the analysis of the NSS exploration results, including [1, 2], the general NSS mathematical model is represented by the next model – vector stochastic process:

$$\Xi_2(\boldsymbol{\omega},t)=(\xi_1(\omega_1,t),\xi_2(\omega_2,t))\ \ \boldsymbol{\omega}=(\omega_1,\omega_2),\quad t\in \mathrm{T} \tag{1}$$

Specific NSS models are described by the different component combinations $\xi_1(\omega_1,t)$ and $\xi_2(\omega_2,t)$, for example: additive or multiplicative combinations.

Focus on the model components description in details (1). In this model, $\xi_1(\omega_1, t)$ — is a noise stochastic process presented as a piece-stationary stochastic process wherein time intervals of each homogeneous components are determined by instant moments of the time decomposition, namely:

$$\xi_1(\omega_1, t) = \sum_{i=1}^{n} \eta_i(\omega_1, t) I(t, \Delta T_i) \qquad (2)$$

At the Eq.(2) there are: $\{\eta_i(\omega_1, t), i = \overline{1,n}\}$ — a sequence of the stationary stochastic processes, each of which has

$$\mathbf{M}\{\eta_i(\omega_1, t)\} = a_i, \quad \mathbf{D}\{\eta_i(\omega_1, t)\} = \sigma_i^2, \quad R_{ii}(\tau),$$

and $\{I(t, \Delta\mathrm{T}_i), \quad i = \overline{1,n}\}$ — sequence of indicator functions:

$$I(t, \Delta\mathrm{T}_i) = \begin{cases} 1; & t \in \Delta\mathrm{T}_i \\ 0; & t \notin \Delta\mathrm{T}_i \end{cases}, \qquad (3)$$

The following condition is right for functions (3):

$$\bigcup_{i=1}^{n} \Delta\mathrm{T}_i = \mathrm{T}, \quad \Delta\mathrm{T}_i \bigcap \Delta\mathrm{T}_j = \varnothing, \text{ if } \; i \neq j \qquad (4)$$

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$$[0, \Delta\mathrm{T}_1) + [\Delta\mathrm{T}_1, \Delta\mathrm{T}_2) + \ldots [\Delta\mathrm{T}_{n-1}, \Delta\mathrm{T}_n] = \mathrm{T}, \qquad (5)$$

where $\{\Delta\mathrm{T}_i, i = \overline{1,n}\}$ — the instant time change-points of process (2).

The second component of the model (1) $\xi_2(\omega_{2,} t)$ — piece-homogeneous periodic stochastic process, namely:

$$\xi_2(\omega_2, t) = \sum_{j=1}^{m} \zeta(\omega_2, t) I(t, \Delta\mathrm{T}_j) \qquad (6)$$

where $\{\zeta_j(\omega_2, t), \; j = \overline{1,m}\}$ — a sequence of homogeneous periodic stochastic processes and $\{I(t, \Delta\mathrm{T}_j), \; j = \overline{1,m}\}$ — sequence of indicator functions, for which conditions (3),(4),(5) are right.

Should be noted, that for purpose to justify a constructive model of noise stochastic process as a sequence $\{\zeta_j(\omega_2, t), \; j = \overline{1,m}\}$ — the set of the periodically correlated stochastic processes is used.

The alteration of NSS model from the piece-stationary stochastic process to piece-periodic stochastic process is accompanied by the change point. Detection of the last one probably includes information about technical system state and can be useful for the further processing of NSS (for example, useful for NSS segmentation to a signal pieces).

It is known [3, 4] that the problem of change point detection of NSS is widely used at the radiolocation and hydroacoustics. At those research areas it is a problem to find a signal on the noise background. Methods for solving such problems are based on the calculation of the test statistic – likelihood ratio (LR) and its comparison with the value of set threshold [3, 4]. LR is expressed by the signal and noise correlation and the spectral characteristics [3, 4].

Based on the common positions of NSS investigation and analyzing the well-known setting objectives and results of detection problems they should be attributed to the problems of change-point detection task. Therefore, discuss their analysis in details.

It is known, that the change-point detection methods of NSS are divided into: a consistent and posteriori. Thus, the consistent methods for change-point detection of NSS are based on the information obtained as a result of previous consecutive steps of applying detection algorithm. The main types of consistent method are [5]:

1) *exponential smoothing method* compares the smoothed deviation from the mean value of the NSS and bilateral threshold. Exceeding the last one indicates about the change-point detection.

2) *Girshik-Rubin-Shiryaev method* compares exponential value of the NSS with the threshold at each step.

3) *Cumulative sum method*, which calculates the so-called cumulative sums by increasing or decreasing the mathematical expectation at each step. The resulting cumulative sum is compared to a threshold.

4) *Brodsky-Darhovsky method* relates to methods with a memory wherein the signal values at previous M time points are used for the calculation of decision function at each step. The decision function is compared to a threshold.

Posteriori methods of indicating change-points are post factum. In this case the final data sample of observations is collected beforehand and therefore it is possible to use all the information about the NSS for more precise detection.

Optimal posteriori change-point detection methods are obtained using the maximum likelihood method [6], depending on the a priori information about the NSS.

Methods based on discrete wavelet transform are also posteriori methods which use the sum or maximum of squares of wavelet coefficients.

The posteriori change-point detection methods also include parametric methods based on the autoregressive moving average model, methods which use Mann - Whitney U-test, Brodsky-Darhovsky method and its modifications [1].

In practice the posteriori methods are adapted for tasks of the consecutive change-point detection by using a sliding time window with fixed or variable length [2].

Discuss briefly the further statistical estimation methods of the NSS characteristics that based on the obtained sequences of evaluated results $\{\Delta T_i, i=\overline{1,n}\}$ and $\{\Delta T_j, j=\overline{1,m}\}$ — an instant time change-points of model components (1).

Obviously, the obtained results of the statistical estimation of the change points make possible to use well-known statistical evaluation methods of stationary and periodic component characteristics of NSS. For example, there are many articles and publications about the stationary stochastic process [7, 8] and the periodic stochastic process [9].

Based on the above written information the following results are concluded.

Conclusions.

The general mathematical model of the noise stochastic process is approved as a vector stochastic process. The components of this model represent the effects of two main formatting factor sets – the impulse and periodic of the NSS. Different component combinations of the suggested model give the opportunity to describe the broad NSS set in practice. Using the well-known instant time change point statistical estimating methods and getting the results of their usage determines the further NSS exploring characteristics. The statistical evaluation methods of the stationary and periodic stochastic processes are used at this statistical NSS characteristic estimating phase**.**

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Methods of spherical data modeling overview

The paper presents the basic features of spherical data: application area, visualization techniques, coordinate system types, the main distributions, methods of simulation. The results of the random vectors modeling are given in polar coordinates.

Introduction

The measuring data can be represented in several forms: linear, circular, and spherical. Thus, the directional data analysis is the important scientific and technical part of the measurement theory. The spherical observation results, or data samples in the form of directions in space, is applicable for such fields as: navigation, astronomy, geodesy, cartography, geology, geophysics, meteorology, physical oceanography, mathematics, crystallography, animal physiology, bioinformatics, text analytics, etc. The examples of the vectorial data processing potential tasks are: risk management, the determination of the density of wind direction, hotline phone calls, earth temperatures, or earthquakes, etc.

Random vectorial data modeling is the important stage of data origination for random vectors statistical experiment. The simulation of the samples on the sphere of unit radius can be useful for evaluating a new statistical procedure, assessing the variability of an estimate from data [1-6].

Spherical data representation

Let ψ to be the arbitrary vector with a direction to (α, β). The spherical observation results used to be described as a collection of points $P_1, \ldots, P_n$, $n = 1, 2, \ldots, N$ on the surface of the unit-radius sphere centered at the origin O of the three-dimensional coordinates x, y and z, where P_i can be identified with a unit vector $\overrightarrow{OP}$. P_i is corresponding to $\overrightarrow{OP}$ by polar coordinates (θ_i, φ_i) and the direction cosines [1]:

$$\begin{aligned} x_i &= \sin\theta_i \cdot \cos\varphi_i, \\ y_i &= \sin\theta_i \cdot \sin\varphi_i, \\ z_i &= \cos\varphi_i, \end{aligned} \qquad (1)$$

where $i = 1, \ldots, n$; $0 \le \theta \le \pi$, $0 \le \varphi < 2\pi$.

The spherical coordinates definition depends on coordinate system and summarized in the Table 1.

Depending on the task purpose and the scope of application spherical data visualization techniques can be divided into: polar or equatorial projections (Wulff, or “stereographic”, projection; Lambert, or Schmidt, projection; orthographic projection; gnomonic or central projection), sunflower plots, density contour and shade plots, directional/spatial plots.

Table 1

Spherical coordinate systems

Spherical coordinate system	Angles definition
1. Polar coordinates	Colatitude, longitude
2. Geographical coordinates	Latitude, longitude
3. Geological coordinates	Strike azimuth, dip azimuth
4. Astronomical coordinates:	
4.1 The horizon system	Azimuth, altitude (elevation angle)
4.2 The equatorial system	Declination, right ascension
4.3 The ecliptic system	Celestial longitude, celestial latitude
4.4 The galactic system	Galactic longitude, galactic latitude
4.5 The super-galactic system	

The major spherical distributions include: the point distribution, the uniform distribution on sphere, the Fisher distribution, the Watson distribution, the Kent distribution, the Wood distribution, the Bingham distribution, the Arnold distribution, the Selby distribution, the Kelker-Langenberg distribution, the General Fisher-Bingham distribution, the Fisher-Watson distribution, the Bingham-Mardia distribution, the Saw distribution, the Mardia-Gadsden distribution.

Methods of spherical data modeling

It is possible to formulate the following ways for unite vectors modeling:

1. Using the routine technique for samples of θ and φ pseudo-random variates modeling described in [1]. This way is the most suitable, but only in case if the technique for specified distribution is available.

2. Using the marginal probability density functions $f(\theta)$ and $f(\varphi)$ of each polar coordinate, θ and φ, with the next inverse function method application.

The method of spherical data modeling by usage of the marginal probability density functions of polar coordinates includes the following steps:

1) obtaining the cumulative function of the $f(\theta)$;

2) application of the inverse function method [2] to the cumulative function for modeling the sample of θ-coordinates $\theta_1, \ldots, \theta_n$, $n = 1, 2, \ldots, N$, $0 \leq \theta \leq \pi$;

3) execution of steps 1-2 for modeling the sample of φ-coordinates $\varphi_1, \ldots, \varphi_n$, $n = 1, 2, \ldots, N$, $0 \leq \varphi < 2\pi$ [1-4];

4) rotation of the set of modeled coordinates (θ_i, φ_i) directed in (0, 0) to the specified direction (θ, φ) with a rotation matrix given in [1].

The imperfection of the method is in the particularity of the marginal functions definitions.

3. Using the probability density function $f(\theta, \varphi)$ of the arbitrary vector $\psi(\alpha, \beta)$. The approach provides modeling unite vectors samples by given probability and its parameters, such as location and shape parameters. The disadvantage of the approach is in lack of methodical and engineering-software assurance. The issue of spherical data modeling directly by its probability density function is perspective for future scientific-engineering researches.

Modeling results

Based on the method of spherical data modeling by usage of the marginal probability density functions of polar coordinates the samples of points on the unit sphere are modeled for the Fisher (Figure 1) and the Watson (Figure 2) distributions in the MatLab software.

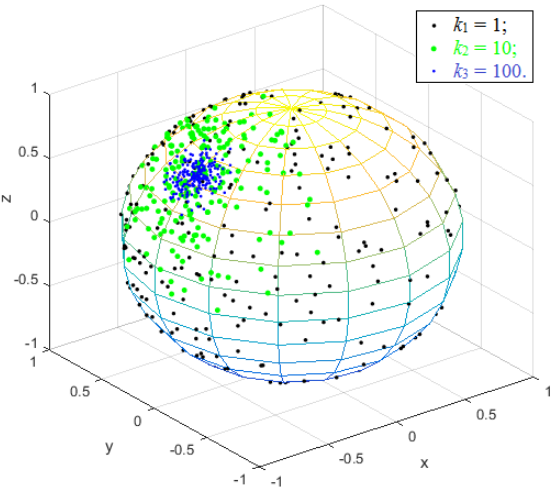

Figure 1 – Points sampled from three Fisher distributions on the sphere

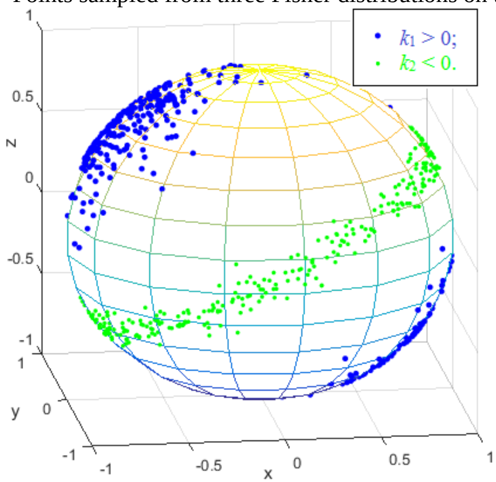

Figure 2 – Points sampled from two Watson distributions on the sphere

The probability density function of the Fisher distribution is [1]:

$$f(\theta,\varphi) = C_F e^{k(\sin\theta\sin\alpha\cos(\varphi-\beta)+\cos\theta\cos\alpha)}\sin\theta\,,\ 0 \le \theta \le \pi,\ 0 \le \varphi < 2\pi, \qquad (2)$$

where α and β are location parameters, the distribution having rotational symmetry about the direction (α, β); $k \geq 0$ – a shape parameter called the concentration parameter, since the large value of k the more the distribution concentrated towards the direction (α, β), when $k = 0$ the distribution is uniform on the sphere; C_F – the normalization constant: $C_F(k) = \dfrac{k}{4\pi \sinh k} = \dfrac{k}{2\pi(e^k - e^{-k})}$.

The probability density function of the Watson distribution is [1]:

$$f(\theta,\varphi) = C_W e^{k(\sin\theta \sin\alpha \cos(\varphi-\beta) - \cos\theta \cos\alpha)^2} \sin\theta,\ 0 \leq \theta \leq \pi,\ 0 \leq \varphi < 2\pi. \quad (3)$$

The distribution has a rotational symmetry about the direction (α, β); the normalization constant is $C_W(k) = \left(4\pi \int_0^1 e^{ku^2} du\right)^{-1}$. When the concentration parameter $k > 0$, the distribution is bipolar, when $k < 0$ – girdle or equatorial. The large value of |k| the more the distribution is concentrated in the bipolar case round the poles (α, β) and (π - α, β ± π), the more it is concentrated in the girdle case round the great circle in the plane normal to (α, β).

Conclusions

1. The basic features and the methods of simulation of spherical data are described.
2. The results of spherical data modeling from the Fisher and the Watsons distributions are presented on the unit sphere.
3. The perspectivity of the spherical data modeling method development by the probability density function of the arbitrary vector application is justified.

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Investigation of estimation of the mixed second-order moment in bilinear unbiased estimates class

The best estimate (with minimum variance) of the mixed second-order moment in a class of bilinear unbiased estimates is proposed.

The solution of problems related to the reliability of products and choice of optimal technological options for the production is a very important issue in modern terms. It is connected with both a permanent complication of the manufacturing technology and the need improving the economic performance of production. To solve technological problems the probabilistic and statistical methods are used. The application of these techniques allows for the statistical analysis of accumulated data with the aim of generalization of the information in formulas. One of the main tasks that arise is the definition of distribution law of random variables and corresponding numerical characteristics on experimental data.

The main characteristics of random variables include the expectation, variance, covariance.

Let $K(x,y)=m[x-m(x)][y-m(y)]$ be the covariance of random variables x,y where $m(x)$ and $m(y)$ are expectations of x and y correspondingly. Covariance is known to be one of the most important characteristics of measure of random variables dependence.

The covariance is equal to zero for independent random variables. But the inverse statement is not correct because there are examples of dependent random variables with zero covariance [1]. But for many random variables *x, y* having the given common distribution $F(u,v)=p(x<u,y<v)$ which belongs to a certain class (for instance to the class of compatible normal distributions) of independent random variables the following equality is hold $K(x,y)=0$ [2]. That is why in practice statistical analysis of the results of empirical observations the small covariance is considered a sign of low dependence of variables *x* and *y*.

Let x, y be the pair of random variables and $K(x,y)=m[x-m(x)][y-m(y)]$ is covariance. Let us transform

$$K(x,y)=m(xy-xm(y)-m(x)y+m(x)m(y))=m(xy)-m(x)m(y)-m(x)m(y)+$$
$$+m(x)m(y)=m(xy)-m(x)m(y).$$

It follows that for the evaluation of covariance $K(x,y)$ it's necessary to assess the mixed second-order moment $\gamma=m(xy)$ and expectations $\alpha=m(x),\beta=m(y)$.

Let $(x_1, y_1),..., (x_n y_n)$ be the set of pairs of sample values obtained from the general population using simple random selection. It means that all random values (x_i, y_i) have compatible and two-dimensional distribution $F(u,v)$ and these pairs are independent each other. Hence for any two Borel's sets M_1, M_2 in the plane
$p((x_i, y_i) \in M_1, (x_k, y_k) \in M_2) = p((x_i, y_i) \in M_1) \cdot p((x_k, y_k) \in M_2)$
if $i \neq k$ [3].

We consider the class of linear unbiased estimates of the mixed second-order moment $\gamma = m(xy)$

$$T = \left\{ \begin{array}{l} u = \sum_{i,k=1}^{n} a_{ik} x_i y_k = (Ax, y), A = \|a_{ik}\|_{i,k=\overline{1,n}}, x = (x_1,..., x_n), y = (y_1,..., y_n), \\ m(u) = \gamma \end{array} \right\}.$$

From the condition of unbiasedness of assessment $m(u) = m(xy)$ it follows

$$m(u) = m\left(\sum_{i,k=1}^{n} a_{ik} x_i y_k\right) = m\left(\sum_{\substack{i \neq k \\ i,k=1}}^{n} a_{ik} x_i y_k + \sum_{i=1}^{n} a_{ii} x_i y_i\right) = m(x)m(y)\sum_{\substack{i \neq k \\ i,k=1}}^{n} a_{ik} +$$

$$+ m(xy)\sum_{i=1}^{n} a_{ii} = \alpha\beta \sum_{\substack{i \neq k \\ i,k=1}}^{n} a_{ik} + m(xy)\sum_{i=1}^{n} a_{ii} = m(xy).$$

Because this equality should be carried out with arbitrary $m(xy)$ then

$$\sum_{\substack{i,k=1 \\ i \neq k}}^{n} a_{ik} = 0, \qquad \sum_{i=1}^{n} a_{ii} = 1.$$

Thus, the class of bilinear unbiased estimates of the mixed second-order moment has the following view

$$T = \left\{ u = \sum_{i,k=1}^{n} a_{ik} x_i y_k = (Ax, y), A = \|a_{ik}\|, x = (x_1,..., x_n), y = (y_1,..., y_n), \right.$$

$$\left.\sum_{\substack{i,k=1\\ i\neq k}}^{n} a_{ik} = 0, \sum_{i=1}^{n} a_{ii} = 1 \right\}.$$

Let $(x_1, y_n),\ldots,(x_1, y_n)$ be a set of pairs of sample values obtained from the general population using simple random the distribution of which has the final mixed moment of the fourth order. We consider the estimation

$$\bar{\gamma} = \frac{1}{n}\sum_{i=1}^{n} x_i y_i \quad .$$

This estimation $\bar{\gamma}$ belongs to the class T. Really, $\bar{\gamma}$ is the estimation of the view $u = \sum_{i,k=1}^{n} a_{ik} x_i y_k$ with coefficients $a_{ii} = \frac{1}{n}, \forall i = \overline{1,n}$, $a_{ik} = 0,\ \ i \neq k$ satisfying unbiasedness:

$$\sum_{\substack{i,k=1\\ i\neq k}}^{n} a_{ik} = 0\ ,\ \sum_{i=1}^{n} a_{ii} = \sum_{i=1}^{n} \frac{1}{n} = 1\ .$$

Namely $\bar{\gamma} \in T$. Now prove that $D(\bar{\gamma}) \leq D(u), \forall u \in T$. According to unbiasedness condition $\forall u \in T$: $D(u) = m(u^2) - m^2(u) = m(u^2) - \gamma^2$. A minimum $D(u)$ reaches where the function $m(u^2)$ acquires the smallest value.

If the value $m(u^2)$ is found and the unbiasedness conditions $a_{nn} = 1 - \sum_{i=1}^{n-1} a_{ii}$, $\quad a_{nn-1} = -\sum_{\substack{i\neq k\\ (i,k)\neq(n,n-1)}}^{n} a_{ik}$ are taken into account then the problem of searching of a conditional extremum will be reduced to the problem of absolute extremum research.

As a result of transformations we obtain a positive quadratic function with respect to variables a_{ik} which reaches a minimum at the point where the partial derivatives are equal to zero.

Finding the partial derivatives and substituting coefficients $a_{ik}^{*}=0,\ \ i\neq k;\quad a_{ii}^{*}=\frac{1}{n}$ (from the estimation $\bar{\gamma}=\frac{1}{n}\sum_{k=1}^{n}x_k y_k$), we see in the conditions.

Conclusions

The estimation $\bar{\gamma}=\frac{1}{n}\sum_{k=1}^{n}x_k y_k$ is the best (another words it has minimum variance) in class T of unbiased bilinear estimates of the mixed second-order moment.

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Motivic models and applications

We investigate motivic models and motivic approaches to algebraic varieties and to zeta functions of algebraic varieties over fields and indicate applications of the models to coding theory and to cryptography. A framework and elements of crystalline realization is very shortly presented.

Introduction. Motives for smooth projective algebraic varieties was introduced by A. Grothendieck and elements of the theory of motives have developed by A. Grothendieck, P. Deligne, J. Tate, Yu. Manin, S. Bloch, Y. Ihara, M. Levine, C. Soule, J. Milne, Ye. Nisnevich, A. Goncharov, V. Voevodsky, F. Broun and others. We rely on the works of above mentioned authors as well as on works by A.I. Mal'tsev and G. Belyi. Motivic models have many aspects. These include models of curves, models of more general algebraic varieties and schemes, Grothendieck groups, categories of realizations, motivic fundamental groups, comparison isomorphisms, motivic integration, p-adic multiple zeta value and values of the p-adic multiple polylogarithms at roots of unity. Motives connect with coding theory and cryptography by motivic integration, motivic zeta and L-functions of algebraic varieties over finite fields.

Short history and connections among Galois groups, fundamental groups, motives and arithmetic functions are presented in the talk by Ihara [1]. For number fields the category of realizations has defined and investigated by Deligne [2]. Results on multiple zeta values, Galois groups, geometry of modular varieties and motives has presented by Goncharov [3]. Interesting unipotent motivic fundamental group is defined and investigated by Deligne and Goncharov [4]. Tannakian interpretation of p-adic multiple zeta values is given by Furusho [5]. Unver, continues his investigation of p-adic multiple zeta values, presenting a computation of values of the p-adic multiple polylogarithms at roots of unity [6]. The main result of the paper [6] (Theorem 6.4.3 with Propositions 6.4.1 and 6.3.1) is to give explicit expression for the cyclotomic p-adic multi-zeta values $\zeta_p(s_1, s_2; i_1, i_2)$ of depth two.

Here we present very shortly a framework and results to crystalline realization.

Models of curves and models of schemes. There are many approaches to models of curves and models of schemes. Here we very shortly consider wild models of curves by D. Lorenzini [7] and models of schemes [8-10,15].

The wild models of curves are regular models of the smooth proper geometrically connected curves X/K of genus $g > 0$ over quasi-local field (complete discrete valuation field K with ring of integer O_K and algebraically closed residue field k of characteristic $p > 0$) obtained by desingularizing of wild quotient singularities of the smooth models of $X_L/L, [L:K] = p$.

Lorenzini supposes that X/K does not have good reduction and that it obtains good reduction over a Galois extension L/K. Let Y/O_L be the smooth model of X_L/L.

Let $H := Gal(L/K)$, and let Z/O_K denote the quotient Y/H with singular points $Q_1, \cdots, Q_d$ and $d \geq 1$. Let X/O_K be a regular model of X/K. The regular model can be obtained by resolving the singularities of the scheme Z. Let $X/k := \sum_{i=1}^{v} r_i C_i$ denote the special fibre of X.

The main theorem of the paper ([7], theorem 6.8) says that if all ramification points of $Y_k \to Y_k/\langle\sigma\rangle$ are weakly ramified, then, for all $i = 1, \cdots, d$ we have $r_i = p$, and the graph G_Q of the desingularization of Q_i is a graph with a single node C_i of degree 3. The intersection matrix $N(p, \alpha_i, r_1(i)$ of the resolution of Q_i is uniquely determined by the two integers α_i and $r_1(i)$ with \$$1 \leq r_1(i) < p$. The integer $r_1(i)$ is number of vertices of self-intersection -2 (including the node C_i) on the chain of G_{Q_i} connecting the node C_0 to the single node C_i of G_{Q_i}, and this integer α_i is divisible by p.

The proof of the theorem is based on Lorenzini's results on arithmetical graphs (Theorem 6.4 and Proposition 4.3 of the paper [7]) and on computations and properties of Smith group of the intersection matrix by the Lorenzini.

Models of schemes have investigated in paper by P. Deligne [8] and models of unipotent group schemes have introduced and studied in papers by Dolgachev, Weisfeiler [9], by Bogomolov [10]. A group scheme is finite of order m over an affine scheme S if it is locally free of rank m over S. Let H_K be a group scheme over K. Any flat $\mathcal{O}_K$-group scheme G such that $G_K \approx H_K$ is called a model of H_K.

Categories of realizations and cohomology. There are several cohomological theories of algebraic varieties: topological (Betti), de Rham, etale, crystalline. These cohomology define realizations and among them there are comparison isomorphisms. Here we present framework and results about crystalline realization. At first consider Witt rings. Here we follow to the paper [11] of Ramachandran. For any commutative ring A with identity denote the big Witt ring with addition and with the multiplication $*$ by $W(A)$. For any natural n there are a Frobenius ring homomorphsm $F_n\colon W(A) \to W(A)$ and an additive Verschiebung ring homomorphism $V_n\colon W(A) \to W(A)$.

Let k be a field. By GK_k the author of the paper [11] denotes the Grothendieck ring $K_0(Var_k)$ of schemes of finite type over k.

The author proves the following. Theorem 2.1 [11]. Here we indicate first 3 parts of the theorem,

Let X and Y be schemes of finite type over $\mathbb{F}_q$.

(i) The zeta function of the product $X \times Y$ is the Witt product of the zeta functions of X and Y. In particular, $Z(X^n, t) = Z(X,t) * \cdots * Z(X,t)$.

(ii) The map $\kappa\colon GK_{\mathbb{F}_q} \to W(\mathbb{Z})$ is a ring homomorphism. Hence X \mapsto Z(X,t)\$ is a motivic measure.

(iii) If $X \to B$ is a (Zariski locally trivial) fiber bundle with fibre F, namely, there is a covering of B by Zariski opens U with $X \times_B U$ isomorphic to $U \times_{Spec\, \mathbb{F}_q} F$, then $Z(X,t) = Z(B,t) * Z(F,t)$.

Frobenius structures on connections. Let $\mathbb{Q}_q$ denote the unique unramified extension of degree n of the field of p-adic numbers. Let U be an open dense subscheme of the projective space $\mathbb{P}^1(\mathbb{Q}_q)$ with nonempty complement Z. Let V be the rigid analytic subspace of $\mathbb{P}^1(\mathbb{Q}_q)$ which is the complement of the union of the open disks of radius 1 around the points of Z. A Frobenius structure on $\mathcal{E}$ with respect to σ is an isomorphism $\mathcal{F}: \sigma^*\mathcal{E} \cong \mathcal{E}$ of vector bundles with connection defined on some strict neighborhood of V. A meromorphic connection on $\mathbb{P}^1$ over a p-adic field admits a Frobenius structure defined over a suitable rigid analytic subspace [12,16]. Authors of the paper [12] give an effective convergence bound for this Frobenius structure by studying the effect of changing the Frobenius lift. They also give an example indicating that their bound is optimal.

Motivic integral of surfaces over a non-archimedean field. Here we consider very shortly motivic integration of surfaces over a non-archimedean field on the example of $K3$ surfaces [13]. Authors of the paper [13] prove a formula expressing the motivic integral (a canonical element by Loeser and Sebag [14] of the localization of the Grothendieck ring of algebraic varieties over perfect residue field obtained by inverting the class of the affine line) of a $K3$ surface over $\mathbb{C}((t))$ with semi-stable reduction in terms of the associated limit mixed Hodge structure. Secondary, for every smooth variety over a complete discrete valuation field the authors of the paper [13] define an analogue of the monodromy pairing, constructed by Grothendieck in the case of abelian varieties, and prove that their monodromy pairing is a birational invariant of the variety. Finally, they propose a conjectural formula for the motivic integral of maximally degenerate $K3$ surfaces over an arbitrary complete discrete valuation field and prove this conjecture for Kummer $K3$ surfaces.

Conclusion

We gave a short review and present some new results in the field of motivic models with the aim of their possible applications to some related problems of coding theory and criptography.

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Realization approaches of hardware and software complex for braille font reading

In this article the hardware and software complex for Braille font is observed. This complex consists of tactile display for six-dot symbol output and specialized software. In this work, analysis of development and implementation of systems for visually impaired reading in Braille education took place and market of existing devices with common functionality was reviewed. As a result, hardware and software complex was developed, tested, and had its functional modules, operational principles of hardware and software elements documented.

Introduction

According to statistics, in Ukraine live about 70 thousand blind people. In the absence of sight, blind people have to rely on other sources of information such as audio and tactile sensations. So read one of the most common fonts for reading are tactile Braille.

In Ukraine, no more than 10% of visually disabled people know Braille, and this problem resembles a vicious circle where there is no need to print books in Braille font because this type has a small number of readers, but due to lack of variety of books in Braille greater number of readers can't emerge.

The problem of lack of knowledge of Braille and difficulty in mastering it exacerbates other problems: Features of adaptation, personal development of blind and visually impaired people [1, 2, 5]. The majority of specially qualified Braille tutors noted the need for computer technology in the professional training of blind people during the learning process [3, 6, 7].

Today there is a transition from reading in Braille to the audio information. But relief-type tactile font has several advantages over voice communications, as one of the additional tasks that can be realized through the creation of simple to use and inexpensive hardware and software training complex - is to popularize reading Braille. In addition, today we may observe the lack of free speech synthesizers for Ukrainian language, their limited functionality and quality [4], which makes it impossible to synthesize text in Ukrainian.

The purpose and objectives of research

The aim of study is an analysis of practical approaches to implementing hardware and software for learning Braille.

The object of research is the study of possible hardware and software solutions for learning Braille training center.

In order to achieve this goal next tasks need to be resolved:

1. Investigate the existing hardware and software solutions for teaching blind and visually impaired Braille.

2. Improve existing solutions and build our own concept of hardware-software complex for learning Braille.

Analysis of world trends in the development of hardware and software systems for working with Braille

With the advent of modern speech synthesis devices, Braille partially lost popularity. The reasons for rejection of Braille in favor of audiobooks are as follows: the complexity of training aids and their cost, lack of open source software. Braille displays reached worldwide distribution that allow to form Braille characters as output and input, but their use is limited by their price (from 1,000 to 5,000 euros), with no separate class of devices for learning.

Since Braille display - commercial products, the company's developers provide full support and free software to work with their device, but given the fact that the software is developed for a particular series of devices, it is almost always proprietary code. Therefore, the development of new Braille display software must be written almost "from scratch". In addition, there are no training programs for displays, which could incrementally learn to read Braille, and existing courses focused on the use of non-electronic panels with letters (wood or plastic). After training at a specially enlarged letters begins training at normal size letters. Only after mastering the font at a sufficient level user can move to reading with Braille display.

Description of hardware training center development approaches

The general principle of the training center is represented in the diagram on Fig. 1.

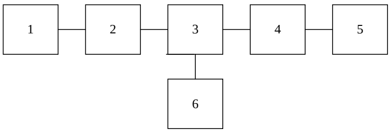


Fig. 1 - Schematic representation of hardware and software training center

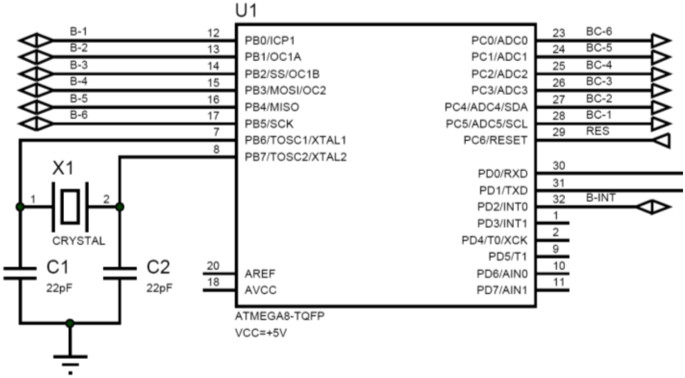
The data sent to the device via USB protocol (block 1). If the control unit (block 3) does not have built-in implementation of interface USB, but only the implementation of the interface UART, in this case, to convert signals must use the appropriate converter (block 2). The data received by the controller are processed by a computer algorithm. After the data controller transmits signals to the display driver (block 4). A driver determines the display state of the display in accordance with the received signals. Tactile display (block 5) is an electromechanical device for displaying information. Control is possible using electromechanical elements of the user interface (block 6).

Based on submitted test approaches was developed several test devices, such as with and without a separate control unit (Fig. 2).

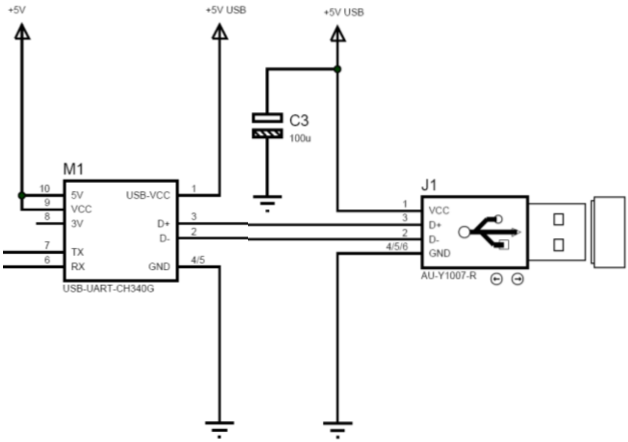
a b

Fig. 2 - Sample implementation of one segment of the Braille display: a - with a separate control unit, b - with built-in power management

The hardware part can be represented by the following design scheme (Fig. 3).



a



b

Fig. 3 - The design scheme of hardware training center: a - control unit b– signal converter USB-UART and USB interface connector

Description of the developed software

In software development we relied on past experience in developing systems to work with texts in which most of the features was put on automatic mode [8, 9].

The developed software has the following functions:

1) opens text files, adds a auxiliary characters. In Braille font there is no division between large and small letters, and before each number special character must be included;

2) allows to use virtually any font. After recording a file alphabet characters and service symbols in a special way user may read in the selected alphabet;

3) forms the package of Braille symbols for transmission to device. In addition to character codes converted according to the alphabet characters passed in a package that can vary, depending on the length of the line in the display;

4) displays the computer's current letters as usual in flat font form, and as braille dots;

5) features automatic scroll to automatically move to the next character, with a specified frequency;

6) receives feedback from the device to implement controls.

The program interface is shown in Fig. 4.

A more detailed description of the software represented in obtained certificate of authorship for software [10].

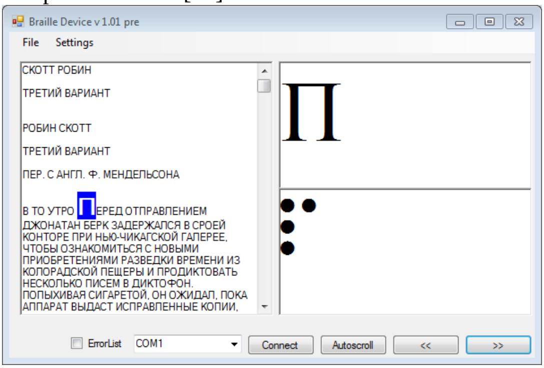


Fig. 4 - Interface software hardware and software training center

Conclusions

Based on the analysis of existing approaches to the creation of e-learning systems for the blind no developments for education of disabled children was found. The world's standard for learning Braille display with 40 or 80 characters per line. All other projects remained at the stage of describing ideas or conceptual schemes - these include sensory and advertised smartphones and tablets with Braille font. A study of electronic devices for educational purposes are not considered even as a concept.

Upon receipt of the first version of the device and its testing by people with sight disabilities were identified major shortcomings of the model that are concerned more to ergonomic than the hardware implementation. The main shortcomings were attributed, narrow space to place hands on displays, a separate box for the location of the control unit, no additional control keys, and more. That is why the new model is out of the four control keys, located equally comfortable for left and right hands.

The practical significance of the research is detailed description of the implementation of hardware and software system that simplifies the transition to industrial training systems for visually impaired people. Results of the study can be used for the production of educational electronic devices not only for the visually impaired, but also for teachers for visually impaired as a means to simplify and accelerate the development of Braille is not only visually impaired, as well as students - future teachers for visually impaired.

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The Lattice Boltzmann method with temperature-dependent transfer coefficients

A new approach to the application of the Lattice Boltzmann equations method of computational modeling is proposed, based on taking into account the collective particles motion by introduction of the two additional stages of calculation. The temperature dependency of the transfer coefficients is considered in detail.

Due to the rapid growth of accessible computing possibilities and large demand in many engineering, biomedical and other applications, computational hydrodynamics develops actively. Currently, the development of mathematical methods of computational hydrodynamics with the aim to extend its possibility and promote efficiency of calculation, is very actual problem. One of methods of the modern computational hydrodynamics is the Lattice Boltzmann equations method (LBM), based on consideration of liquid or gas environment as an aggregate of microscopic particles. The LBM is considered as a promising tool for modeling the Navier-Stokes equations and simulating complex fluid flows. The LBM's advantages are excellent convergence of solutions and easiness of adaptation of the corresponding equations of the model to the spatial structures of arbitrary geometrical forms.

The Lattice Boltzmann equations method is based on formulation of the correlations which describe the kinetic aspect of motion of particles of environment which is divided into microscopic cells. For the account of macroscopic motion of the environment, the Bhatnagar-Gross-Krook approximation is traditionally used [1]. The obtained discrete correlations are used in the iteration process, which includes the two main steps of calculation, repeated in turn: the transfer (motion) step, where the velocity distribution of particles is calculated, and the relaxation (exchange) step which describes their interaction [2]. In both cases, the eventual result of calculation includes the values of velocities and pressure of environment in discrete points in space and time. In the works [3, 4] there proposed the modification of the Lattice Boltzmann equations method for the use in areas with irregular meshes and curvilinear bounds, that allows application of the method for calculations in the areas of arbitrary geometry.

In the classic approach to the construction of model according to the Lattice Boltzmann equations method on a square mesh, the transfer step is described with the assumption that the transfer coefficients have constant values [5]:

1) the coefficient which represents relative number of particles which remained in this cell:

$$k_z = 4/9 \; ; \qquad (1)$$

2) the coefficient of direct transfer that relates to the cell which has a common border segment with an initial cell:

$$k_p = 1/9 \; ; \qquad (2)$$

3) the coefficient of diagonal transfer that relates to the cell which has a common angular point with the cell in consideration:

$$k_k = 1/36 . \qquad (3)$$

On the basis of this distribution for the settled state the «displaced» distribution is calculated. In this displaced distribution the motion of environment is taken into account by means of change of the aforementioned coefficients.

There is a known kinetic determination of temperature as the measure of mean kinetic energy of motion of molecules, based of the Maxwell distribution [6]:

$$\langle e \rangle = \left\langle \frac{mv^2}{2} \right\rangle = \frac{3}{2} kT \qquad (4)$$

where $\langle e \rangle$ is a mean energy of a molecule, m is the mass of a molecule, v is the velocity of a molecule; $k = 1.38 \cdot 10^{-23}$ J/K is the Boltzmann constant, the angular brackets represent finding the mean value for the molecules ensemble (set). From the correlation (4) it is possible to get an estimation for mean quadratic velocity of the molecules:

$$\bar{v}(T) = \sqrt{\langle v^2 \rangle} = \frac{3kT}{m} . \qquad (5)$$

Thus, the distribution of velocities of particles depends on a temperature, while the physical sizes of a model cell do not change, that is why it is possible to make an assumption that the coefficients (1–3) must depend on the temperature. For backward compatibility with the classic model, we shall require accordance of values of the coefficients at the base (reference) value of temperature $T = T_0$:

$$k_z(T_0) = \frac{4}{9}; \; k_p(T_0) = \frac{1}{9}; \; k_k(T_0) = \frac{1}{36} .$$

The part of the matter which leaves a cell during one step of model time at the reference (base) temperature is equal to

$$u(T_0) = 4k_p(T_0) + 4k_k(T_0) = 4 \cdot \frac{1}{9} + 4 \cdot \frac{1}{36} = \frac{5}{9} .$$

The part of the matter which remains in the same cell during one step of model time at the reference temperature is equal to

$$k_z(T_0) = 1 - u(T_0) = 1 - \frac{5}{9} = \frac{4}{9} .$$

Except for it, the introduced dependence must satisfy the two requirements which result from the expression (5):

1) at $T = 0^\circ K$, $k_z(0) = 1$ (there is no motion of particles, so all the matter must remain in a cell);

2) at $T \to \infty$ the velocities of particles grow to infinity, that is why at $T \to \infty$ practically all the matter will leave its cell during one step of model time:

$$k_z(T) \to 0 , \; u(T) = 4 \cdot k_p(T) + 4 \cdot k_k(T) \to 1 .$$

For determination of the general form of dependency of the expence coefficients on temperature, we can introduce a function that satisfies the following requirements:

$$k_p(T) = \frac{1}{9} f(T);\ k_k(T) = \frac{1}{36} f(T);$$

$$f(T_0) = 1\ ;\ f(0) = 0\ ;$$

$$\lim_{T\to\infty} f(T) = \frac{9}{5}\ ,\ \text{then}\ \ \lim_{T\to\infty} k_z(T) = 0\,,\ \lim_{T\to\infty} u(T) = \frac{5}{9} f(T) = 1$$

For the first approximation, we can take the function of the following form:

$$f(x) = \frac{x}{T_0} \quad \text{at } x \in [0..T_0]\ ;$$

$$f(x) = \frac{9}{5} - \frac{4}{5}\frac{T_0}{x} \quad \text{at } x \in [T_0..+\infty)\,.$$

Conclusions

A new approach to the application of the Lattice Boltzmann equations method of computational modeling of fluid flow is proposed, based on taking into account the collective particles motion by introduction of the two additional stages of calculation. The temperature dependency of the transfer coefficients is considered in detail. The form of the function reflecting the temperature dependence is considered.

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Input data filtration in the identification systems

Process of objects identification in the computer systems aims the creation the object identifiers. The object cannot be identified exactly when there is large number of noises. Input data or signals should be cleaned for the possibility of correct objects identification. The article reveals method of evaluation of input data filtration results for definition of the filtration method with minimal difference between received and expected results.

Introduction

Nowadays various approaches are revealed in the special scientific and technology literature to solve the automatic image identification tasks. Large number of approaches is conditioned with capacity of processed data for formation of knowledge base in the recognition systems and with difficulties in identification of bounds of objects that are located at the image. There also are the problems connected with human factor and they influence the quality of decision accepting during the constant work. The perspective way of overcoming these difficulties is automation of image processing that permits significantly reduce the amount of routine and consuming work at the converting used images.

But in order to overcome this task it is necessary to introduce the input data in the prepared form that reduces the overload (and the demands to the hardware) from the recognition system and permits to implement the processes in parallel.

Object identification process in the computer systems aims the creation the object identifiers and a lot of problems go together with it. High influence of noises in the input data is among them. Thus it is impossible to identify objects at the images exactly; it makes recognition process including object classification as well as definition of exact specimen impossible.

Thus in order to get correct object identification it is necessary to provide the previous filtering the input data from the noises and bringing these data to the mathematic representation that simplify further identification process. For the image deliverance from the described noises one of the filters is used. Selection of filter is fulfilled according to decision of user and depends on the expected result of process. Setting of automatic filter selection implies usage of expert system that on the base of image parameters will be able to select filter for each final image.

Problematic

Filtration of input data from noises is fulfilled with the help of various filters. Depending on the type of noise some types of filters can be much more effective than the others. In practice, for noise suppression the following filtration methods are used: linear and nonlinear (median) filtration, adaptive filters are also used. Filtration method is chosen depending on the type of noise in the signal. The usage of optimal filtration method detecting algorithms depending on the type of noise in the input signal will reduce the number of problems connected with the identification process. For the selection of the optimal filtration method, the system has to be able to quantify the acceptability of filtration methods. Therefore, the purpose of the study is to obtain methodics of evaluation of input data filtration results for determination of filtration method with minimal difference between obtained and expected results.

It is necessary to consider each algorithm separately to create a filtration methods selection algorithm, and on the base of analysis results, to create a method for determination of the most efficient technique of filtration for each output image.

Linear filtration

During linear filtration usage, the mask response is set as the sum of pixels products in the filter covering area. As linear smoothing filter the averaging filter is used, the output value of which is the average value of the filter mask's bounds. Such filter is used to remove image grain effects which were caused by an impulse noise [3,5]. The formula of averaging filter response designed to filter the f -image with the following sizes [1]:

$$g(x,y)=\sum_{s=\frac{m-1}{2}}^{\frac{m-1}{2}}\sum_{t=\frac{n-1}{2}}^{\frac{n-1}{2}} w(s,t)\,f(x+s,y+t)$$

where *w(s,t)* - is an element of the convolution nucleus of an image with the sizes *m*n*; *s*, *t* - the coordinates of the convolution nucleus on the X and Y axises.

The suitable programming form of such filter application can be represented in the form of:

$$G_{i,j}=\sum_{s=\frac{m-1}{2}}^{\frac{m-1}{2}}\sum_{t=\frac{n-1}{2}}^{\frac{n-1}{2}} W_{s,t}\cdot E_{(i+s),(j+t)}$$

where $G_{i,j}$ - matrix element after filtration;

$W_{s,t}$ - convolution nucleus array element with $m\times n$ size;

$E_{i,j}$ - initial image matrix element.

Nonlinear filtration

During application of median filtration, the pixel values are represented as the average value of the points the plane. During solving of noise removal problems, median filter is usually more efficient than simple averaging, as it doesn't lead to great borders distortion of selected objects. As a mask used in the Two-dimensional median filtering window with central symmetry is used as a mask during median filtration and the center is situated at the current point of filtration [2,6]. The formula of the two-dimensional median filter is the following:

$$G_{i,j}=med\lfloor E_{i+s,j+t};(s,t)\in W\rfloor;\ i,j\in Z^2$$

where $G_{i,j}$ - image matrix elements after filtration

$W_{s,t}$ - image aperture array elements with $m\times n$ size:

$E_{i,j}$ - input image matrix element

Adaptive filtration

The basis of adaptive filtration is Weiner filter, which is one of the linear filter types for adaptive local image processing. If the value of the root mean square deviation pixels intensity in a given local area is great the Weiner filter performs smoothing and, conversely, the smaller deviation is the bigger smoothing area is. This approach is often more efficient than conventional linear filtration. [2,7].

The advantage of adaptive filter is that it keeps the edges and other high-frequency object parts of the images. Weiner filter requires more time for calculations than linear filter [4]. Average brightness value is calculated for the central pixel of the mask that contains the original brightness value of an input image in the local area covered by mask.

$$\overline{w} = \frac{1}{m \cdot n} \sum_{i=1}^{m} \sum_{j=1}^{n} W_{i,j}$$

The mask dispersion is calculated as:

$$\delta^2 = \frac{1}{m \cdot n} \sum_{i=1}^{m} \sum_{j=1}^{n} (W_{i,j} - \overline{w})^2$$

In this algorithm for each new position of the mask window the corresponding values are calculated again. Noise smoothing is measured by standard deviation.

The filtration qualities assessment of the image.

To evaluate the quality of images filtration, a method that requires three images is proposed: E - input image, Y - image with noise, H - image that was received after the implementation of the filter to the image Y.

The first step is blending filters on noisy image Y for obtaining filtered images receives H1 - Hn, where n - number of image which was under the one from above mentioned filtration algorithms.

After filtration of noisy image Y we obtain an image approximation of E (the original image). The lower the difference between the input and filtered image is - the lower the noise level on the image is. To assess the differences in the images it is necessary to obtain the resulting matrix. Obtaining of the resulting matrix image with the dimension m × n:

$$R_{i,j} = \left| E_{i,j} - H_{i,j} \right|$$

where: $i = \overline{1, m}$, $j = \overline{1, n}$; R – resulting matrix, obtained with subtraction of filtered image from input image.

After that numerical index r is obtained by averaging of matrix values.

$$r = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} R_{i,j}}{(m \cdot n)}$$

Ideally, it should tend to 0. The value ry is calculated almost the same as the value of r, but only for the resulting matrix R the following formula is used:

$$R_{i,j} = \left| E_{i,j} - Y_{i,j} \right|$$

The larger the substraction is:

$$\Delta r = r_y - r$$

and the closer the value of r to 0 is - the smaller the difference between the input image and the filtered one is (Fig. 1).

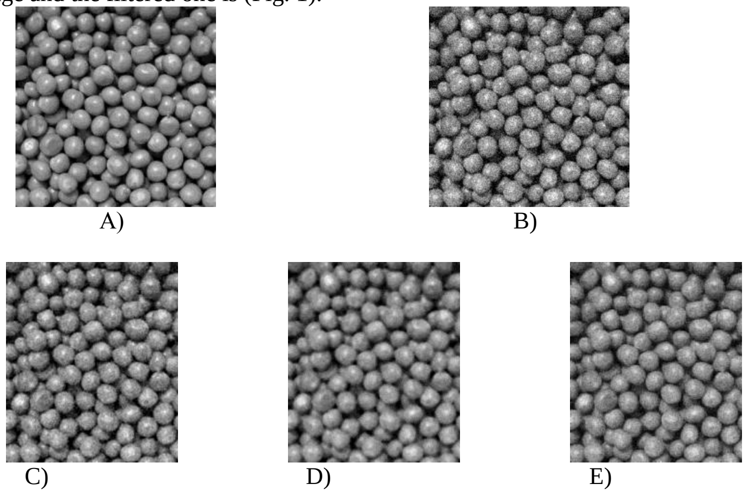

Fig. 1. The view of the input, noisy and filtered images: a) an input image, b) noisy image, c)the image after linear filtration d) image after non-linear (median) filtration, e) image after adaptive filtration.

The figures show the difference between the input image (Fig. 1, a), image with noises overlapping (Fig. 1, b),linear filtration algorithm, (Fig. 1, c), median filtration algorithm, (Fig. 1, d) and adaptive filtration algorithm (Figure . 1D).

The results of the images average deviation calculation are also represented.

During the experiment it was conducted the assessment of more than 100 filters of noisy images as well as comparison of obtained results with expert analysis which was based on the visual analysis of the filter usage results. The results of investigation showed that the average deviation without filter is equal to 3245, with linear filtration - 2846, with non-linear one - 2315, with adaptive filtration - 1782.

The assessment according to quantitative index calculation showed 89.54% conformation of expert view.

Conclusion

In the article it was proposed the method that allows to choose the most adequate method of filtration of output images based on the existing noise analysis.

During the investigation, a series of experiments were conducted, they showed that this method allows to evaluate the efficacy of the specific filter application.

The proposed method can be used in computer systems where it is necessary to solve the problem of filter usage efficiency assessment. The examples of such computer systems are the video surveillance systems, number identification systems and augmented reality systems.

The estimated method requires the presence of input image without noise for valuable assessment of filter used efficiency, but it is inconvenient in case of real systems usage, so the further investigation will be focused on the usage of filtration quality assessment for the filter selection in the automatic systems for random input data.

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Research of the method for determining the reliability and diagnosis of computer-aided technical systems

The article has stated the method of diagnosis of radio-electronic components using Lissajous (curves) figures. Modeling of random samples has been performed by Monte Carlo to determine the probability of failure-free operation. The authors have made the analysis of the quality of statistics, the analysis of statistical array, which consist of random numbers using Pearson fitting criterion χ^2.

Despite the rather broad coverage of the matter of components of electronic systems and devices diagnosis, the improvement of existing methods of diagnosis will always remain urgent. First of all it is connected with the development of science and as a result technology. New materials for the manufacture of radio engineering elements and new technologies appear nowadays. As a result of all these factors they become more reliable, economic, technological, and get smaller in size. All these factors are pushing the development and improvement of the existing diagnosis technologies and creating new ones.

Unfortunately, nowadays the existing methods of diagnosis of radio equipment rarely pay attention to such effect as Lissajous figures. They use them (due to their properties) to adjust one source of signal to another [1]. In [2] they called Lissajous figures, unfortunately, almost useless.

Meanwhile, despite all this, useful properties of Lissajous figures can be used to diagnose some electronic components such as a capacitor, a resistor, a diode, etc.

Therefore, it is necessary to develop a method for diagnosing electronic components using Lissajous figures using a computer sound card as an oscilloscope.

Now we solve this problem. Lissajous figures [3] (named after a French physicist J. Lissajous) - closed trajectories of a point that make simultaneously two harmonic, oscillatory motions in two mutually perpendicular directions. A type of Lissajous figures depends on the correlation between the periods (frequencies), the phases and amplitudes of both oscillations and it allows to determine the correlations and a form of the oscillations. Lissajous figures can be seen, for example, on the screen of a cathode-ray or digital oscilloscope if variable voltages with equal or multiple periods are fed to two pairs of deflecting plates. The trajectory of the beam movement will have definite shapes at different correlations of frequencies.

The mathematical expression for Lissajous figure is as follows [4]

$$\begin{cases} x(t) = U_x \sin\left(f_x t + \varphi\right) \\ y(t) = U_y \sin\left(f_y t + \varphi\right) \end{cases}$$

where U_x, U_y – the oscillations amplitude, , f_x, f_y - frequencies, φ - shift of the phases.

The mode of the figure strongly depends on the correlation f_x/ f_y . When the correlation equals 1, Lissajous figure looks like an ellipse, under certain conditions it looks like a circle ($U_x= U_y$, $\varphi = \pi / 2$ radians) and a line ($\varphi = 0$). Another example of Lissajous figure – is a parabola ($f_x/ f_y = 2$, $\varphi = \pi / 2$). Other correlations produce more complex shapes which are closed by the condition f_x/ f_y - rational number. It is assumed that the visual shapes of these figures are often a three-dimensional knot, and indeed, the projection of the plane of many knots, including units Lissajous knots, are Lissajous figures.

As the software Visual Analyser 2014 was used. Before using the soundcard as an oscilloscope input (Line in), it is necessary to increase the input resistance of the Line in input (right and left channels). This is a rather trivial task, which is a simple calculation of the voltage divider. The resistance of Line in (right and left channels) should be considered. As the probes can be used oscilloscopes probes. In order Lissajous figures to take place the oscilloscope must be switched to the XY mode of (Fig. 1). The computer must be securely grounded. As a generator there can be used the external one or one that is built-in in Visual Analyser 2014.

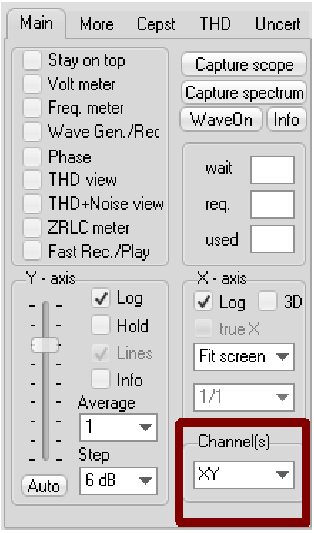


Fig. 1. Switching the oscilloscope in the mode to display Lissajous figure.

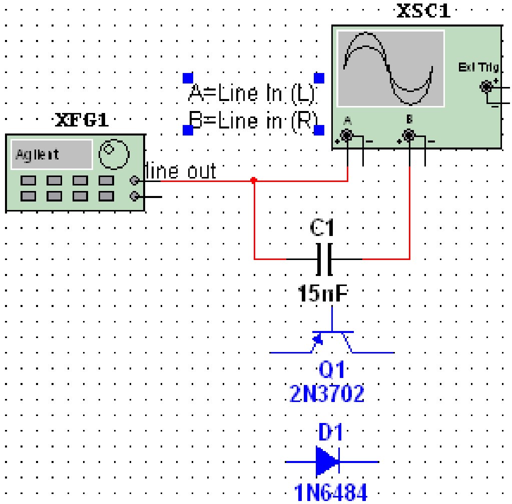


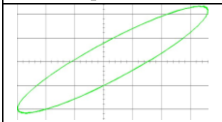
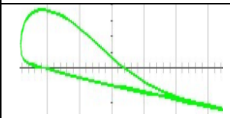
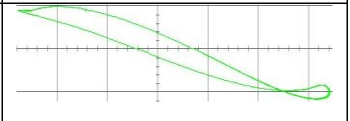
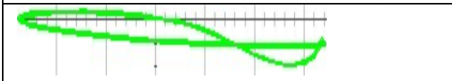
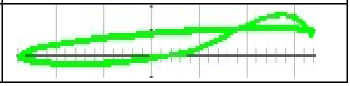
Fig. 2. The chart of connection the devices (for connecting to a PC).

Fig. 2 shows the chart of the devices connection. Inputs A and B of the oscilloscope are a line input of the sound card. A signal is supplied through the voltage dividers to this input, which increase the input resistance of the sound card.

As a generator can be taken an external (low-frequency) generator or the generator of Visual Analyser. In this case, a signal generator, is being taken from the line out of the sound card. With the above stated method was tested a capacitor, a diode, a Zener diode and a transistor (Table. 1).

Table 1.

Oscillograms of electronic components in a fault-free condition.

The capacitor 47n	Diode 1n4001	Zener diode ks156a
		
2t312b transistor (collector-base)		transistor (emitter-base)
		

Modeling of the tests

At the diagnosis of electronic components in some cases it is necessary to accumulate statistics of failures for a further determination of the probability of failure-free operation.

Let's consider a problem connected with hypotheses testing - namely, the question of coordination of theoretical and statistical distributions using Pearson fitting criterion χ2. The following laws of distribution and mathematical expressions have been used. The studied statistics looks like this:

$$\vartheta = \frac{r}{N},$$

where r - a number of samples which rejected, the operating time t of N samples which were set to the test.

Normal distribution (N):

$$\mathrm{F}(\vartheta) = \mathrm{N}(\vartheta, \hat{\mu}, \hat{\sigma}) = \Phi\left(\frac{\vartheta - \hat{\mu}}{\hat{\sigma}}\right),$$

where $\hat{\mu} = \frac{\sum_{i=1}^{n} \vartheta_i}{n}$ - sample mean; ϑ_i - the value of statistics for the i - that sample; n - a number of samples; $\hat{\sigma} = \sqrt{\frac{1}{1-n}\sum_{i=1}^{n}(\vartheta_i - \hat{\mu})^2}$ - standard deviation; Φ - normalized normal distribution.

Distribution Releya (R):

$$F(\vartheta) = R(\vartheta, \hat{\sigma}) = \frac{\vartheta}{\hat{\sigma}^2} e^{\frac{-\vartheta^2}{2\hat{\sigma}^2}}$$

where $\widehat{\sigma}^2 = \left(2 - \frac{\pi}{2}\right) D$, $D = \frac{1}{n-1} \sum_{i=1}^{n} (\vartheta_i - \widehat{\mu})$

Cauchy distribution (C) (Lorentz distribution or the Breit – Wigner distribution):

$$F(\vartheta) = C(\vartheta, \widehat{\mu}, \gamma) = \frac{1}{\pi} \frac{\gamma}{(\vartheta - \widehat{\mu})^2 + \gamma^2}$$

where γ - coefficient of the scale.

Weibull distribution (W):

$$\mathrm{F}(\vartheta) = \mathrm{W}\left(\vartheta; \widehat{b}, \widehat{a}\right) = 1 - e^{-\left(\frac{\vartheta}{\widehat{a}}\right)^{\widehat{b}}},$$

where $\widehat{b} \cong \frac{1}{\tilde{v}}$; where $\tilde{v} = \frac{\widehat{\sigma}}{\widehat{\mu}}$ coefficient of variation, $\widehat{a} = \left(\frac{1}{n} \sum_{i=1}^{n} \vartheta_i^{\widehat{b}}\right)^{\frac{1}{\widehat{b}}}$.

Log-normal distribution (LN):

$$\mathrm{F}(\vartheta) = \mathrm{LN}(\vartheta; \breve{\mu}, \breve{\sigma}) = \Phi\left(\frac{\ln(\vartheta) - \breve{\mu}}{\breve{\sigma}}\right),$$

where $\breve{\mu} = \ln \widehat{\mu} - \frac{1}{2} \ln\left(\frac{D}{\widehat{\mu}^2} + 1\right)$; $\breve{\sigma} = \left(\ln\left(\frac{D}{\widehat{\mu}^2} + 1\right)\right)^{\frac{1}{2}}$.

We also used Pearson fitting criterion χ^2 :

$$\chi^2 = \sum_{j=1}^{r'} \frac{\left(m_j - n_{p_j}\right)^2}{n_{p_j}},$$

where r' - a number of intervals after their joining; m_j - a number of elements of statistics θ that got in the j interval; $n_{p_j} = p_j n$; p_j - - a probability of theoretical distribution; n - a number of samples.

The application of χ2 criteria provides a breakdown of the area of the random value in k intervals and counting the number of observations n_i, which got into them, and a probability of getting into the intervals $P_i(\theta)$, where θ - a known value of the parameter (scalar or vector), corresponding to the theoretical law.

To estimate the adequacy of the mathematical apparatus it is not always possible to carry out a real experiment. To resolve this problem some different modeling techniques are used. In this case we can offer a modeling by Monte Carlo mode, which was conducted as follows. In order to check the hypotheses testing a hundred samples were made, each of which contained one hundred elements. The samples were modeled by Monte Carlo mode.

The results of the research which were obtained after checking of the hypotheses testing are summarized in Table 2.

Таблиця 2.

The observed values of χ^2 and the corresponding them equal values ρ for F = 0,1

N	R	C	LN	W
ρ=0,01	The hypothesis is disproved	The hypothesis is disproved	ρ=0,05	The hypothesis is disproved

Conclusions

The proposed method of diagnosis is quite simple and easy to use. The use of the computer leads to significant savings on costs to buy the diagnostic equipment for maintenance of the sound frequencies equipment.

Analyzing the modeling results for different types of empirical distribution facilities of the operating time (Table 2), we can say that is normal distribution and log-normal distribution do not contradict the experimental data. But to handle the modeled statistics, in this case, it is better to use normal distribution.

Using the criterion χ2 (like any other) a chosen hypothesis can be disproved only in some cases which cannot clearly co-ordinate with the experimental data.

To choose the most appropriate theoretical function of distribution it is necessary to put forward several competing hypotheses and check these hypotheses testing. It allows you to choose the correct theoretical distribution, to align statistical array and also, what is very important, to estimate the precision that we make when taking a particular theoretical distribution

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Modern methods of analysis of unstructured data in information systems

The methods of analysis of structured and unstructured data in information systems. An hardware and software for analytical processing of large volumes of information.

In today's job market great demand for experts in business intelligence, that employees of businesses that use methods of business intelligence analytics needs of organizations to identify business problems and offer their solutions.

During the analytical research in different areas of the economy operates according to a specialist who treats certain practices regarding the goal.

In today's world it is necessary to handle large amounts of data that formed the concept of “Big Data”, which examines the classic structured and unstructured data.

Recently, various media are increasingly encountered the term “Big Data” and related posts about the beginning of “Era of big data”. Now all mankind produces about 2.5 quintillion bytes of information per day and it is too much for what would process all the information by the personal computer, so extraction of important information in this huge volume of useless information is one of the biggest problems facing modern society.

Today it is not difficult to collect and accumulate a huge amount of data to be taken from various sources available, from the media and others. For example, the network of any supermarket can generate daily record of one million sales and service Twitter generates per day 12 terabytes of information, etc. Such large sets of various data implied a universal means by the term “Big Data”.

So, big data in information technology – a set of tools, instruments and methods of processing of structured and unstructured data volumes and huge significant diversity. To approach this series also includes media-vaguely parallel processing unstructured data technology solutions NoSQL, MapReduce algorithms, software frameworks and libraries project Hadoop.

For big data the following characteristics: volume – the value of volume; velocity – the speed of growth, and the need for high-speed processing and obtaining results; variety – simultaneous processing of different types of structured and semi-structured data.

Examples of major sources of data are the data that come from continuous measurement devices, events from radio frequency identifiers, streams of messages from social networks, meteorological data and remote sensing, flow of location data of subscribers of cellular communication devices, audio and video recording. It is expected that the development and the beginning of widespread use of these sources initiates penetration big data technologies in both research and development and in the commercial sector and public administration.

For big data can be used the following methods of analysis:

– methods class Data Mining – association rule learning, classification (new methods of categorization on the basis of data that were previously applied to the available data)б cluster analysis, regression analysis;

– crowdsourcing – categorization and enrichment of data by the broad, unspecified persons involved on the basis of a public offer, without joining the labor relations;

– data fusion and integration – a set of techniques that allow you to integrate disparate data from various sources to enable in-depth analysis as examples of techniques that make this class provides methods for digital signal processing and processing of natural language;

– machine learning, including teacher training and without it, and Ensemble learning – using models built on the basis of statistical analysis or machine learning for comprehensive example based on basic models (constituent models);

– artificial neural networks, network analysis, optimization, including genetic algorithms; pattern recognition; predictive analytics; simulation;

– Spatial analysis – class methods using topological, geometric and geographic information in the data;

– statistical analysis, as examples of methods are A / B-test and analysis of time series;

– visualization analytics – presentation of information in the form of drawings, diagrams, using interactive animation capabilities and how to get results, and for use as input data for further analysis.

There are hardware and software systems that provide configured solution for processing large data: Aster MapReduce appliance (corporation Teradata), Oracle Big Data appliance, Greenplum appliance (corporation EMC). These systems installed in data centers that contain managed servers and software for massively-parallel processing.

By making this for big data include hardware and software systems based on traditional relational database management systems – Netezza, Teradata, Exadata, which can effectively handle terabytes and exabytes of structured information, solving the problem of fast search and analytical processing of enormous volumes of structured data.

Methods for analyzing large data include content analysis that can be implemented in IBM Content Analytics. The modern interpretation of content analysis is a formalized method of studying the text and graphic information which is to transfer the information taught in its quantitative and statistical analysis. Classical content analysis - a purely quantitative method, the basic and central tool which supports system categories. The simplest type of assessment categories is counting the number of occurrence category (assuming that the frequency of occurrence between content and meaning there is a relationship). The idea of content analysis is to systematize these intuitive feelings, make them visible and those that are checked and develop a methodology focused collection of textual evidence on which these feelings are based. The method of content analysis is to fix some pieces of content studied, as well as the quantification of the data. The object content analysis content may be different publications, radio and television programs, films, advertisements, documents, public speeches, materials, forms and more.

Solutions IBM Content Analytics with Enterprise Search (ICAwES) is a search-analytical platform that uses an analysis of formatted text for new applicable in practice knowledge from different sources and types of text content, including corporate content, web-content (including content social media), email and databases.

In practice IBM Watson Content Analytics (WCA) can directly perform analytical reviews WCA to quickly gain knowledge from large sets of content. Such reviews often operate with facets where facets - are important aspects of the documents received or metadata that are structured (eg, date, author, tags) or concepts extracted from text content.

Extraction of information objects or concepts for use in analytical review or other final decisions. For example, reporting the results of medical laboratory tests to fill the histories of patients; Objects extract named entities and relationships for use in software research; typology definition sentiments expressed on social networks for more accurate statistical analysis of consumer behavior.

WCA uses word Natural Language Processing (NLP) to extract information from unstructured data. This information can be extracted in the following forms: basic concepts or information objects such as persons, places, companies, parts of aircraft, industrial operations; combination of the above information, reflecting the typically some level of relationships between concepts. Examples of such combinations: the man and his work, the company and its scope, operation maintenance node specific aircraft, describing the patient's history of family ties and health problems.

Conclusions

Analysis and processing of structured and unstructured data require visual interpretation of values, preparation interactive queries based on knowledge, the development of adaptive algorithms "machine learning" that can get the desired result.

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Distributed security systems of information resources in corporate networks

New approach of corporate network information resources safety provision using self-similar distributed systems was offered.

The main feature of corporate networks is the informatization and management of large organizations manufacturing requirements. Despite the fact that those networks are heterogeneous in nature, use different protocols, have heterogeneous environment of data pass, computer platforms, operating systems and patching facilities, which are produced by different manufacturers, generally they are oriented to solve a single task of large system of administrative management . In addition, they are characterized by presence of various production sites, which are usually distributed in a regional scale. That's why computer systems that will ensure necessary security level of those networks should also be distributed. But in this case there is a problem of resource balance provision between functional features of distributed system and safety facilities of information resources. So development of new systems concepts focused on solving of this problem is currently central. One of such possible approaches is creation of self-similar distributed systems.

As you know, the purpose of security administration subsystem is to ensure the confidentiality, integrity, availability and procedural monitoring of informational resources circulating in computer networks in time and space. It can be shown that the categories of confidentiality, integrity, availability and procedural monitoring that are considered in coordinates of time and space, have sufficient completeness for the synthesis of a variety of features implementing information security. For example, the category of confidentiality is the foundation of such functional features:

– identification;
– authentication;
– unauthorized access;
– electronic signature and so on.

Category of information resources integrity in time and space allows to regulate the following characteristics of information security subsystems:

– integrity;
– preservation;
– tolerance;
– resistant to failures;
– reservation, and so on.

Finally, the category of procedural monitoring allows to synthesize:

– security;
– accountability;
– audit and other characteristics of system.

This definition of information security subsystem necessitates the development of appropriate architecture. The main goal here is to create the model of information security subsystem invariant to hardware and software computer telecommunications.

In addition, it should be noted that the process of security organization includes features, agents and security mechanisms. Agents implement functions through mechanisms [1]. Also, the overall security status of distributed computing systems can be defined on the basis of safety criteria based on the condition of the individual system components. This occurs because of the reason that distributed systems are usually layered, each of the components is a multi-subsystem, which in it's turn also a multicomponent and so on down to the most primitive components. At that there is a decomposition of security policies, functions and mechanisms of security and safety management hierarchy.

We know that any informational technology can be built on three conceptual states regarding information transformation: processing, storage and transfer. If we add to those states the necessity of objective information management, we will get a certain structure of computer technology. Graded organization of information technologies in the coordinates of space and time is based on the same processes: processing (transformation), storage, transfer (interaction) and management. However, organization of those processes on separate levels has some differences. Moreover security facilities of information resources are usually add-in over listed processes. If we add to classical "quartet" protection process, then the received "five" can serve as a basis for building secure information technologies (Fig. 1) [1]. In addition, the main feature of this approach is to organize the process of information transformation using listed "five" in the coordinates of time and space.

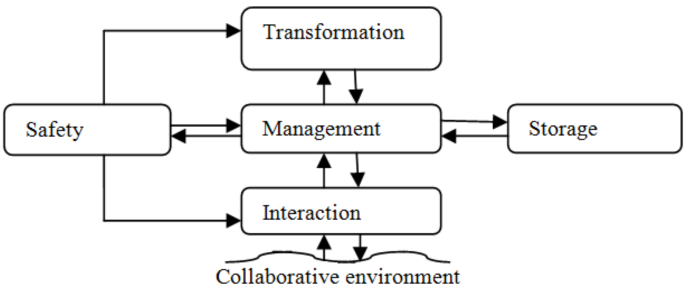

Fig.1. Model of the most elementary component (agent) of security system

If system architecture of security subsystem is constructed using the proposed model, it will be characterized by the following features:

1. Intellectualism (with protection). It means that the key element of system architecture is agent – intellectual hardware and / or software module, which will have universal functional structure [2].

2. Distribution. Interacting agents will form a physically homogeneous multiagent system.

3. Corporativity (with self-organization). As a result of differentiation and integration of individual agents functions universal functional structure of a

higher level will form. Obviously, the agent (i + 1)st level will consist of at least five agents of i level. In turn, the agent of i level will also be composed of at least five agents of (i – 1)st level.

4. Self-similarity. In theory functionally homogeneous self-similar system with an infinite number of levels and agents on each level - so-called matrix will take place.

The concrete filling of "empty" matrix final volume will allow to create a system profile that can display any of its practical implementations. The system will be a uniform structure in all sections and levels. It should be kept in mind that, unlike classical homogeneous systems, the proposed architecture on each section and level of procedure-algorithmic functions of processing, storage, transfer management and protection can vary considerably among themselves. That is in what the property of self-similarity consists of. In other words, self-similar systems will consist of identical (homogeneous) components that in fact will perform the same processes, but the algorithms of which can be and will be different at different levels of the system.

In terms of distributed security systems of information resources the self-similar multi-agent environment will allow to realize almost any policy to protect them. Moreover, the recovery ability of self-similar elements will allow to minimize interlayer traffic load.

Besides "incapsulation" of self-similar elements in separate similar models of the OSI can transfer task of protecting the integrity of the system to the appropriate level. In this case, similar to analogy with seven-layer model, interaction cognominal levels in distributed systems will happen taking into account protection policies of those levels resources. This differentiation will not only minimize overhead, but also will increase the level of security of distributed systems in general.

Such architecture of distributed systems is a new solution in the field of information technologies and is able to solve problems of resource balance between functional tasks and tasks that ensure their implementation.

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Aircraft maintenance routing for single air company

Airline planning and scheduling operations have posed many great logistics challenges to operations researchers. Article focuses on concepts of optimizing flight schedules, maximizing aircraft utilization and minimizing aircraft maintenance costs.

Introduction

The airline network is one of the world's most sophisticated, yet very complex, networks. Airline planning and scheduling operations have posed many great logistics challenges to operations researchers. Optimizing flight schedules, maximizing aircraft utilization, and minimizing aircraft maintenance costs can drastically improve the airlines' resource management, competitive position and profitability. However, optimizing today's airline complex networks is not an easy task. There are four major optimization problems in the airline industry including flight scheduling problem, fleet assignment problem, crew pairing problem, and aircraft maintenance scheduling problem. These problems have been widely studied over the past few decades. Yet, they remain unsolved due to the size and complexity. In this paper, we provide a review of advances in optimization applied to these logistics problems in the airline industry as well as give a thorough discussion on the aircraft maintenance scheduling problem. Several mathematical formulations and solution methods for the aircraft maintenance scheduling problem will also be presented.

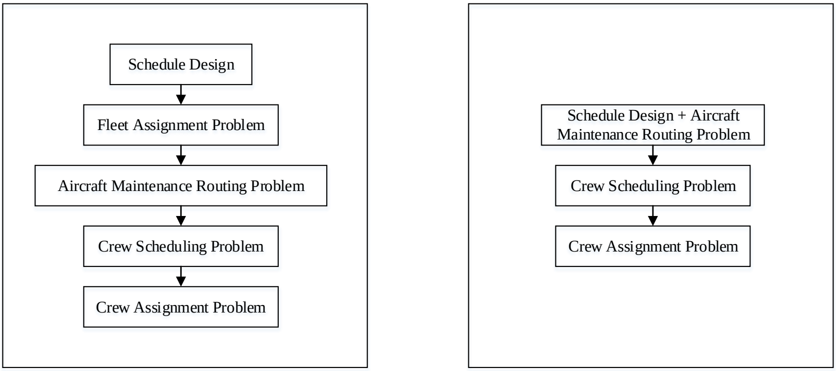
The aircraft maintenance scheduling (routing) is one among the major decisions an airline has to make during its operation. Though maintenance scheduling comes as an end stage in an airline operation, it has potential for cost savings.

Given a flight schedule with aircraft assigned to it, the aircraft maintenance-scheduling problem is to determine which aircraft should fly which segment and when and where each aircraft should undergo different levels of maintenance check. The objective is to minimize the maintenance cost and any costs incurred during the re-assignment of aircraft to the flight segments. This paper provides a complete formulation for maintenance scheduling and a heuristic approach to solve the problem. The heuristic procedure provides good solutions in reasonable computation time.

We propose to find simultaneously the flight schedule design and the aircraft routing, considering at the same time maintenance requirements. This approach leads to a closer global optimal solution than the typical sequential one, and it is practical for the case of airlines with a single fleet, such as many emerging young low-cost airlines.

The formulation of this optimization problem is a Longest Path Problem with maintenance requirements as side constraints. It is based on a network diagram where a flight schedule is defined as the set of legs included in all routes to be flown. Then an algorithm to solve this integrated problem is proposed. It is a greedy heuristic that starting from a given large number of potential flight legs, it identifies at each cycle the route that provides the maximum profit.

However this highly costly software and their sequential strategy is not necessarily the most appropriate for small and/or single fleet airlines that are becoming to be well known as low-cost airlines. Therefore two or more problems of the planning process could be solved simultaneously, yielding solutions potentially better for their specific needs, as shown in Fig. 1.



a) b)

Fig. 1 – Traditional sequential (a) and partially-simultaneous (b) planning process

Clearly, for all these small airlines it is not required to solve the fleet assignment problem. Either, they have only one fleet or they already have pre-assigned their few fleets to sets of destinations considering constraints such as aircraft size or travel distance, especially in the case when they have strong hub networks.

For these single fleet airline companies, the sizes of the optimization problem for the planning process are reduced drastically.

Therefore the sequential approach is not necessary any longer and two or more problems of the planning process could be solved simultaneously. Solutions obtained in this manner are potentially better than the ones that it can be obtained using the models created for the large airline companies. This work focuses on finding aircraft routes and the corresponding flight schedule, considering maintenance constraints that maximize the profit function for the case of single fleet airlines companies.

Flight and maintenance operations

Aircraft maintenance takes place in a series of checks of increasing diligence with the exception of unscheduled fixes. The frequency of these checks depends on the combination of flight hours and number of take-off and landing cycles, and may be performed at any site appropriately equipped. Because each aircraft type has different inventory requirement, little savings can be achieved by combining facilities for different fleets.

This paper gives an outline of the different types of maintenance for aircraft: scheduled and unscheduled maintenance, line and hangar maintenance, routine and non-routine checks, etc. Various terms are used to refer to the same type of maintenance. These four types can also be considered as part of scheduled or preventive maintenance types.

The first major check actually mandated by the requirement occurs at every sixty flight-hours, or about once a week. This type checks involve inspection of all major systems such as landing gear, engines and control surfaces.

The second major is performed every four hundreds flight-hours, and entails a thorough visual inspection plus lubrication of all moving parts such as horizontal stabilizers and ailerons.

The very major checks designated as 3-th and 4-th are done about once every one to four years, respectively, and require taking the aircraft out of service for up to a month at a time.

Because type 3-th and 4-th checks are spaced at relatively large intervals and because of the dynamic nature of the market, these two checks need not be taken into account in maintenance scheduling.

Problem conditions. Variables and constraints

The maintenance-scheduling problem is most naturally modeled as a closed loop network. Using OD (Origin-Destination) schedule as input, the maintenance-scheduling problem is formulated as a min-cost multi-commodity network flow model with integer restrictions on the variables, as such each plane represents a separate commodity. Usually fleet of different aircraft is considered rather than individual aircraft in scheduling, but since maintenance requirement is considered in this scheduling problem, each aircraft should be considered as separate commodity. Each OD pair segment has an upper and lower capacity of one unit of flow. Now define n_d as the planning horizon and n_c as the number of cities in the OD schedule. The total number of nodes in the underlying graph is $n_d n_c$. But not necessarily each node should have input and output arcs. If n_p is the total number of planes in the fleet, then the total number of arcs is $n_d n_p$. This is because each aircraft is assigned to exactly one OD segment, and each OD segment is covered by exactly one aircraft. This produces a large graph.

Origin is the airport where an aircraft leaves in the early morning after spending previous night. Destination is the airport where the aircraft spends the night for that day. Each arc in the network represents a unique OD trip assigned to an aircraft in the flight schedule. In case of two aircrafts having the same Origin and Destination for any given day, then each trip of those aircraft for that day is identified by the subscript r. For example an aircraft is assigned to a trip, which start, from *A*-airport to *B* to *C* to *D* another aircraft is assigned to a trip from *A* to *K* to *L* to *D*-airport in the original flight schedule. In this case for both trips *A* is the Origin and *D* is the Destination. Since the proposed formulation only needs to consider the Origin and Destination (intermediate stops are not considered), to make these two trips unique subscript r is introduced. In this formulation we do not need to consider the intermediate stops because they have no effect on the maintenance schedule. The flight schedule including the sequence of flight legs that are to be flown by an aircraft during a day is an input to the problem and we refer to it as an OD trips. The proposed formulation is only concerned with assignment of aircrafts to these OD trips.

The following notation is used in the model:

n_{p} : number of planes in the fleet.

n_c : number of OD-points (cities) in the network.

n_{d} : number of days in the planning horizon.

i : index for planes $i = 1; 2; \ldots ; np$.

j, k : index for cities; $j, k = 1, \ldots , nc$.

Among the factors considered in maintenance scheduling are passenger demand, revenue, seating capacity, fuel costs, crew size and maintenance costs. Many of these factors are captured in the objective coefficient s of the decision variables and others are captured by the constraints. For example, the potential revenue generated by flights can be determined by forecasting the demand for seats on those flights and multiplying the minimum of the forecasted demand and the seat capacity by the average fare. This model satisfies balance constraints that force the aircraft to circulate through the network of flights.

Constraints 1-th ensure that the aircraft that come into the point (city) k on day d should leave city k on the next day. Constraints 2-th ensure that any OD trip could be served by one and only one aircraft. Constraints 3-th are node capacity constraints for one-type maintenance checks that ensure that each maintenance base can serve only a certain number of aircraft at a time. Typically the capacity is based on the number of available mechanics and the inventory of various parts of the aircraft available. Constraints 4-th are availability constraints of aircraft i at city j on day d for one-type maintenance check. These constraints ensure that aircraft i is assigned for maintenance check of one-type at city j on day d only if it is vailable at city j on day d. Constraints 5-th force the aircraft to undergo one-type maintenance check once in 4 days. Constraints 6-th ensure that the aircraft undergo their second-type maintenance check once in the given cycle. Second-type maintenance check is usually done once in two months, it does not necessarily mean that the aircraft has to take the second-type maintenance check once a week. Since the schedule is repeated every week, the second-type maintenance can be done once in every eight sweeks at the optimal city and day. That is why a fraction of the second-type maintenance check cost is used as a cost coefficient rather than the actual cost. So in case of the scenario explained before, one eighth of the actual cost would be used as the cost coefficient for second-type maintenance check.

Constraints 7-th are availability constraints of aircraft i at city j on day d for second-type maintenance check. These constraints ensure that aircraft i is assigned for maintenance check of second-type at city j on day d only if it is available at city j on day d. Constraints 8-th are to make sure that the same aircraft is not used for two cyclic schedules. In other words, the same aircraft should not be assigned to more than one link between any two given consecutive days.

The Objective function consists of three components.

$$\min \sum_{i=1}^{n_p} \sum_{j=1}^{n_c} \sum_{d=1}^{n_d} (T_1, T_2, T_3).$$

The first one is the total cost of one-type maintenance check – T_1. The second one is the total cost of second-type maintenance check – T_2 and the third one is the penalty for assigning inappropriate aircraft to the OD trips – T_3.

Solution test

The first aircraft and the first node are chosen from the respective list. Then an exhaustive depth first search is performed from the node to find the best cyclic schedule for the chosen aircraft. Then the assigned links are removed from the network. Now the second aircraft is chosen from the list, if the number of outgoing arcs in the first node is not equal to zero, again a depth first search is performed to find the best cyclic schedule for the second aircraft. If the number of outgoing arcs is equal to zero, then the second node from the node list is chosen and an exhaustive search is performed from this node to find the best cyclic schedule for the aircraft. This procedure is repeated until there is no more aircraft or nodes in corresponding list.

After processing all the aircraft in the above-mentioned procedure, a feasible schedule and the objective function value is found. This objective value is compared with the objective value obtained from the previous iteration and the better solution is saved. For the next iteration the node list and aircraft list are perturbed (shuffled). The procedure is performed for the new list of nodes and aircraft.

The steps of the algorithm are as follows:

1. Make a list of aircraft in any order. Make another list of nodes (cities) for any given day. Initialize number of iterations = 1.

2. Let n = 1.

3. Pick the nth aircraft from the list of aircraft.

4. Let k = 1.

5. Pick the kth node from the list of nodes.

6. If there are no more nodes available for the allocation in the kth node, let $k = k + 1$ and go to step 5, otherwise go to step 7.

7. Do depth first search to find the best possible cyclic schedule for the nth aircraft. If a feasible cyclic schedule exists go to step 8, otherwise let $k = k + 1$, go to step 6.

8. Add the route to the schedule. Delete the arcs from the network that are assigned to the n-th aircraft.

9. If n = number of aircraft, a) reconstruct the network (in step 8 arcs are removed from the network, for new iteration, these arcs need to be placed back in the network), b) perturb the aircraft list randomly (construct a list by choosing each aircraft in random from the list of aircraft), c) perturb the node list randomly (construct a list by choosing each node in random from the list of nodes that belongs to any given day). If a feasible solution was found in the previous iterations, compare the current solution with the existing one and if the current one has a lower

objective function value save the current solution and delete the previous solution. Otherwise let $n = n + 1$ and go to step 3.

10. If the number of iterations is less than the maximum number of iterations, increment the number of iterations and go to step 3, otherwise stop. Fig. 2 shows the flow chart of this heuristic procedure.

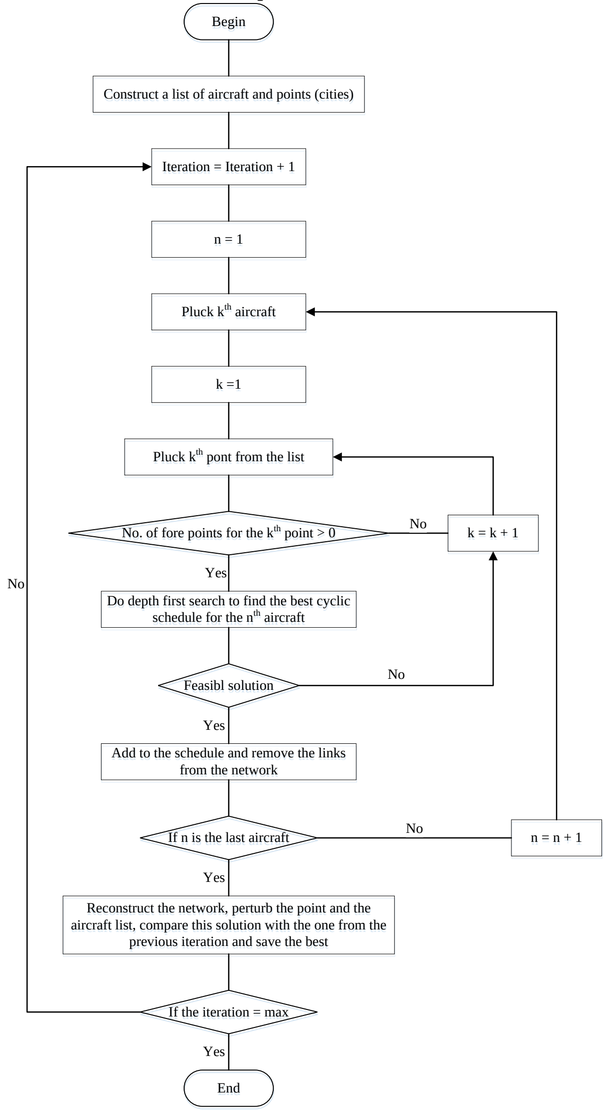


Fig. 2 – Procedure algorithm

Increment the number of iterations and go to step 3, otherwise stop. Fig. 2 shows the flow chart of this heuristic procedure.

Ten sets of problem were solved in this study. Each set of problems is identified by the number of cities considered in the problems in that set.

Conclusion

The consideration of constraints for typical maintenance checks in an aircraft maintenance scheduling has been shown to be a critical one for any airline operation. The key to solve a large scale integer programming problem is development of efficient heuristic procedures.

This paper presented a formulation for the aircraft re-assignment and maintenance scheduling and a heuristic method to solve the problem efficiently and quickly. Since the solution time for solving larger integer-programming model gets into astronomical units, a heuristic was proposed in this paper to solve larger problems. This heuristic is a hybrid of random search and

depth first search. The closeness of the solution produced by this heuristic to the global optimal solution largely depends on how many different combinations of orders of aircraft and orders of nodes were explored.

Developing a procedure to generate a lower bound on the value of the objective function is yet another fruitful area for future research. Such lower bounds are the best measures of the quality of the solutions obtained using the heuristic procedures especially in large size problems where exact solutions cannot be obtained.

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Software engineering and aviation safety

Engineering area is characterized by activities aimed at creation: only effective solutions that obtained by the given resources and meet the specified requirements; practical solutions with specific customers; decisions based on knowledge of basic sciences; decisions on the basis of experience, the use of which precludes the development "from scratch"; " tangible" solutions that can be used to destroy and amenable to study using empirical methods of knowledge.

Software engineering

With the development of humanity there are many engineering fields, past its formation in three phases "maturation." These phases are characterized by performers, resources, methods of implementation and use of work products.

For the first phase: artists – it is virtuosos and talented loners; resources - is intuition and brute force; methods - a random transfer of expertise, extravagant use of materials; the use - it is production for themselves.

For the second phase: artists – are the manufacturer masters; resources - are separate tools; methods - a mechanical training (e.g., "do as I do"), consideration of economic factors in the choice of materials; the use – it is production for sale, market creation.

For the third phase: artists are experienced professionals; resources are machines and systems; methods - the theoretical and empirical knowledge transfer through differentiated instruction; use - it is market segmentation.

First, software engineering (SE) was defined as the practical application of scientific knowledge to design, development, use and maintenance of programs, and related documentation of these processes [1 4]. Now SE is a systematic, regulated and qualified approach to solving problems of development, operation and maintenance of software. It is important that processes and software meet the specified technical, economic, social and legal requirements.

The basic concept of the SE is a life cycle and its three components: products, processes, resources. Life cycle consists of the phases and at this time there is a significant number of ways (models) of life cycle software implementation. From choosing one of them for the implementation also depends a software security.

Performing of the software life cycle may be in forward direction, to create the software or in the reverse direction to recover the information about the software. In this connection are distinguished direct software and reverse engineering software. Products, processes and resources of both engineers can coexist and support phases of elimination.

For solving SE also developed: principles; life cycle model; economy development and maintenance; methods of marketing and management; methodology for analysis, design and programming software; methods and means perform domain analysis, specifying requirements, architectural and detailed design, coding, testing and verification, software utilization.

For understanding and using the principles, methodologies, techniques and tools SE requires knowledge from various disciplines of computer science, economics, psychology, management and marketing application systems. They constitute knowledge SE.

For solving SE are needed engineers are professionals who have the appropriate knowledge and can use appropriate technologies, which are aimed at creating useful software. Preparing professionals with SE carried out in conditions which are characterized by the transition from programming "in the small" to programming "in the large" of development "from scratch" to develop a finished architectural solutions and components; from individual to group activities; from development to maintenance; from ignoring the standards of their mandatory use; from undocumented to documented development; from inconclusive action to evidence; from random acts to planned; from computer scientists to licensed professionals - engineers.

With the new requirements for professionals are developed models of curricula and programs focused on training with SE.

Engineering methods in software aviation systems

Creating software projects are long complex processes, which are realized through the use of appropriate resources to meet the requirements of the customer in strict time, cost and quality frames. Effective solution of the problem of creating software projects is impossible without knowledge of the characteristics of objects and processes, so the use of empirical methods in software is one of the ways to acquire knowledge and solve the following problems: obtaining the required parameters of the objects and processes; improving the efficiency of software development and maintenance; efficiency software management.

Application engineering methods are based on the use of structured programming, modularization of programs, programming styles.

Structured programming – it is programming method with the use of structured operators that are serially connected during the programming. Operators can be numbered in sequence and input first structural sequence operator will input the program and the output of the last - exit the program. A program written in accordance with the method of structured programming, called *structured*. Operators are used as part of the lexemes and expressions, and the interface (shell operator) has an organizational constraint (prohibition) of random access to the instructions in the operator (for example, limiting the use of the operator *go to*) and any output from the operator (for example, limiting the use of operators *break*, *exit* or *continuous*), although it is technically possible. Structural operators are the basis for the operator basis of programming languages. Assumed three types of structural operators, which should be used to create any programs: transforming operator (based on the assignment operator), the operator selection and application operator. Within the framework of structured programming uses three types of program transformations that can be performed manually or automatically:

– conversions, allowing to receive any structural program from a single converting specification block. This type of transformation is used to build structural programs called top-down development program (top-down), or downward programming;

– transformations, allowing to lead any structural program to a single converted block (action). This type of conversion is used for the understanding of programs and proving their correctness;

– transformations, allowing any unstructured program lead to a structural view. This type of transformation is used to restructuring programs (as part of reengineering), which from time to time is needed to perform in the maintenance software process. The existing practice of making changes directly in the source code and insufficient dissemination CASE- technologies leads to the fact that the source code, which is accompanied with the passage of time becomes non-structural, then use this type of structural transformation. Furthermore, this type of transformation used in the stage of learning the programming that is lead to the development of structural thinking of the programmer.

The modularization of programs based on the abstract data type defined type which requires a description of not only a set of values, but also a variety of operations. The basis takes ADTs data structure. Implementation of data structures can be both vector and related (dynamic). Abstract data type as any type of language used to describe the objects in the program. All operations on the objects described as abstract data types are divided into:

– constructors that change the state of the object (e.g., written in the stack, read from the stack);
– selectors, evaluating the value of the object (empty, full, what is the length value, which value in mind that at its top);
– considering iterators (investigating) an object value, for example, the values of all the components one by one sequentially.

Furthermore, during the operation over values of abstract data types can situation arise program called exceptions (e.g., the exception "stack empty", which occurs when you try to perform constructor "read" and the value of an empty object).

Regarding programming style in the aspect of security, for example, should avoid potentially contributing to the appearance of "error programming language constructs. They may even be banned by the standards critical processing systems, and in some cases can develop requirements that programs written on a subset of the language, which excludes unreliable design styles such subsets are called programming language, and they were designed for languages Pascal, Modula-2, Ada.

In the process of on-board software developing to ensure the security of critical respect, may include duplicate actions. These actions can be used at different stages of development software board. But they are most common on phases of architectural design and coding. Such actions include, for example, following:

– using during the architectural and detailed design of different methods;
– application software for coding different programming languages;
– the use of different media tools or development environments;
– using different versions of requirements specification.
– Implementation of these actions prefers having multiple teams of developers, are both involved in implementing software.

Empirical methods in the software

Scientific methods of knowledge are divided into empirical and theoretical. In the software, until recently widely were used theoretical methods: abstraction, formalization, generalization and theoretical empirical - analysis and synthesis, induction and deduction , modeling. These methods make it possible to gain knowledge of the software by examining the formal properties of abstract objects and relations between them, and also form the basis of methods of designing and implementing software. However, only the formal knowledge of properties and relations is not enough to improve the effectiveness of software processes, product quality, research and software management testing. Now there are prerequisites for application in software of empirical methods: measurement, control , identification, scientific experiment.

When using empirical methods, e.g. in the measurement software may include:

- definition of software objects, their properties and finding the relationship between the properties;
- definition of displaying properties and relations of objects in a set of properties and relations of formal objects;
- investigation of the set of resulting properties and display them on the provision of an equivalence relation, order and additivity;
- providing empirical characteristics of the software research techniques - surveillance, monitoring, counting, measurement, identification, scientific experiment;
- provision of interpretation in the context of software physical quantity;
- specify a plurality of those properties which are physical quantities and values that can be obtained by measurements taken;
- provision of interpretation in the context of software measuring conversion, comparison scale transformation steps;
- providing classification measurements methods and algorithms for measuring software;
- development of principles of construction information and software tools (basic facilities), which implement in the context of software measurement conversion, comparison, measure, scale transformation;
- development of information and software tools that allow the use of empirical methods
- Investigate and develop means of processing the results of empirical methods of application software;
- specify the scope of the effective application of empirical methods in software.
- Consider the approach to software safety assessment by applying one of the empirical methods of measuring on the example of two types of compound software life cycle (product and process) and for the three phases of software life cycle (specifying requirements, architectural design and maintenance).

Security software is a factor models of software quality. Development of requirements that guarantee security and their implementation - it is an integral secure of software life cycle, which is offered standard safety management IEC6150. One of the common indicators of software security requirements in terms of their stability is, therefore, advisable to use a metric of "stability requirements", which has the following form:

- RS = BS/AS. Where BS – is an initial number of requirements; AS – total number of requirements.In the design of software architecture is one of the main criteria - privateness]. To estimate the closure, given that the most commonly used object-oriented software architecture, choose three metrics:
- factor of private method

$$MHF = \frac{\sum_{i=1}^{TC} M_n(C_i)}{\sum_{i=1}^{TC} M_t(C_i)}$$

Where TC – is a number of classes in architecture; M_n (C_i) – number of open methods in class C_i ; M_i (C_i) – total number of methods in class C_i (inherited methods are not included);

- behavioral closeness of information

BHI = WEOC/WIEOC

Where WEOC – weighted operations on external class; WIEOC – weighted external and internal operations to the class;

private property factor

$$AHF = \frac{\sum_{i=1}^{TC} A_n(C_i)}{\sum_{i=1}^{TC} A_d(C_i)}$$

Where A_n (C_i) – number of public properties in the class C_i ; A_d (C_i) – total number of properties in class C_i (public and private).

Another criterion affecting on the software safety from the architecture is its simplicity. To assess the safety of this criterion, considering the most common object - oriented approach used in architecture, we choose, for example, such metrics:

– number of scripts scenarios N58, which directly proportional to the number of classes needed to implement the requirements (at least one script protocol subsystem);

– number of key classes NKC depending on the complexity of the domain, and takes up 40% of the total number of classes; if NKC < 20%, it is necessary to additional investigation of the domain;

– number of NSUB subsystems, which should be more than three and it should be connected, on the one hand, with the type of life cycle, and on the other - with the general costs integration software.

IEC6150 standard devotes considerable attention to maintenance phase, as well as many problems are associated with safety; arise due to poor maintenance software. One of the types of support associated with the previous life cycle phases is corrective maintenance, and therefore supports the process in terms of security representing two criteria of corrective maintenance: correctness and efficiency.

Correctness for example will be estimated by “error density” metric:

DE = A/S Where A - is a number of knowing errors; S – size of product and effectiveness – by “effectiveness of errors elimination” metric.

$$ED = 100\frac{\sum_{i=1}^{N} f_i}{cf}$$

Where f – is a total number of errors; cf – number of errors in a programming code.

Usually security model sets only qualitative connection between the criteria and metrics. To obtain quantitative estimates of the required matching, funds and scientific experiments involving experts.

Software engineering tools for the application of empirical methods In the software, the key is the concept of life cycle. There are three classes of objects in the framework, for the study of which should be used empirical methods:

– processes - actions that caused software life cycle (specifying requirements, design, implementation, maintenance and liquidation);
– products - any results of the processes (specification of requirements, design, program codes, tests, documentation, components and architectures that are reused);
– resources the means necessary to perform the processes (analyzers, converters, abstractor, extractors, compilers, loaders, debuggers, databases, programming environments, CASE, CARE).
– Software objects and their properties, which are characterized by attributes, are the subject of empirical methods. To investigate the properties of program objects using empirical methods required matching funds. Work on solving specific problems that are associated with the use of empirical methods in software, being a long time. Now these works are together within the funds Computer Aided Empirical Software Environment (CAESE).

The purpose of the application of these tools – is learnings about the software that allows to solve a certain problem, test the hypothesis or answer the questions. The result of using tools - knowledge that is necessary for understanding, developing or maintaining software. Knowledge is acquired through data - the results of the use of empirical methods. Obtaining these data is carried out using the tools which users are the experimenters.

The main part of the CAESE can be means that allows you to explore a variety of properties object and give their display on the equivalence relation and order of additivity. It actually displays the status of the object properties by one of the independent values. Defining that value can be based on the identification of the state of the object program.

To implement this operation proposed a software tool (measuring instrument). Consider the appointment of members of the meter. Scanner sequentially reads characters program. Information on the output of the scanner also appears in succession text characters; control lines (indicated by dotted lines) are intended for the exchange of "start-stop" signals to the control program. The analyzer is designed for selection program constructs that are contained on the appropriate level of examination program text (lexical, syntactic, procedural, cool, modular). Stream analyzer output is marks of programming constructs at predetermined levels of consideration. Control lines are used to configure the analyzer.

The identifier is used for identifying objects using defined signatures templates. With the advent of the input identifier of the corresponding object on his output signal formed unit "found" and the values that correspond to the signature. The control program configures the Authentication ID in the specified objects by selecting an appropriate template.Template set contains a description of the object, necessary to identify the corresponding object in the program, and the values that correspond to him. For example, to determine number of methods (M_n (C_i) in factor MHF) as objects that are identified and use routines that are responsible methods. The level of review of the text of the program – is subroutine and level of description - appropriate grammar.

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Instrumental software for aviation safety

In connection with the massive introduction of information technologies, the main instruments in the aviation industry are computer programs. And because of the safety of aircraft operation is a defining part of the concept of "quality of the aircraft", the software tool is the focus and control object by the competent state and inter-state organizations

Introduction

Quality of any technical products directly depends on the instrument by which it is created, and which is now also certified in all spheres of human activity. Complex technical products also accompanied by a special tool to support their life cycle.

Modern tools and functionality

In connection with the massive introduction of information technologies, the main instruments in the aviation industry are computer programs. And because of the safety of aircraft operation is a defining part of the concept of "quality of the aircraft", the software tool is the focus and control object by the competent state and inter-state organizations in the USA – PAA, in Europe – JAA, in Ukraine AP IAC and UkrAviaTrans.

With the software tool in the field of aviation linked practically all activities spheres of the development and operation of modern aircraft and its components. So it is clear what should be the focus degree on such types of products. If, for example in the package of application programs that are used to calculate structural strength of the aircraft, contained undetectable error, then it is not necessary that it manifested during the static design test not only because of the limited functional testing, or for example, due to the nature of static loads. Error may occur much later, at the time of operation of aircraft in very narrow dynamic conditions. In addition, the consequences of such manifestations may be very serious. It should be noted that during the static strength test for processing of their results computing equipment is used, and therefore - the corresponding software instrumentation. And it may also contain errors. The same applies to software that is designed for aerodynamic calculations, material handling of blow down models in the wind tunnel, for the design of specific structural units of air vessels - wing or tail unit, for the manufacture of parts of structural elements on machines with numerical control, recording and processing of the results of flight tests.

A typical example for understanding the differences between analog and digital instrumentation systems can serve the stage of test results aircraft processing and its components. At this stage the most used different means of measuring art as a universal application, and specially designed means to test a specific system. The main purpose of their use - obtain quantitative estimates of the technical characteristics of the aircraft and confirm the stated requirements, and finally get a certificate of compliance for the aircraft.

Measuring the correct value should be guaranteed. World experience has developed a form to obtain such guarantees for analog measurement technology in the form of a special organization and carrying out related activities, i.e. for all instruments and tools (note - the ones that are not computer equipment), with which is monitored and subsequently certified by one or the other function of aviation system, responsible service General Metrology, which keeps records of regularly inspects and certifies these devices. By that time, when digital electronic equipment appeared on the aircraft onboard, service instruments of General Metrology were the main tool of the proof for proper functioning of onboard system.

Now onboard electronics is digital, on one hand, the developers of the onboard systems refuse specialized in CMH favor of computer equipment total destination, on the other - the usual appliances became impossible to verify on-board function. This can be done only with the help of computer technology, which is equipped with the specialized software tool.

Software for modern means of measuring apparatus, based on computer technology, directly involved in the conversion function of physical quantities, their processing and visualization. Therefore, it becomes a full metrological significant component of the measurement process and it is needed to put into practice mandatory and reporting verification procedures, quantify and guarantee proper operation of the software. At the same time as a separate software tool metrology needs to be documented, recorded, tested for proper functioning, to receive official approval for use and, of course, be adequately protected from errors, tampering or loss.

In addition, software used in measuring equipment, constructed on the basis of computer technology, now holds the measuring (instrumental) software, which is designed to measurement in software. Such software may include all that has been said about software instrumentation based on computing.

Despite the widespread use of computer technology as a means of measuring processes to test modern aircraft of its units and systems and the lack of viable alternatives, without addressing the certification of software tool can’t officially refer to such measuring instruments as a means of proving compliance. Therefore, the list of tools for different checks, tests, measurement units and aircraft components in western regulation documents near with the usual micrometers, thermocouples, voltmeters, oscilloscopes there are computer programs too. They are subject to all the requirements, which must respond to the instrumental controls, as well as to the software demands are as a particular kind of product, regardless of its specific purpose. In particular, PAA created several instructions quality management and certification software tool. The main requirement of the software, which is used as a tool should qualify before the use.

Thus, we can state the following:

– functionality of the tool covers all phases of the software life cycle of the aircraft, namely: design, estimated and development work, experimental studies, pilot production, refinement, testing, certification of aircraft systems and its components (including avionics software), batch production, maintenance of aircraft, as well as organizational and managerial activities of businesses and organizations that are involved in these processes;
– instrumental importance of software, its impact on the safety of aircraft operation and the degree of responsibility for the correctness of its operation is not lower than the target software (application, functional, and in particular on-board), so to software tools, which are subject to qualifications, must be submitted to the same requirements that are for onboard software too.

Features of software tools and its applications

Specificity of product engineering software fundamentally changes not only the process of creating digital systems, in contrast to analogue, approaches to them, but also views on the use of tools.

From a security perspective of the aircraft identified four features that are not inherent in samples of analog equipment, but typical to the digital: tools as a source of error, phenomenon of "freezing" of the system, the conditions of non-functioning, multiversioning of the function.

Limiting of software avionics systems, software tools are usually divided into two types: tools of onboard software development processes and processes tools of its verification [295, 830]. As the result of the first is the product of the board software development tools that can be sources of errors, specifically, those tools can directly introduce errors in the software side, i.e. in function of the system, and this is a very significant feature. Verification tools do not make mistakes in the test product, although they can not find them, and there seems to be a coincidence that appears to analog testing instruments. Nevertheless, the error made at the design stage of analog equipment, and later - at the stage of testing may not be found only in the case of unfixed fault test equipment that provide all relevant process steps and instructions. Digital technology also has the opposite feature.

In addition, the differences between software development tools and its verification tools now formally defines the different categories of control tools. Last position controversial as:

– first of all, development tools and software verification in practice are combined, i.e. to demonstrate complete separation that applied to the software tools between design functions and verification, as a rule, almost impossible. Hence the necessity of a single and higher category control tools, that draws attention to the document KT-178B;

– secondly, and this is important in terms of security guarantees for the aircraft, it does not matter who or what introduced a bug that ultimately resulted in the emergence of a special situation, as well as the fact that the same situation may arise due to a bug in the software, but because of a hardware failure. Moreover, in cases where the tool is a tool for creating software (including all kinds of tests) of the target software, their connection and at this higher level is so close that even a very thorough inspection of the target software, seemingly the main, due to insufficient attention to the instrument software can be quite ineffective.

Vivid example - it's a mistake of writing a point instead of a comma in a single operator of the hundreds of thousands who had been detained in the control program of the first flight of the spacecraft at Venus. This error led to the loss of several hundred million dollars and was made by a programmer, but because of the features of the used tools (in this case the compiler) was not detected in the verification procedures.

Most effective measures to reduce the risk of introducing errors still remain limitations to apply the tools of choice of programming to support the data types and operators. Next, it is typical for software, a feature that appears only during the operation of the system - the phenomenon of "freezing" or loops when the technical data of the system remains serviceable and workable (calculations performed), but the expected result computing the user is not in the specified time, it is necessary to qualify as a malfunction and system failure. This phenomenon is quite complicated in terms of detection, and therefore widespread and dangerous.

The problem is that the traditional system testing for the functioning guarantee its normal operation only in predetermined specification conditions. Here the definition of the boundaries of the possible conditions difficult as the complexity of the software logic, which, as is well known, even in relatively small programs exceeds the available for the human border analysis and the fact that these conditions may result not only of programming errors, but also unexpected actions of crew members or other personnel and equipment failures. Critical real-time systems, in contrast, for example, from computer-aided design should be continuously operate in spite of external or internal disorders, or incorporated in such cases of the predetermined mode from which it has a safe exit.

In such circumstances, for the product are assumed special tests of logic, when developed and applied software instruments aimed at calculating borders cycling beyond the specified conditions. This implies that in investigated product provides protection mechanisms move beyond cyclical or beyond the specified time of the duration cycle.

Another feature of the software is under the non-functioning system. Essence is as follows.

Test analog equipment where circuitry implementation functions virtually guarantees inefficiency of the investigated equipment outside the specified conditions for the operation, usually held in these technical requirements specified limits and are considered adequate for digital equipment, more precisely, for its software, except similar tests on operation, must be additionally provided robust tests, i.e. tests for ultimate conditions, and for including input data. The purpose of robust tests demonstrate the ability of the software most definitely react to abnormal inputs and conditions. Moreover, atypical can be quite typical provided data, but, for example, where the gradient changes under real operating conditions is impossible.

Recommendations for robust test cases include: checking system initialization of unforeseen circumstances, checks using invalid equivalence classes for variables checking with a shift data width. This also should include studies of the arithmetic overflow conditions of the dynamic elements such as filters, delay and integrating circuits.

Multiversioning function implementation is also a typical feature of the software critical systems. To obtain a more reliable product in the most severe cases of software development, consciously develop several versions of the software for the same system functions. It is difficult to imagine a similar situation for the analog system, where in such cases simply duplicate the original version of the system for redundancy (particularly responsible system is reserve twice).

Set of dissimilar software versions created a combination of these methods: project development software and source code by different groups of developers; the use of different programming languages; code generation by different compilers; editing and downloading of the object code by different linkers loaders; object code execution on different processors; version verification tests in different environments.

Verification Methods of multi-version software materially differ from the methods of single-version verification software because of the dependence of the functioning of its software architecture and the combined hardware architecture, i.e. emphasis on verification testing mingle event aggregation and integration software. Therefore, although more, the main importance for multi-version software in order to verify the satisfaction of the requirements for compatibility with the correct versions of both, and at malfunction.

Thus, the principal and integrating feature of the software tool and its application is its focus not on the proof of the correctness of the system studied as analog test processes (although this is also necessary), and to find the conditions under which the software is not work or may not work properly. Only in this way it can be minimized, and possible initiation of software defects in step its development and the consequences of undetected defects in the following stages of its life cycle.

In this sense, a formalization of the research techniques of software development processes as well as the actual product, may be the only reliable access to the current situation.

Programming style ontology-driven tools

As case study, the instrumental tool using of programming style in programming safety software is presented.

Programming style is a set of rules or guidelines used when writing the source code [1, 2]. Programming style reflects existed not only technical, but also a cultural experience. Following a particular programming style will help programmers to understand source code. Through a collective development and reuse style has relation to many of software life cycle processes. Applying styles increase the effectiveness of development and software maintenance. Using the programming style in a particular program may be derived from the coding standards or code conventions of a company or other computing organization, as well as the preferences of the author of the code. Programming style is one aspect of software quality.

Application of programming style is associated with the following tasks: the first, the using of style, when source program text is wrote; second, check the text for style; and the third task is convert text from one style to another. In this thesis decisions the first and second tasks with the help of ontology are looked.

Our study showed that programming style ontology could be consisted of three levels of knowledge representation [3, 4].

On the first level, the knowledge about programming style and the programming language is presented. On this level programming style rules taxonomy and the link with programming language units are descripted. On the second level, informal description of programming style rules is presented. The knowledge of first and second levels consists of programming style taxonomy and programming style rules verbal description. On the base of this knowledge, the tool for decision the first task was created. It was called the programmer assistant. This tool can be created on the anything ontology oriented system, for example, Protégé. The programmer uses this tool when her or his write source code using concrete programming style.

The third level of ontology consists of formal programming style rules descriptions. Description logic is used for rules representations [5]. For example, the following rule: Do not add an Event suffix (or any other type-related suffix) to the name of an event in ALG: EventIdentifier $\sqsubseteq \neg \mathit{hasSuffix}.\{\text{‘Event’}\}$.Then ALG description is transformed in OWL and a reasoner using information from the source code analyzes OWL text of rule. On the base of this ontology level representation was created the tool for decision the second task that is called programming style controller.

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Constructing augmented reality applications

Methods of the building of augmented reality applications on platforms Unity and Vuforia are proposed. Results of performance testing mobile implementation are presented.

Introduction

Due to the rapid growth of technology, the scope of application of augmented reality (AR) [1] has grown significantly over the past two decades. AR may increase the efficiency of navigation devices. Information can be displayed on the car windshield, indicating the direction and purpose meter, weather, terrain, road conditions and traffic information, as well as warnings about potential dangers on their way. On board ships, the AR can afford the bridge pillars guards to constantly monitor important information such as the title and the ship's speed when driving over a bridge, or other tasks.

Review of the potential augmented reality engines

There are three main solutions that are best suited for augmented reality application creation: Unity 3D,Unreal Engine, ThreeJS. lies in the platform supports the engine, the output format and the number of functional application for augmented reality.

Augmented reality functionality of engines is compared in table 1.

Table 1.

Comparison of the engines augmented reality functionality

	ThreeJS	Unity 3D	Unreal Engine
Output format	HTML5 Web-page	Different format for every platform	Different format for every platform
PC AR Support	Full	Partial	Full
Mobile AR support	No	Full	No
AR SDK Presence	No	Yes	Yes
Flexible input	No	Yes	No
Flexible data storage manipulation	No	Yes	Yes
Flexible network manipulation	No	Yes	Yes

The main advantage of this approach is that the application is written only once and does not require the device for other platforms. After the HTML-page that contains content created with the help of AP, it can be run in any browser that supports HTML5, without any platform dependencies. Devices using this technology may not be limited to a PC or mobile platforms. The only requirement is to have the appropriate browser for this platform.

Also ThreeJS is the only engine that provides full support for the PC platform, which allows using the application of augmented reality using a webcam. But since the use of these applications is very narrow, it is completely covered with the advantage of a lot of flaws.

On the other hand, the use in HTML5 can be a great disadvantage, particularly in these days. The main problem is that the HTML5 technology is not fully used, even on the PC browser. Only a limited number of phones support HTML5, which is due to the large differentiation of mobile equipment and high hardware requirements HTML5-based application AR.

Also, if analyzed from the flexible visual interface creation suitability, any web based solution suffers from the few more critical problems:

Web based applications are often limited in the hardware usage due to security reasons.

Web based applications are also limited in the local network usage due to the same reasons.

Inability of creation of flexible input interfaces that wrap different hardware drivers with the unified input handlers.

These problems can be transparent in the case of visual interfaces, which serve as one input. But, with one input and solutions should be easily extended to multi-input. And this is impossible without easy and flexible access to the hardware input.

So, as a web-based solution may be easier to make cross-platform and begin to develop, they still have to be a big increase in popularity of mobile platforms and to develop a more flexible scheme of hardware interaction.

Augmented reality modeling overview

For implementation an augmented reality were selected following steps and methods of creating modeling patterns related to our current application. Patterns design data will be used to create a model of the application as a template to create applications of augmented reality.

There are main pattern that will be used to create applications using augmented reality technology. This pattern mentioned in the previous sections as augmented reality with recognized objects.

This model should be modeled in great detail how these models can potentially become a base for the creation of several different types of augmented reality applications. This model can be subsequently used to construct any application of augmented reality on the basis of recognition objects.

Also, these models should be strictly structured. This involves using rigorous methodologies and rigorous development tools such as Vuforia. When using these modeling tools with high accuracy is very important stage of the design methodology for the subsequent development of applications based on the recognition of objects.

The main reason for the use of design patterns to create a model of applications based on the recognition of objects for use in augmented reality is that most applications of augmented reality have the same type of structure, and has no particular need for the design of each individual specimen with complete details of the model. Usage patterns can significantly reduce development time of similar applications.

Also, because of the high degree of refusals of applications should be designed based on a high degree of protection against failure. Designed model should allow the creation of third-party applications from connecting to the network, since the refusal to connect to the Internet is one of the most extended the causes of errors in applications based on augmented reality. This model should have a partial shutdown mode functionality of the Internet. In this case, the module object recognition must take on additional functionality.

Anyway, the design and development of augmented reality applications with the recognition of objects, applications based on geolocation and mixed applications have a large number of differences from the difference between the input data. The difference between the input data leads to a need to change some of the data analysis technique, but also entails a certain structure changes architecture application, which subsequently leads to a change in time and cost of application development.

Basic modeling augmented reality applications is the means of Unified Modeling Language. Specifically: use-case model, logical model and model components.

Use case model was developed as a use-case diagram (here not presented) by using of two patterns of recognition The size and position are internal data, and are used to render objects in space on a layer of augmented reality.

The main entities of logical model are determined: VuforiaHalper, ObjectRecognizer, ObjectPool, ObjecOne, ObjectTwo.

VuforiaHelper - the shell is used primarily for communications applications with a set of libraries provided by Qualcomm in their set of libraries called Vuforia. This entity is intended connection Vuforia, miscalculation of data obtained at the entrance of the library, sending data to the output device, and receiving the final data from the input device.

ObjectRecognizer - used to recognize objects, respectively, with patterns of recognition laid down in the database module vuforia. This module takes the suitable objects from ObjectPool and checks them for the appropriate pattern recognition.

ObjectPool - is a conditional store objects found component Object Recognizer, at the analyzed site. In ObjectPool stored data on found objects on the screen of the real world, as well as data on the patterns of recognition, which came under the found objects.

ObjecOne and ObjecTwo - pattern recognition inherent in component ObjectPool. In these patterns include the information necessary for visual object recognition, and external data object, such as its metadata.

In a typical use case methodology, we get approximately the next process sequences:

1) ObjectPool receives data about the objects.
2) Recognizer objects selects the object from the list of objects found in ObjectPool.
3) VuforiaHelper receives data and conducts processing.
4) Data processing VuforiaHelper.
5) VuforiaHelper sends data to the output device, a layer of augmented reality.

Logical model was developed as Collaboration diagram and sequence diagram for actual prototype of application (here not presented).

The process of the exchange of data between components is strictly distributed. This is dictated by the total area of use. Since the application was built on the model described can perform tasks of high complexity, the model itself should be as simple as possible. Actions pool concept is a method for separating complex tasks, so that any object, no matter how difficult it is not implemented in a single unit operation on the object pool.

Also, in the structure of private data patterns to create a strict hierarchy of the data and make a clear separation between external and internal data pattern recognition. This is a significant measure will enhance the protection of future applications of the exemption of power on the internal data pattern. More interaction is provided by only one of the modules of the system, it allows even more to protect the logical structure of the application of the Malfunction of use.

The third step in the creation of the model is to determine all the possible states of the model. The reason for the need for this process is that the application must conform to the model as much as possible, and this can only be achieved if all states in which there is an application may be the same and will not contain the critical differences for the creation of a typical application of augmented reality on the basis of this methodology.

Thus, the main condition of the recommended applications based on augmented reality is:

- Expectancy of data changes.
- Processing of data obtained from the recognized objects.
- Performance of certain action, which is based on processed the recognized objects data.

Thus, we hold constant analytical checks on updated data, in order to find even minor updates to them. This will allow us to optimize the process of recognizing objects. As there will be no need to re-recognizing the object, all we need to do in this state of the object, it analyzes its data and state until the object is found on the screen. Tracking has recognized an object in space is made tracking component library Vuforia automatically.

It is important hard division of processing and calculating data. This division will allow us to carry out the processing and counting on different do not affect each other layers, and are in different states. This separation allows you to spend less resources on the count data to identify the object. All comparisons object pattern recognition performed in a state the object, and its data processing and tracking it, produced in the data processing state.

Identifying objects are partially similar to the pattern of the object. It produces components pool facilities in the state of the system is responsible for the recognition of objects from the real world images taken with the camera device. Recognition of this system has been a component recognition system library Vuforia. As a standard pattern recognition objects used as the standard company Qualcomm and database to standardize and analyze patterns visual recognition and visual processing systems of two-dimensional and three-dimensional images.

The decision is made only once, because the data is received and processed to meet one of the conditions of action. All state and transfers between them were implemented in State diagram for Augmented Reality-based object recognition (here not presented.

It is clear that any State should be optimized itself, keeping any action necessary for the transmission between the serial and the state as small numbers as possible. Well, that's one action for the transfer, which means that any state and any actions are atomic and can not be divided in any other sub-states or sub-shares. Model action that fulfills this requirement was developed as an Action diagram.

Action diagram shown in Fig. 1 is a very important and integral part of the design methodology for applications, especially when it comes to augmented reality applications, as described in this diagram condition data acquisition and display of the data in the area of end-user visibility.

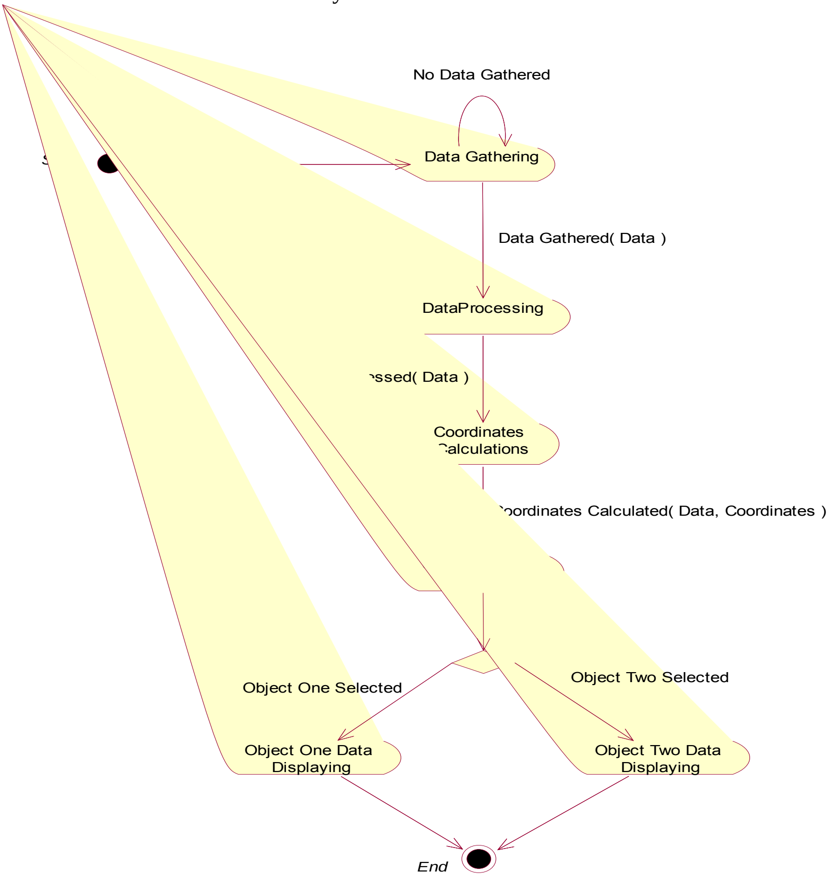

Fig. 1. Action diagram for actual prototype of application

Component model we can contemplate the component diagram n Fig. 2,. It shows the two main members of the library Vuforia. This library .a extension for devices with IOS operating system and a library with an extension .so for devices with Android operating system. The presence of two libraries in the package allows us to significantly facilitate cross-platform component applications

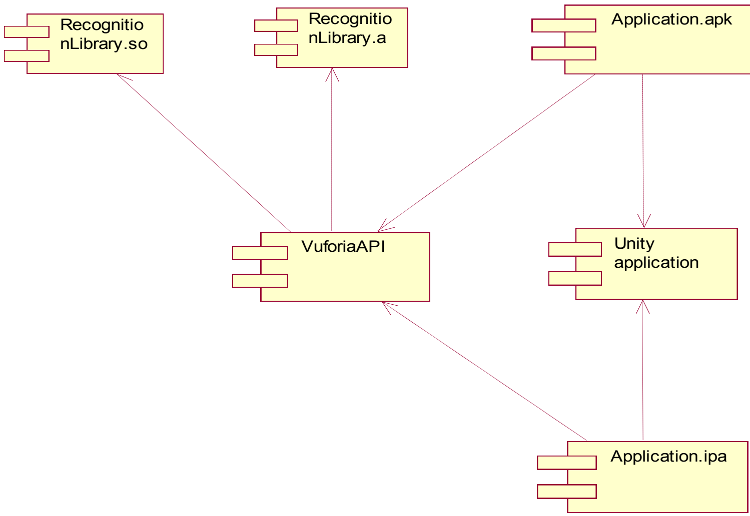

Fig. 2. Component diagram for Augmented Reality-based object recognition

The component diagram shows the two main members of the library Vuforia. This library is an extension for devices with IOS operating system and a library with an extension .so for devices with Android operating system. The presence of two libraries in the package allows us to significantly facilitate cross-platform component applications.

As this diagram shows the component device applications and the like all libraries in Unity Recessed shell.

Mobile platforms testing

The following tests for mobile platforms should be performed:

• CPU consumption test.

• Test memory consumption.

• Consumption test GPU.

In order to determine the level of resource consumption on mobile platforms and its growth in the complexity of the task and the intensity was a test at three levels of payments processor difficultness. These three levels are:

• Baseline - multiple simultaneous tasks without data correction rotation.

• The average level - a large number of simultaneous tasks without correction data rotation.

• Complex level - a large number of simultaneous tasks correction data rotation.

Testing is performed on a mobile platform based on two types of devices:

• Android-based devices.

• IOS-based devices.

In terms of real application performance, the performance criteria of the processor is simple - you need to use to consume the amount of CPU time in percentage, no more than 50% of the time in the CPU tick at peak stages. Compared with the conventional performance criteria, this criterion has several advantages:

• To confirm the criteria for complicated calculations do not need to perform.

• Calculation of growth in consumption of CPU time does not matter, as soon as the peak consumption issues.

• To adjust the peak consumption of the prototype is already installed on the middle peak of consumption in the most common applications of augmented Reality, there is no need to be translated into most applications.

Results of the CPU consumption test are presented in Table 2.

Table 2.

Mobile platforms CPU resources consumption

	Basic level	Average level	Complex level
High-end Android devices	27.41%	42.17%	52.13%
Average Android devices	53.78%	60.94%	88.41%
High-end iOS devices	29.41%	45.02%	52.76%
Average iOS devices	42.94%	55.80%	60.92%

The first case is the most powerful Android devices available on the market. In this case, the amount of processor time consumed was exceeded only in the most difficult level testing. The amount exceeds 1.42% was compared with the criterion. However, this amount may be neglected, and the test that was performed on high-end Android devices can be considered successful.

The second case is the average Android device common to everyday use. These devices show a low efficiency, as the criterion has been exceeded at the most basic level test. And in the most difficult case I was exceeded by 28.88%. This amount can not be neglected. In this case it is considered the prototype cannot be used in the average Android device.

The third case is the most powerful device IOS available. In this case, the most sophisticated level of testing criterion consumption exceeded 2.76%, which can also be regarded as a success.

The fourth case - the average IOS devices shown successful results on the basic level, however, a slight excess of the criterion has been registered at the secondary level test and more exceed the most sophisticated level. However, the devices are suitable for simple applications, augmented reality without many challenges.

The results of all testing confirm that the model of visual interfaces created on the basis of the rotation as a basis is prototype viable and suitable for use for a future augmented reality based on it.

Conclusion

Perspective create applications based on augmented reality was disclosed. Augmented reality is one of the fastest growing trends in multimedia technologies for today's date.. It has been suggested possible markets where this technology is already developed, and can be introduced to commercially available for several years. Since the standard approach to the development of applications based on augmented reality it was not there, was proposed methodology for creating applications that unifies and standardizes the approach to the development of such applications. Considerable work has been done to optimize the methods of tracking images. By using the accelerometer and gyroscope turned out to significantly improve the accuracy of the data display and significantly increase productivity.

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Review methods of software cost estimation

The problems of timely and accurate cost estimation of software development are considered. The existing approaches to determine the cost of software development projects are analyzed.

Software cost estimation.

Modern organizations use software development to meet the challenges of the company and increase the efficiency of labor and production. Software cost estimation in the early stages of development is very important both to the customer and the executor at the growing quantity of high budget projects. Correct estimate has a significant impact on the value and profitability of any software project. The main causes of estimation errors is the uncertainty factor, especially in the early stages of the project, poor project management, creates additional uncertainty, unstable requirements, is not included in the calculation of the tasks, the excess optimism of estimate , the presence of subjectivity in assessments, ill-considered and unfounded assessments ignorance of the subject area, simplification of the evaluation when transferring it to the top levels of management, lack of a unified mechanism for valuation. The latter is an important issue for companies with large projects, the quantity of which can reach more than a hundred a year, and for companies engaged in software development for aviation.

In order to get of accurate estimates for cost software development have been developed methods and models of estimate . The importance of their use is reflected in the need [1]:

– determining whether to make investments or take other financial decisions related to software development;

– implementation of control over the budget and project schedule;

– decision making than it is worth sacrificing a certain situation – monetary costs, time, functionality, interface, or quality;

– decision regarding the risks associated with the project cost and schedule of works;

– decide which part of the software should be developed, which re-use, and some purchased from an external producer;

– determine which parts of the software to modify the first; what parts to remove, on develop what parts to appoint external performers in the case of developing a new version of the system.

At the moment, among the existing methods and models of estimate software cost can single out three groups [1, 2]: the algorithmic model, non-algorithmic methods and combined. In the first case, the mathematical formulas in the second – certain principles and schemes, in the third –to combine several models and methods.

The most popular not algorithmic methods are: expert judgment, estimating by analogy, «Poker-planning».

Expert judgment method. In application of this method the software system is decomposed to the level of elementary components. Estimation of the size of each component is made either by an external expert, with experience in the development of such systems and are prototypes or specialist developer and customer. Each of the experts should give optimistic, pessimistic and realistic estimate. The experts used a variety of formal methods, walkthrough; inspection. The method of «expert judgment» usually have to be complemented by other methods of estimate such as algorithmic methods.

Method «Estimating by analogy» offers a comparison of the current project with a similar previous project which already completed. Current information on completed projects is collected and used for the evaluation of the current project. Stages of estimate of this method: the determination of the current characteristics of the project; selection of the most similar, already completed projects, whose characteristics are stored in the company database; the conclusion estimates for the current project with similar, already completed projects, using the analogy.

«Planning Poker» is a variation of the method of Wideband Delphi and used in agile methodologies. Realized estimate of «User Story», which takes place in several rounds, with the participation of all team members, which takes a considerable amount of working time. This approach minimizes the effect of binding by a survey of each of the team members so that no one knows another's solution until simultaneous announcement of the choice of each participant.

Algorithmic methods are designed to apply mathematical equations to represent estimate of cost for software development. These mathematical equations based on research and used to inputs the SLOC, the number represents of functions, languages, development metodology, skills levels, risk assessment, etc. Algorithmic methods are well known and many models based on them, such as COCOMO model and the models based on function points..

COCOMO model is based in 1981 on the experience development of many software projects [2, 3]. COCOMO uses a simple regression formula with the parameters defined from the data collected on a number of projects.

COCOMO II – an improved version of the basic model COCOMO. It includes three models [2, 3]:

1) Application Composition Model – used at an early stage of the project in order to evaluate: the user interface, the interaction with the system and productivity. For initial size is taken the number of screens, reports, and 3GL-components.

2) Early Design Model – a high-level model, which need a small number of output parameters. It is designed to assess the appropriateness of the use of certain hardware and software in the development process. To determine the size used Unadjusted Function Point. For her transformation in the LOC used table data [2].

3) Post Architecture Model – the largest detailed model, which is used when a project is ready for development. To estimate the cost of the software with her help needed package by description of the project life cycle, which stores detailed information about the factors of cost and allows for a more accurate assessment. It is used at the stage of actual development and maintenance of the project.

To estimate the size can be used as the line code (LOC), and functional point (FP) with modifiers, which take into account reuse of code [2].

An important feature of the model COCOMO II is that to increase the accuracy performed estimates by project manager may eventually to retune rating scales and coefficients to suit your needs – to produce a so-called calibration model.

Calibration can be done in two ways: by expert estimates and by multiple regression analysis.

Function Point Analysis (FPA). The estimate is based on determining the size of a software system in terms of the number and complexity of functions implemented in software code. The future system is described as a multi-level graphical model. Each of the functions includes input and output, conversion, external interfaces. The procedure estimating of a software system includes the following steps [1, 2]:

1) extracting of a set of functions (business processes);
2) estimation of the number of function points of the business process of each category;
3) determining the weighting factors of complexity of each function;
4) accounting the factors and requirements of a software system development environment;
5) calculation of integral indicators of complexity;
6) calculation of final number of function points;
7) determining sizes of software system in indicators LOC;
8) determining the size of a software system as a whole.

In determining the amount of the functions of each business process should be guided by the following requirements: to consider only the complex functions listed in the specifications; during decomposition of complex function are taken into account all of the logical conversion with data. Calculating the number of function points for each business process tabulated.

Conclusions

Under current conditions index FP and its derivatives are among the most successful ways to measure the amount of work on the software project. Important advantages of this indicator is its focus on specific business functions of the software and the ability to effectively use the early stages of working on a software project. However, application domain of this indicator is limited primarily to large and medium-sized projects, the use of this indicator is considered to be not justified for smaller projects.

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Complex of the programs for support of information integrity while displaying the integrated dynamic scenes in automated air traffic control systems

A new approach is proposed to display the integrated dynamic scenes on the basis of programmatic support of information integrity in the automated air traffic control systems. The result of combining the components of different scenes is semantically correct and consistent image of the air situation observed on-screen.

XXI century: mankind has entered the information technology era; data carriers have become cheaper than information, stored on them, a value of which is determined by content. In this regard, any modern information system is faced with problems of information security and data integrity. Especially it concerns the large distributed real-time systems, to the class of which the automated air traffic control systems (AS ATC) belong.

Importantly, a modern form of the information systems are data banks, which include in its structure a computer system, one or more databases (DB), a database management system (DBMS) and a set of application programs. Growth of requirements to characteristics of applications that as part of AS ATC provide the processing of complex data about the current location of the observed aircrafts and geospatial information, correlated with them, and also ensuring the implementation of a number of calculations [1] for generation of the output integrated dynamic scenes, entailed the development of these systems towards the improvement of 2-D scenes' imaging technology to support the informed decisions of ATC controllers.

If initially the primary importance when developing such systems has been an increase in the speed of access to data and a minimization of amount of stored data and service information related to them, then afterwards, with appearance of more rapid element base and with increase of the memory volumes, the requirement of reliability of information storage [2] moved to the fore, that, in turn, led to the need for redundant data storage.

Evolution of the information systems is linked, foremost, with development of relational database technology. One of the fundamental concepts of database technology is the concept of integrity associated with the fact that a database reflects an object or a set of related objects of the real world in the informational form. In the relational model such objects are represented as a set of interconnected relations [3]. By other words, in the theory of databases the integrity implies the accordance of informational domain model, stored in database, to the objects of the real world and their relationships at each time point. Any changes in the domain, which are meaningful to the constructed model, should be reflected in database, with saving the unambiguous interpretation of information model in terms of subject area.

It is known [4] that support of integrity in the relational data model in its classical sense includes three aspects: structural, language and reference.

Support for structural integrity consists in that a system, based on the relational data model, should be allowed the work only with the homogeneous data structures such as "relations". At the same time to ensure integrity of database, the constraints of integrity are imposed in the form of certain conditions to be fulfilled by data stored in base. Examples of such conditions are:

- limitation of the range of possible values of attributes of objects, the information about which is stored in database;
- absence of duplicates of the tuples determined by the rows of relations;
- arising from the previous statement, the mandatory presence of the unique primary key that is one or more columns-attributes, which uniquely identify each record in table, that is allow clearly to distinguish one record from another;
- absence of concept of ordering of tuples.

In addition to the structural integrity it is necessary to consider the issue regarding the uncertain (Null) values. Null-value in a relational database is interpreted as a value, which is unknown at this point. At appearance of additional information at any time this value can be replaced with a certain specific value.

The support of language integrity is treated as an opportunity to ensure description and manipulation of data using SQL language, by eliminating the possibility of the low-level data manipulation tools that do not conform to the SQL standard. That is why access to the information stored in database, and any changes to this information can only be performed using SQL language operators [3, 4].

Support for referential integrity means ensuring one of the principles defining the relations between the instances of tuples of associated relations: the tuples of subordinate relation are destroyed or are modified when removing the tuple of the main relation, associated with it. Thus, in second case, Null-value is placed to the site of the parental relation key.

Referential integrity excludes the errors of links between the primary and secondary key, providing support for a consistent database state during modification of data when performing operations of adding or deleting. Examples of violations of data integrity are the existence of records-orphans (child records that have no connection with parent records) or the existence of identical primary keys.

The above integrity constraints in general do not define semantics of database; therefore other methods are needed to determine the restrictions which are related to database content. These methods are summarized in support for semantic consistency. The semantic support can be provided in two ways: declarative and procedural. The declarative support is executed by means of the SQL language, and procedural one is to use a code implemented in DBMS as stored procedures and triggers.

If the system supports neither declarative mechanisms for integrity constraints nor triggers then the code that monitors the database correctness must be placed in the user application. It substantially hampers the programs design and, most importantly, does not protect against the possibility of the user fulfillment of the operations violating the data integrity, bypassing the restrictions implemented by the application. A situation is particularly complicated in the case where database works with many different applications, rather than alone. Each of such applications must contain the same code, responsible for maintenance of the database integrity and which at necessity of change of character of integrity constraints must be modified in all applications synchronously.

Thus, securing the database integrity is a prerequisite for the successful operating of not only database, but also of application using it, as a whole.

Organization of AS ATC in the form of client-server applications produces the high demands on database performance with considering transmission of data arrays of large volumes over the network [5]. Moreover, the current real-time system should provide not only effective access to the files, but also protection against unauthorized access and the data consistency.

Scheme of the computer flight data processing in modern AS ATC contains the risk of loss of data integrity [6]. According to the intention underlying the functioning of these systems, the solution of general task – maintenance of the integrated technology of work of controllers' staff – is divided into two directions:

1) maintenance of updatable data about the environment in which the ATC process develops – about the state of atmosphere, the bandwidth of the airspace structure elements, the technical condition of the radiometric tools and communications equipment;

2) support of data about the objects of management – aircrafts, accomplishing flights.

Subsequently, both types of data are integrated into the sequence of the displayed dynamic scenes combining the variable layers of cartographic background and the symbols of varying degrees of complexity reflecting a state of controlled mobile objects.

Accordingly, structure of AS ATC software is built on the principles of separation of functions of its elements [7]. So, the testing and management operations of radars, direction finders, data transmission channels are assigned to the complex of the programs (CP) for control of the peripheral information sources. CP for processing of meteorological information summarizes the data about weather in the area of responsibility of the system. Special programs transmit the data about the mode restrictions (into the workplaces of controllers) regulating the order and the access levels for different groups of users to databases, which contain detailed information about the cartographic background of dynamic scenes [8].

As a result of work of the listed programs the geospatially referenced and the stand-alone updated descriptions complemented mutually (about every air field, about every source of measured and planned information, about situation in sectors) are created in an appropriate system database. The resulting descriptions may overlap, for example, coordinates of aerodrome, its name, airstrip code, and may partially differ (state of cloudiness, air temperature, boundaries of sectors of approach and circle).

Similarly, each object of control – aircraft – is accompanied in the separate descriptions of CP for handling of the planned and measured in real-time radar and satellite information. In accordance with the objectives of the two subsystems – planned and actual – each of them uses different mathematical models for computation of trajectory of the same aircraft.

The programs-schedulers work with an accuracy of the scheduled messages, in which time is indicated in hours and minutes, the distances are converted from coordinates and names of air fields, air traffic areas and routes, and a height is set to within a echelon. However, at computations they take into account neither the rotation maneuvers in the inflection points of tracks nor other nuances of the flight path.

In contrast to the algorithms of work of the planned subsystem, in the process of calculation of trajectory, CP for handling of radar data monitors the parameters of the aircraft movement with accuracy of the radar measurements and uses a powerful mathematical formalism of theory of optimal statistical solutions.

Each maneuver of the controlled aircraft that characterizes a change in its speed and direction of motion is displayed in a dynamic scene on the user's screen in a corresponding change in the position and angle of the movable object symbol [9, 10].

In turn, CP for data processing of automatic dependent surveillance (ADS) receives from the on-board equipment of aircraft the results of the radio-navigational measurements together with computations of deviations of actual path from the predetermined. It is necessary to underline that the ADS reports also contain calculations of aircraft maneuvers to correct the mentioned deviations.

As a consequence, the descriptions of each element of the airspace and each aircraft, accompanied by a variety of CP of AS ATC software, are not identical. Over time, the mismatches become all more substantial, and probability of loss of data integrity increases.

A significant role in this trend is assigned to the implementation of data input by users for the purpose of DB correction. Every act of reception and transmission of management, change of callsign signal of the aircraft, as a rule, corresponding to the registration number assigned it, specification of motion parameters, which are sequentially executed by various controllers, are recorded in each copy, both in the address space of computers of workplaces, and in the DB of system server. Fixing points are separated in time and are subject to the discipline set in the local network, of exchange and access. Under such conditions, there are probable differences not only in data of interacting functional CP, but also in their copies on the server and on the workstations.

The ambiguity of copies results in display of an inconsistent information, in errors in computations and other effects, which coincide by nature of manifestations with the results of inadequate debugging of software. In addition, there is a probability of loss of part of information that leads to violation of DB integrity due to insufficient synchronization of CP.

The proposed way for prevention of integrity violations is based on reconfiguration of AS ATC software through inclusion of developed CP, which provides support for information integrity when displaying the integrated dynamic scenes that are built on the basis of attributive information got by selecting from database.

In the context of the integrated dynamic scenes the integrity of information means correctness, accuracy, timeliness and consistency of the data involved in the formation of such scenes, and also includes the integrity of links between these data. The offered CP for support of the designated integrity is based on an ontological description of selected domain objects; it allows to take into account its semantics in the visual presentation of these objects in the dynamic scenes.

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About mathematical foundations for software model to model transformation approaches

Mathematical formal foundations for software model transformation approaches are analyzed in this paper. This analysis is based on domain model "Model-Driven Architecture formal methods and approaches". The aim of this analysis is to define a collaboration of mathematical methods and approaches that better satisfy business needs of software model transformation approaches.

Interconnection between mathematical foundations and constituents of software model transformation approach

Model transformation is a key activity of model-driven architecture (MDA). Target of model transformation activity is to analyze together information from different software development lifecycle processes. In order to achieve this goal the next model transformation activities are implemented: Model to Model (M2M), Model to Text (M2T), and Text to Model (T2M) transformations.

Model of problem domain "Model-Driven Architecture formal methods and approaches" is represented on Fig. 1

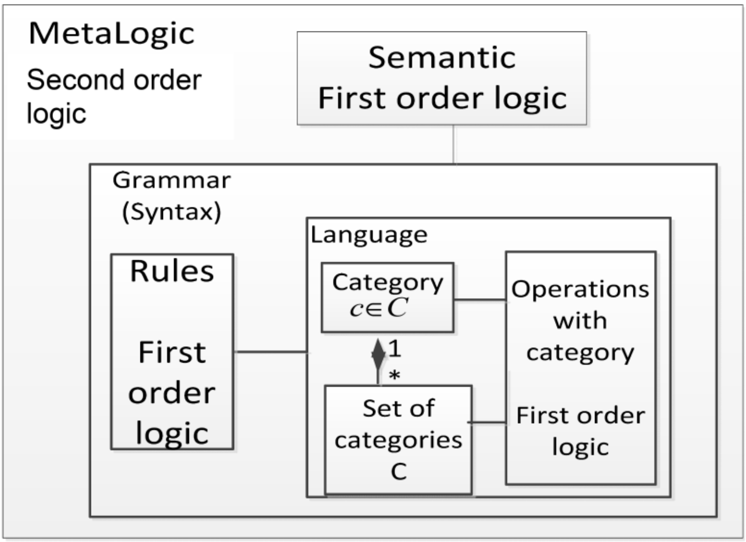

Fig. 1. Model-Driven Architecture formal methods and approaches

Detail explanations of this model and process of its designing are represented in paper (Chebanyuk, 2016).

Interconnections between mathematical foundations and constituents of transform approaches are represented in the table 1.

Table 1.

Interconnection between mathematical foundations and constituents of software model transformation approach

Mathematical foundation	Application of mathematical foundation in software model transformations	Transformation operation description
First-order logic	Formulates expression necessary to be estimated	Is used for designing 1. (metamodel) restrictions in query languages 2. software model verification tools
Theory of categories	Describes internal structure of objects and relationships between objects	Reflects interconnections between categories of software model elements
Formal languages	Used for formal description of different logical elements and expressions	1. restriction languages 2. graphical languages
Transformation grammar	Recognizes the relationship among the various software model elements uses processes or rules to express these relationships.	Is used to design transformation rules in graph transformation approaches
Metalogic (second-order logic)	Defines interconnection between syntax (grammar) and semantics	Estimates the correctness of resulting model

Case study of defining mathematical foundation for software model to model transformation approach

Let's consider transformation from use case diagram to class one. Such transformations are related to up-bottom transformations (Greiner, 2016), namely class diagram has much more precise notation than use case. Table 2 represents stages of this transformation method and proposed math foundation for every stage. The prototype of such method was proposed in paper (Favre, 2016).

Table 2.

Correspondence between mathematical foundations and stages of model transformation methods

Stage of transformational approach	Mathematical foundation	Description
Analytical representation of entire software model	Theory of categories for description interconnections between entire software model elements (for example classes, enums, and interfaces on class diagram) Theory of categories for description of model elements internal structure (for instance of class elements)	Precondition: Analytical representation should be compatible with mathematical apparatuses providing transformation rules and model semantic checking (see fig. 1). Analytical representation should be compatible with text formats for model storing, namely XML, XMI or JSON. Analytical representation should cover all elements in graphical notation
Checking entire software model	Metalogic to check analytical descriptions of entire software model First-order logic for designing semantic rules	See precondition above
Estimation entire software model	Formal language to define logic scope	See precondition above
Transformation operation	Transformation grammar of chosen formal language defines the content of resulting model First or second order logic is used to design transformation rules which define transformation process	Terminal symbols of grammar correspond to software model elements, non terminal symbols to composition of software model elements; syntax is defined by rules and restrictions of formal language grammar.
Checking resulting software model	The same as "checking entire software model"	See precondition above

Conclusion

Defining collaboration of mathematical approaches for software model transformation methods is an important and actual task for successful performing of transformation techniques. In this paper the approach to solve mentioned task is proposed. Firstly transformational technique is divided into stages. Then tasks of every stage are formulated (table 2) and description of every task is matched with possibilities of mathematical foundations (table 1). It allows to formulate some condition (preconditions) for choosing proper model representation compatible with all operation inside transformation method or technique.

Defining a collaboration of mathematical approaches in design stage has the next advantages:

- formalize operations, needed to be performed in transformaion technique;
- refine transformation algorithms by means of analysing analytical records of transformation operations;
- set a collaboration of tools, enviroments, and plugins for performing transformation operations, and many others.

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Cooperation between science and defense in the unmanned aviation field

"Ukroboronservice" is a state company which major activity is the realization of state interests of Ukraine in the field of export / import of products, military-technical and special-purpose services.

The Company was found according to the decision of the President of Ukraine in 1993. During the time of its existence, the Company has established business contacts with state and private establishments and companies from more than 30 countries of the world and gained a reputation of a reliable business partner.

High professional potential of the Company allows it concluding and fulfilling the contracts of any complexity and subjects within fixed terms and with a high quality level.

Activities are the following:

– Export, import and sales of military goods at domestic and international market.

– Design, manufacture, sale, purchase, repair, modernization, and disposal of weapons, military equipment, weapons and ammunition for it.

– Organization and holding of the activities of humanitarian demining in Ukraine and outside it.

– Testing and certification of all kinds of weapons, military equipment and ammunition.

– The implementation of military property.

– Disposal of all known types of ammunition, missiles, fuel products and special chemicals.

– The production, testing of ground components of space infrastructure.

– Scientific and technological activities, including research and development activities.

– Design, installation, execution of internal and external engineering networks and systems.

– Manufacture and repair of firearms not for military purposes.

– Organization of training and retraining (in-plant training) of foreign military experts.

State Enterprise “Ukroboronservice” has an effective program of weapons and equipment modernization manufactured in the former USSR, with the participation of enterprises from the Ministry of Defence to increase their efficiency level of existing models. Highly skilled personnel, unique equipment, extensive experience in performing various types of repair of weapons and military technology allows SE “Ukroboronservice” to conduct a fruitful and mutually beneficial cooperation with many countries. In addition to traditional forms and methods of military-technical cooperation, experts of SE “Ukroboronservice” are able to assess the technical state of weapons and equipment and carry out repairs and upgrades on certain topics, both in stationary workshops, and in places of deployment.

Using a well established network of military and special educational institutions of Ukraine, State Enterprise “Ukroboronservice” offers education and training (skills development) of foreign military experts in the interests of the customer of all kinds and types of troops.

Military educational institutions of Ukraine have modern training facilities, highly qualified teaching staff and many years of experience in training military specialists for all kinds and types of troops.

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State and Prospects for Development of Unmanned Aviation Technologies at the National Aviation University

Development of own unmanned aircraft systems (UAS) required equipment, a comprehensive national legal framework of their application, the development of international cooperation and coordination on regulation UAS is important for Ukraine as a country that includes a full cycle of development, production, operation of aircraft, training aviation personnel and has significant potential for development, production and operation of its own unmanned aircraft systems, and the ability to export them abroad.

The feature of today are extremely fast and intense process of robotic systems for special purposes, which is associated with the formation of an idea of the place, role and tasks undertaken by unmanned aircraft devices. The optimal combination of all of modern aircraft-based remote sensing, and data processing will develop system of information support facilities of the national economy, which covers the whole territory and providing timely and high-quality seamless collection of data critical to the security of the functioning of the economy, and drones are considered as a promising component means aerial monitoring.

Given the deployment of these business processes in the areas of heavy availability, remote areas with difficult climatic conditions, information support operations becomes critical for safety, rational planning, control and management of resources and means. There is development in all major sizes of unmanned aerial vehicles. The level corresponds to the current level of development of aeronautics, communications, control systems and remote sensing. Some of the developments are in the stage of readiness for serial production of prototypes and offered as a complete system, including carriers of different size, complex target loads, ground support equipment and processing.

National Aviation University (NAU) has become one of the first institutions in Ukraine, which drew attention to the current problems of Unmanned Aviation Systems (UAS) civil and military purposes. NAU has a scientific achievements, significant technical base, and the necessary resources for efficient automatic unmanned aviation systems development for all the industry problems.

The integration problems of the civil unmanned aircraft systems (UAS) into the common aviation system are concerning all the issues to be addressed and establishes a step-by-step approach to address them, aiming at an initial UAS integration by 2016, in three main areas: a Regulatory Approach, a Strategic Research Plan, and a Study on the Societal Impact. In particular, a Strategic R&D Plan identifying the technology enablers and the research activities necessary to achieve a safe integration of UAS. Safety integration of remotely piloted aircraft systems in uncontrolled airspace is a long work, that involves multi-stakeholder involvement and their expertise in the following areas such as development of airframe, engines, avionics and navigation complex, issuing certificates of crew members and medical examination of UAS-crew, creating systems to detect and prevent the use of spectrum (including the protection against accidental or unlawful interference), providing separation for other aircraft, as well as working out a reliable legal framework, creating the necessary theoretical basis.

In terms of International Civil Aviation Organization (ICAO) objective consideration of the characteristics in addressing unmanned aviation is to provide the fundamental international regulatory framework through Standards and Recommended Practices (SARPs), with supporting Procedures for Air Navigation Services (PANS) and guidance material, to underpin routine operation of UAS throughout the world in a safe, harmonized and seamless manner comparable to that of manned operations.

One of the important factors of efficiency of industrial-economic complex of Ukraine is the development of remotely piloted aircraft systems. Such systems can effectively resolve a wide range of problems from agricultural oriented tasks to environmental monitoring, condition of pipelines, protection of state borders etc. Worldwide experience of UAS using confirms their high efficiency, profitability, and feasibility of increasing their share in the overall structure of both civilian and military aviation.

The theoretical investigation and development the own remotely piloted aircraft systems, necessary equipment, a comprehensive national regulatory for its application, the development of international cooperation and coordination on UAS regulation is important for Ukraine as a country, which includes the full cycle of development, production, operation of aerial vehicles, training of aviation specialists and has significant potential for development, manufacture and operation of its own remotely piloted aircraft systems, as well as exporting them overseas.

National priorities for own unmanned aircraft systems application is the operation in various sectors of the economy and in military affairs. Most aviation work performed in agriculture, construction, environmental protection, health care, aerial search of mineral resources, study the earth and water surfaces, fighting floods, oil and gas industry, fire protection, participation in disaster mitigation and man-made disasters, for internal affairs field, and others. At the same time the economic efficiency of remotely piloted aircraft systems for these tasks in comparison with classical manned aircraft is much higher, confirming the relevance of creating their own experimental UAS based on the two-engine unmanned aircraft equipped with modern nano-engineering equipment with control based on new information technologies. Implementation of works in this area provides a comprehensive approach to creating and using of UAS.

Ukraine is one of the few countries that has a powerful air-industrial potential. The development of air-design sectors allows to overcome the lag in the creation, production and operation of competitive unmanned aircraft systems. Existing in the National Aviation University scientific, technical and technological capacity facilitates the establishment of attractive conditions for public funding and investment in projects on modern UAS creation.

In general, implementation of scientific and technical programs and projects in high-technology air-construction, appearance in the internal market competitive technology, equipment and tools, increasing export potential is one of the priorities of Ukraine's economic development.

The difficult economic situation causes to look for less costly areas of work. One of the ways that allows to realize new ideas and professional experience as a final product is a small size unmanned systems design. Unmanned aviation is used extensively in the civilian sphere to perform the following functions: the border security, the law maintaining, deal with the consequences of natural disasters or technogenic accidents, the environment ecological condition monitoring, etc.

The problems of unmanned aircraft equipment are not connected with the unmanned aircraft, because they are only a part of remotely piloted aviation complex, which includes aircraft, modern special on-board equipment and ground control systems, launch and landing. Thus, remotely piloted aviation complex is a sophisticated aviation technical system which includes one or more unmanned aircraft, control point and communication facilities, equipment startup and rescue service, as well as transportation.

The elaboration of these components in the construction of remotely piloted aviation system requires high development of aircraft design, electronics, information and other technologies. Therefore, many countries haven't got a complete cycle of this unique manufacture, beginning with the construction of the aircraft and its equipment and finishing with the target ground control points.

Along with the elaboration, manufacture and application of remotely piloted aircraft systems regulatory base of common use of airspace by the remotely piloted aircraft systems and by the manned one is forming in the world. Lack of systems to prevent collisions between unmanned aircraft with other aircraft, high probability of uncontrolled fall to the ground make the flights of unmanned aircraft impossible in the same space with other aircraft as well as their application in the areas of settlements. As a result the benefits from the use of civil remotely piloted aircraft systems are lost, and the application of UAS in the airspace with busy air traffic and in the areas of settlements is completely impossible. In such civil areas of application as the Earth remote probing, communications and control of borders, relaying signals remotely piloted aircraft systems reduce the cost of production of services in comparison with traditional space and aeronautical systems. Concepts of certification, standardization and regulation of unmanned aircraft flights at the level of international governmental and nongovernmental organizations have been creating.

In Ukraine the field of unmanned aircraft develops very quickly. National Aviation University was one of the first institutions in Ukraine, which drew attention to the problem of development of unmanned aviation complex of civil purposes. Currently in Ukraine there are no such important components as the classification of remotely piloted aviation complex according to the common terminology, tactical and technical requirements to the complexes from potential customers, regulatory base for creation, testing and operation of the remotely piloted aviation system, funding from the concerned central authorities.

The use of remotely piloted aviation system in the national economic sector, in the interest of environmental authorities, enterprises of fuel and energy complex and other subjects of the national economy, in the problems of emergency situations, as well as for air surveillance and border security, for the monitoring of the situation on the highways, in the interests of regional bodies of economy, the bodies of land utilization, municipal and regional administrations, etc., which will improve the effectiveness of operational control by means of various departments during the performance of assigned missions in money saving with a help of creation of unified remotely piloted aviation system are very important. Ukraine for a short term can receive national advanced unmanned aviation complex of civil purposes with a help of joint efforts of relevant authorities of executive power and their focus on main areas is a topical issue. According to all listed industry problems Ukraine has a serious technical base, and all the necessary resources to create effective automation unmanned systems. More attention both from the government and business representatives is paid to the projects of remotely piloted aviation systems creation.

The purpose of the complex approach is the construction and design principles establishment for the relevance experimental UAS creating based on the two-engine unmanned aircraft equipped with modern engineering equipment with automation control based on new information technologies. The purpose implementation is to obtain and implement new knowledge in the field of remotely piloted aviation system, focused on the UAV use in the economy of Ukraine and other countries. The main use of unmanned aircraft can be defined aerial photography, real-time video surveillance and patrolling of linear and planar objects. The obtained results can allow to Ukrainian developers and manufacturers of unmanned aircraft to get the effective tools for the development of remotely piloted aviation system of national production.

At the **National Aviation University** are created a number of experimental UAS based on different types of unmanned aircraft, equipped with modern nano-technical facilities with the control based on the advanced information technology using the equipment for the secure transmission of telemetry data and video surveillance, methods for multi-threaded processing operative information of certain purpose, object detection and recognition equipment , and other components, depending on the orientation of the task. Since the 2014-2015 academic year at the Department of the Air Navigation National Aviation University started training specialists in the design and operation of unmanned aircraft systems. Active recruitment of students to the educational qualification of "Bachelor", qualification - "Bachelor of Air Navigation" (6.070102) for qualifications: 3121 «Information Technology Specialist» / 3144 Operator of ground control facilities for unmanned aerial vehicles.

At the present stage of aviation development the remotely piloted aviation system form a new component of general aviation system, and now the International Civil Aviation Organization ICAO, numerous regional and national organizations such as the European Aviation Safety Agency EASA, the European Organisation for the Safety of Air Navigation EUROCONTROL, the European Defence Agency EDA, the European Space Agency ESA, the European Organization for Civil Aviation Equipment EUROCAE, the North Atlantic Treaty Organization NATO, the U.S. Federal Aviation Administration FAA, the National Aeronautics and Space Administration NASA, the Radio Technical Commission for Aeronautics RTCA, and other organizations are working related to remotely piloted aviation system study, performance and ultimately integration.

These systems are based on the latest developments in the field of aerospace technologies to implement new, more sophisticated uses of aircraft in civil, commercial, military purposes and to improve flight safety and efficiency of civil aviation in general. However, removal of the pilot from the aircraft board defines important technical and operational issues, the nature of which requires long study of active and continuous monitoring of the aviation community.

Given the above, National Aviation University in recent years has refined theoretical principles, concepts, technical and technological solutions for the program implementation of remotely piloted aviation system into the practice of Ukraine civil airlines. For this purpose, were organized a series of works devoted to optimizing the UAV dimension-type, construction, and structure of its air-navigation, telemetry, radiocommunication, and other vital systems, and also personnel training. At the National Aviation University are developed a number of remotely piloted aviation system types to address a wide range of tasks most civilian and military.

In terms of Ukrainian aviation market development is extremely important to develop its own remotely piloted aviation system and national laws – the legal basis of UAS use, that should be based on the modern international norms and standards. In order to combine different groups efforts and research of the National Aviation University scientists and experts according comprehensive implementation of these strategic objectives for the country the performers team has been formed for the research and development the complex work on a remotely piloted aviation system prototype generation. This work is a priority direction in the world market regarding the scientific and technical prospects.

Conclusion

National Aviation University has adequate scientific, technical and technological capacity, which is important for government funding and attractive for investment, which will take its rightful place in the competitive and development, production and operation of unmanned aviation systems, and training of highly qualified personnel for the industry. Projected assumptions about the development of the object of study - the results will enable Ukrainian developer and manufacturer of unmanned aircraft vehicles get effective tools for the development of unmanned aircraft systems national production.

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Formation of a compact system shape of a mortar launch unmanned aerial vehicle

Examined problems of launching unmanned aerial vehicle by a mortar launch systems. The parameters of the launcher device, which allows to realize the acceleration of the aircraft at the minimum section of the guide. The analysis of the formation of solid fuel charge for a given value of the progression of burning law.

Introduction. Known disposable class of unmanned aerial vehicles (UAV, drone) are not equipped with propulsion systems that make planning a flight on a parachute or a flexible folding wing. For such objects in the initial launch phase on a ballistic trajectory at the expense of the reserve of kinetic energy obtained from the ground launching device (GLD, catapult). Maximum high energy input into the flight UAV can provide GLD active pyrotechnic type – mortar system.

From the single shape and the massive use of this class of UAV project directly follows the requirement of minimizing the cost of avionics (avionics), which prevents the use of specialized hardware in vibro-impact-protected execution.

Functional properties of remote sensing of the earth's surface complexes are determined by the duration of data communication session. In the case of use in planning their composition or parachutes UAV requirement that means providing the necessary height of the throw, which depends on the initial velocity.

Giving high speed provided by the starting overload limit is possible due to sufficient acceleration duration is included in antagonism with the dimensional requirements of the catapult.

The problem of the study stems from conflicting requirements to ensure minimum construction dimensions, maximum high speed input into the flight UAV by limiting the starting overload. On the basis of research by the authors proposed a method of designing compact mortar systems satisfying the above requirements.

Forming system shape. These launch parameters can be obtained by exposing the constant maximum allowable overload the starting launching object. Start overload up to a dimensional constant determines the force acting on the bottom of launch container. In its turn, at a constant pressure of the bottom area should also remain constant when moving UAV along the barrel guide.

$$p(x)=\frac{m_{UAV}n_X^*g}{F}=p^*=\text{const at } \forall x\,, \tag{1}$$

where $p(x)=p^*$ – expansion pressure; m_{UAV} – mass launching UAV; n_X^* – maximum allowable longitudinal overload; g – acceleration of gravity; F – cross-sectional area of the barrel guide; x – distance traversed by drone during acceleration.

On the other hand due to the multiple increases the working volume compared to the initial, there is a proportional drop in pressure in the expansion machine [1]. For this reason, to maintain a constant level of pressure needed progressive arrival of gas. Communication consumption of combustion products and volume under the rone, which is determined by the distance traversed by the UAV in the barrel guide, gives the equation of state:

$$G(x) = \frac{p^{*}Fx}{RTt}, \tag{2}$$

where $G(x)$ – consumption per second of combustion products of the solid rocket fuel (SRF); R – gas constant; T – temperature of the combustion products; t – current time.

The degree of progressivity of increasing the flow rate is determined by the ratio of the initial and final lengths of the expansion machine. The pyrotechnic systems characteristic of the working fluid consumption is proportional to the surface of SRF or powder charge.

$$S = \frac{G(x)}{u\rho_F}, \tag{3}$$

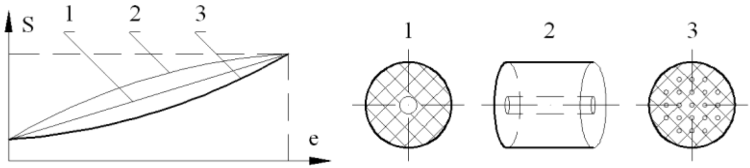
где S – burning area; u – burning rate SRF; ρ_F – fuel density.

Thus, to obtain a permanent law starting overload necessary charge SRF progressive law burning, which increases in proportion to the surface coordinate UAV. Due to the fact that path traversed by the drone in the container is proportional to the square of the time characteristic of the consumption should have a nonlinear dependence bulge downward. The extent progressivity of the burning of the law expressed by the ratio of the final and initial checkers of surfaces [2]:

$$\sigma = \frac{S_E}{S_B}. \tag{4}$$

Under the law mean burning arch of the dependence on the combustion surface. The standard ring-charge mortar systems in this case do not apply, as they have a regressive law grain burning. In the rest should be guided by the standard system parameters, such as the caliber of 120 mm. The known length of the barrel guide and the reduced length of the unused «under rocket» volume, allow us to estimate the required degree of progressivity of the charge, which shall not be less than 44.

Progressive characterized by tubular SRF charges with the external surface of the armor and the internal cylindrical channel [2] (Figure, position 1). The nonlinear dependence of the bulge give up charges tubular with a cylindrical channel in which one butt is not armored (position № 2). The nonlinear dependence of the bulge down with a high degree of progressivity possible to obtain multi-cylindrical monoblock, armored on the external surface (position № 3). The diameter and arrangement of channels allow you to program the nature of their closing.



a b

Picture – Progressive burning laws (a) and implementing
their charges configuration SRF (b)

The outer diameter of checkers (adopted by 110 mm) is limited by the caliber the barrel guide and inner diameter of the channel (in the amount of 60 pcs.) is determined based on the value obtained above progressivity – 6 mm. The low value of the arch combustion and the short duration of the startup process require the use of fuel with high burning rates (for example, ACC). Tenfold limit (compared with the standard mine) starting overload (300 g) to the maximum to reduce the cost of avionics UAV allows to reach a speed of 100 m/s at the outlet of guide. As a throwing angle selected value of 80º, giving a maximum elevation on the trajectory using the maximum charge [3].

Conclusions

Giving high dynamic performance planning and parachutes UAV feasible GLD pyrotechnic mortar type. Standard barrel guide can be used to launch drone. Propellant charge for maximum compactness of GLD should possess a high degree of progressivity. The desire to reduce the cost of avionics reduces initial UAV speed and without alternative leads to shape of an aircraft, excluding the possibility of using fully passive outer portion of the trajectory due to a lack of elevation of trajectory.

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Combat robots. Flying underwater-ground robot-racer

The analysis of new types of weapons based on drones - unmanned bombers, developed in accordance with the concept of perspective development of unmanned weapons systems that combine both shock and intelligence functions. It completed a comparative analysis of tactical and technical characteristics of certain classes of aeronautical products selected purpose.

The functional equipment of a future multi-purpose combat robot includes its movement in the air, underwater, on the seabed, on land, and overcoming various obstacles. It is able to effectively carry out combat missions in various natural and climatic conditions.

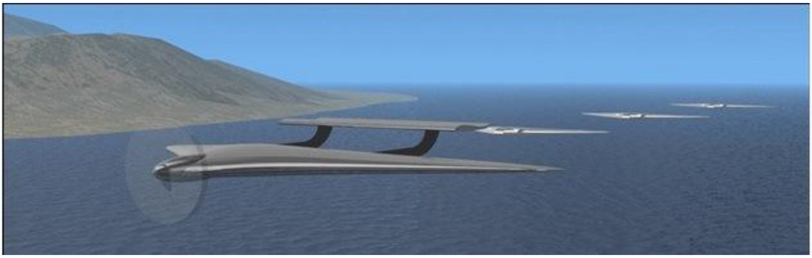
According to experts of **Sandia National Laboratories**, the multipurpose robots can fly, swim, move on the ground and even jump and they will be absolutely necessary in the army and rescue services.

Sandia National Laboratories has developed a number of such systems, for example, a jumping robot.

Fig.1. Jumping robot *Sand Flea*

A low-observable UAV is able to cover long distances in the air, secretly steal up to the enemy coastline under water, approach to the ground objects on wheels and, moreover, jump over the fence and into the windows of (Fig. 1).

The new unmanned system running within the **Multi-Modal Vehicle Concept** will have broad mobile capabilities. For example, a typical mission for reconnaissance on the coast is as follows. From board the ship, aircraft, UAVs or flying field a drone is launched (Fig. 2).



Fif. 2. Aircraft with combat robot

On approaching the water area, which is defined in the task as the area where the UAV can already be detected, the robot dives under the water (Fig.3).

Fig. 3. The robot dives under the water

When the task is carried out, the wings and the engine are being separated, and they extend the streamlined body with "fins" for silent movement under water. The robot approaches closely to the shoreline, and, if necessary, collects information on the topography of the seabed, minefields, etc. At depth of several dozens of centimeters the robot takes off the "fins" and extends wheels for movement on any surface, including the sand and land (Fig. 4). The robot is also equipped with a special device which overcomes obstacle up to *10 meters* high, jump over fences, cars and other obstacles. The whole mission can be performed independently in a program mode or in a semi-manual or manual mode, under the direct control of the operator. The advantage of the **Multi-Modal Vehicle Concept** is the not necessary coordination of the units of unmanned aerial, underwater and ground robots from different manufacturers with different communications systems and means of delivery. It is obvious that such coordination needs substantial means for careful planning and precise performance.

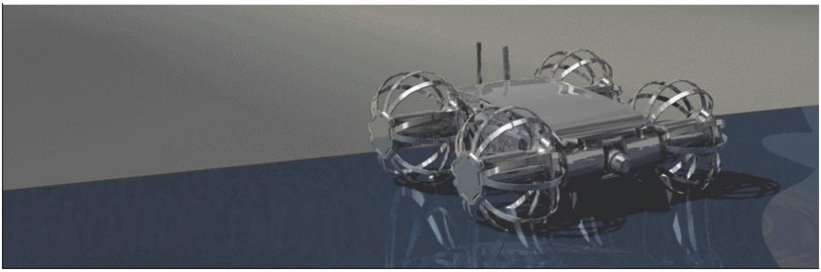


Fig. 4. The movement of the robot on the soil and on land

But, nevertheless, the probability of trouble in connections and the emergency situations remains unacceptably high.

A universal robot is able to fulfill the mission from beginning to end, relying on the ability to adapt itself to changing environmental conditions. Such robot is perfect for intelligence and sabotage operations in top secrets conditions.

One-time use of the robot is the main disadvantage of the given concept. The robot will discard unnecessary components of the design while performing combat tasks so, that it excludes them not only to be detected but also renewed.

SANDIA NATIONAL LABORATORIES have performed a limited testing of a new conceptual equipment of the robot. However, for the present, the experts say that the concept is mature and can be implemented using modern technology [http://www.cnews.ru/news/top/index.shtml?2013/11/15/549784].

Conclusions

Thus, for the protection of the territorial boundaries of states and adjacent waters now serve ballistic intercontinental and space rockets of different classes and facilities-based, nuclear submarines and strategic missile forces. Today's launch vehicles (LV), as we know, are able to deliver the means of destruction in any part of the globe, not only with great precision, but also in the minimum time allowed.

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Experimental study of aerodynamic characteristics of closed parabolic wing

The article presents the results of experiment model with closed parabolic wing in the wind tunnel T-5 of the National Aerospace University – Kharkov Aviation Institute (KhAI), made in order to assess its overall effectiveness. Performed comparison of results obtained in wind tunnel T-5, with the results and the panel-vortex method and finite element method.

Introduction. The main driving factor in the development of designs of aircrafts include: requirements for the home, storage and transportation of products. A large number of developed aircrafts [1] is a sufficient proof of this.

For efficient simultaneous implementation of the requirements of portability and the aerodynamic efficiency of our proposed concept of a ring airfoil. Based on the results in the open press flight test aircraft with closed parabolic wing (CPW) [2], you can make an educated guess about the relevance of the research.

Formulation of the problem. By physical experiment in a wind tunnel to qualitatively and quantitatively determine the aerodynamic characteristics of the CPW. Perform analysis and generalization of experimental and theoretical results obtained previously.

The experimental setup. A model ring wing with asymmetrical profile from the National Aerospace University – Kharkov Aviation Institute (KhAI) was made for carrying out the experiment in a wind tunnel in accordance with recommendations [3].The materials include - balsa, aircraft plywood and ABS plastic , also steel 30HGSA . The experimental model of the design and process are identical to that in the experimental studies [3]. Fig. 1 shows a conceptual diagram of the models under study on Fig. 2 - the appearance of models in the working part of the wind tunnel T-5, Fig. 3 – 5.

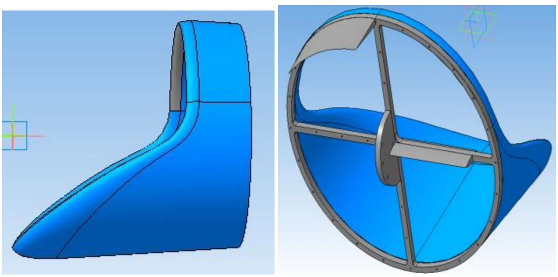

Fig 1 - Overview of a CPW

Fig 2 - CPW model in the work space of the wind tunnel T-5 KhAI

The experimental setup. The educational aerodynamic installation T- from the aerodynamics department of the KhAI [4,5] represents a closed tube type with open working part (fig. 3,4). Below in table 1 are the characteristics of the wind tunnel:

Table 1.

Features of Wind tunnel

WT DESIGNATION	T-5
Test Section (m)	∅0.75 m
Length of Test Section	1.5 m
Max. Flow Velocity	40 m/s
Typical Value of Turbulence Intensity	0.8%
Balances	3-component
engine power	32KW

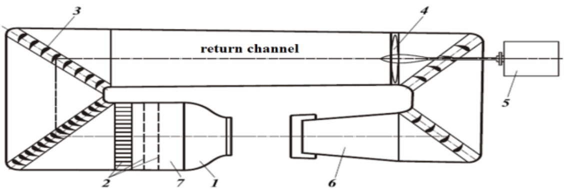

Fig 3 - A ring type low speed tunnel with open operating part .1 - collector; 2 - honeycomb; 3 – guide blades; 4 – ventilator ; 5 – electric motor; 6 - a diffuser; 7 - prechamber

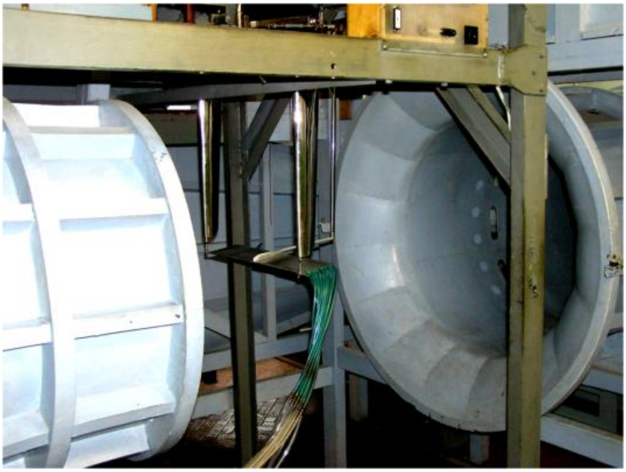

Fig 4 - Ring type wind tunnel- T - 5 KhAI

Wind tunnel provided with the necessary research equipment includes various static and dynamic pressure coordinate devices, and others.

Installation allows you to:

to determine the distribution and overall aerodynamic characterics of the aircraft models;

explore the perturbed velocity field around the model;

explore the practical features of the complex aerodynamics of the aircraft in terms of form.

With the application of the above, experimental models CPW of the performed aerodynamic experiments in the laboratory of the aerodynamics department of KhAI.

Experimental results. In our work we present an analysis of the research results of the CPW in a wind tunnel, made in order to assess its overall effectiveness.

Below, in тable 2 shows the experimental test program model.

Table 2.

The definition of the aerodynamic characteristics of the model.

α	V	Re
$-12^0 \ldots 40^0$ $\Delta\ \alpha=+2^0$	35 m/s	$1.21 * 10^6$

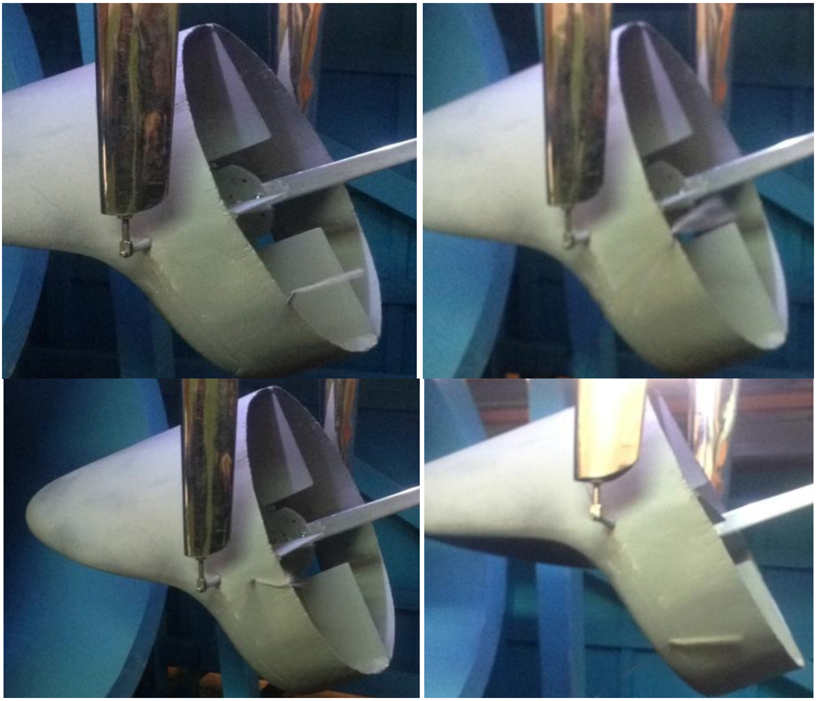

Fig 5 - CPW model with airflow at $\alpha = 24$

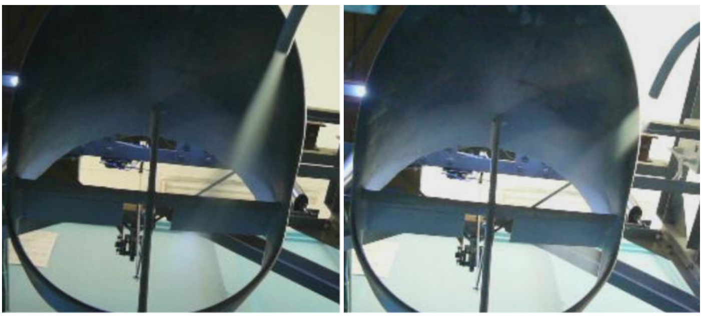

Fig 8 - CPW model in wind tunnel T-5, airflow V=35 m/sek.
Smoke visualization

Below, in Fig. 9 - Fig. 12 shows the results of the trial tests as described in the above experimental models, and as a comparison of results obtained in wind tunnel T-5, with the results and the PVM and FEM [6,7,8,9].

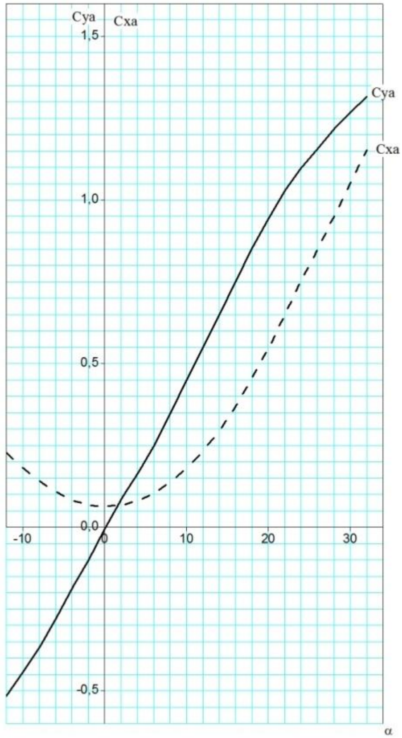

Fig 9 - c_{ya}, $c_{xa} = f(\alpha)$ data.

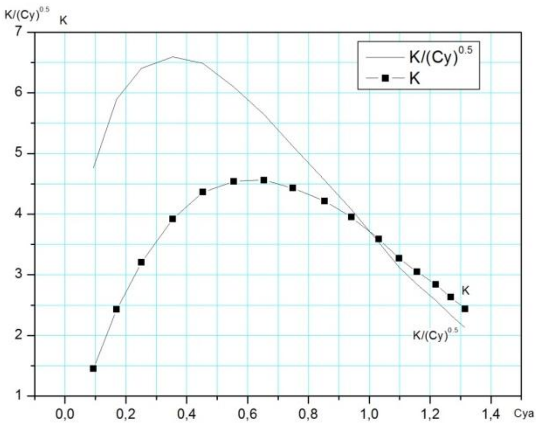

Fig 10 - $K/(c_y)^{0.5}$, $K = f(c_y)$ data

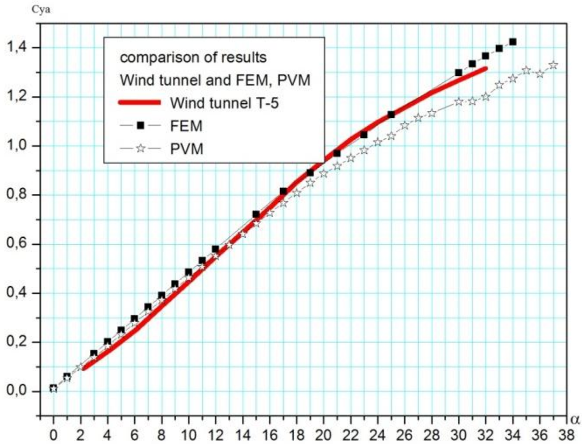

Fig 11 - $c_{ya} = f(\alpha)$ data

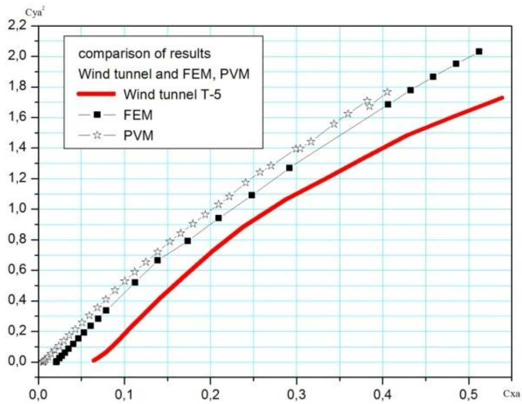

Fig 12 - Dependence $c_y^2 = f(c_x)$

Conclusions

1. The results of the experiment (Fig. 9) clearly demonstrate that the proposed arrangement is substantially greater value of the critical angle of attack ($\alpha_S = 32^0$) than classic airplane. This differs from the two sections of constant values of the derivative c_y^{α}, indicating a change in the vortex circuit bearing surface by increasing the angle of attack, but with preservation of unseparated flow;

2. Dependencies of lift-to-drag ratio (K) and criteria for maximum range $K/c_y^{0.5}$, determined based on the results of the experiment have the same characteristics as that previously defined on the basis of calculation results

[Rahmati, Zinchenko 2012, 2014,2014. Rahmati 2015] - the maximum *value* of $K/c_y^{0.5}$holds for values of $c_{ya} \approx 0.25$, which corresponds to high speed cruising;

3. Visualization of the surface flow and the trailing edge of the experimental model by using soie and smoke generator (Fig.8) demonstrates conformity with the calculated flow models schemes outer surface received streamlines the appearance of bound vortices zones and separated flows. This allows with sufficient accuracy to be used for aerodynamic design PVM and FEM the assumptions implemented in model k-ε and SST;

4. Comparison of the experimental and numerical simulation of flow around geometrically complex CPW (Figure 11. Figure 12) confirms the adequacy of PVM and FEM (SST) for the aerodynamic design of the wings of small aspect ratio of the closed type, ie, .K. Dependence $c_{ya}(\alpha)$ are almost identical, and the polar model, presented in the form of dependence $c_{ya}^2 = f(c_{xa})$ are equidistant to each other. It confirms the identity of determining the effect of inductive vortex flow on the ramps as the method as the PVM and FEM (SST). The difference in c_{x0} caused by the quality of construction experimental models and mathematical assumptions in determining the frictional drag out the methods;

5. The experimental results confirm the hypothesis in general, we have taken at the beginning of the research - implementation of high load-bearing properties and high values of the critical angle of attack, the possibility of achieving the same aerodynamic configuration of small minimum flight speeds (resp. Small distance off and landing) and high cruising flight speeds (and high transport efficiency respectively).

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Determination of the indicated air speed without data from pitot tubes

A method of emergency IAS determination using data from satellite navigation system, magnetic compass and meteorological forecast is considered. An experiment is conducted as well.

Introduction

During the flight of the aircraft three kinds of horizontal speed are usually being measured: ground speed (GS), true air speed (TAS) and indicated air speed (IAS). While GS (rate of relative moving of the ground and aircraft center of gravity) is used by flight crew mostly for navigation purposes, TAS and IAS are very important for aircraft control. If IAS becomes too low, it leads to uncontrolled movement of the aircraft called stall. On the other hand, IAS increasing beyond limit can cause aircraft construction demolition. Nowadays an Air Data System (ADS) is used for IAS measurement. Its sensors are called pitot tubes and they are long sealed tubes, open at the forward end. They are located in the fore part of the aircraft so they can measure full (pitot) pressure which is the sum of static and dynamic pressure. It allows measuring IAS [1]. ADS is very accurate and reliable system, but it has one disadvantage: pitot tubes are inclinable to icing. Several air disasters have already been caused by ice or other pollutions in the pitot tube [2, 3, 4]. It is obvious that reserve emergency system is needed to provide safe landing in case of ADS fault.

Literature analysis

Investigation results in this area were embodied in directive documents issued by airlines. Generally, in case of unreliable speed detection pilots have to be directed by the Pitch-thrust table. This procedure allows keeping safe IAS by choosing proper rate of engines thrust and pitch angle for particular weight and configuration of the aircraft [5]. Desirable values are previously detected during flight investigation for each particular type of aircraft.

The Boeing company in 2013 reported [6] invention of new method of independent IAS measurement. For this purpose flight management and guidance system (FMGS) must know aircraft configuration, weight, angle of attack and its 3D position defined by GPS. Authors don’t divulge detailed formula.

Investigation purposes

The goal of this investigation is development of IAS calculation method which will not tap data from ADS.

Method description

GS, TAS and IAS are interrelated, so we can easily find any of these speeds knowing another one. In our case we use GS measured with GNSS gauge as a basis for further calculations. We can find TAS from GS using Navigation triangle of velocities [7], which includes GS, TAS and the wind speed (Fig. 1).

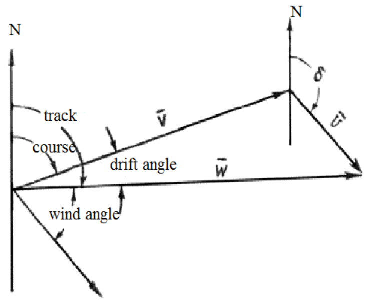

Fig.1 – Navigation triangle of velocities

On the above figure $\bar{W}$ is the GS vector, which direction is defined by the angle called track; $\bar{V}$ is the TAS vector, which heading is defined by the aircraft course. And finally, $\bar{U}$ is the wind speed vector. Its rate and direction can be defined respectively as speed of air moving along the ground and wind angle (δ). In [7] we can find formula for TAS:

$$V = \frac{W - U\cos\delta}{\cos(drift\_angle)} \tag{1}$$

The next stage is calculation of IAS from TAS. These two speeds are approximately equal at the sea level, but as the flight altitude grows IAS becomes smaller while TAS remains the same. The formula for IAS is:

$$IAS = \frac{TAS}{\sqrt{\frac{\rho_0}{\rho_H}}} \tag{2}$$

In formula (2) ρ_0 is the air density on the sea level, ρ_H is the air density on the flight level. Density can be calculated as follows:

$$\rho = 0{,}0473\frac{B}{T} \tag{3}$$

In formula (3) B is the atmospheric pressure (mm hg), T is the temperature in Kelvin.

Hence, the final formula for IAS calculation will be as follows:

$$IAS = \frac{\dfrac{W - U\cos\delta}{\cos(drift\_angle)}}{\sqrt{\dfrac{\rho_0}{\rho_H}}} \tag{4}$$

How can we obtain necessary components from the right part of equation (4) without using data from ADS? GS (W) and track, as was mentioned above, we can get from GNSS receiver, U and δ are known from SITA forecast [8], drift angle is the difference between track and course, and course gauge is magnetic compass. Pressure and temperature on the sea level we can obtain from METAR forecast, and temperature on the flight level is, once again, known from SITA. The most difficult task is to get value of the pressure on the flight level. We can't know precise value without ADS, but approximate value can be calculated using height-pressure table. Each 100 meters of climb cause 10 mm hg pressure decreasing.

Calculation example

For this particular example data obtained during A-320 flight in September 2013 were used. Before the beginning of flight SITA forecast on route was obtained. Its fragment is submitted on Fig. 2:

```
SENAR                   ETP1                    METAT
FL350  352/37  M54      FL350  357/36  M52      FL350  357/36  M52
FL370  354/30  M52      FL370  358/28  M51      FL370  358/28  M51
FL390  356/23  M50      FL390  000/22  M49      FL390  000/22  M49

SANUL                   KTL                     ODOMI
FL350  005/29  M50      FL350  028/18  M48      FL350  033/16  M48
FL370  006/24  M49      FL370  022/16  M48      FL370  025/15  M47
FL390  008/19  M48      FL390  015/15  M47      FL390  017/14  M47

ADISA                   SONIB                   BUKET
FL350  041/15  M48      FL350  069/11  M49      FL350  143/15  M49
FL370  032/13  M48      FL370  061/9   M48      FL370  147/12  M48
FL390  023/11  M47      FL390  051/7   M47      FL390  152/10  M47
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Fig. 2 – SITA fragment

As we can see from Fig.2, meteorological forecast for SANUL point was: on the flight level 350 (35000 ft height) meteorological direction of wind is 5 degrees (which means that navigation direction is 185 degrees), wind speed is 29 knots, and the temperature is -50 degrees Celsius. Due to METAR forecast the temperature at the sea level was +3 degrees Celsius and the pressure at the sea level was 760 mm hg.

At the moment of SANUL crossing actual aircraft gauges data were as follows (Fig.3):

Fig.3 – Gauges data during SANUL crossing

In the upper left corner of navigation display we can see actual GS (434 knots). Next line contains actual values of wind direction and speed – 10 degrees and 26 knots. As we can see, discrepancies with the forecast data are insignificant. We'll believe that we don't have this data (obtained from ADS) and use the forecast data in further calculations. Under the wind parameters line there is course scale. It shows the actual course: short vertical line is placed on 59 degrees. On the same scale we can see track angle: 62 degrees. Hence, drift angle will be: 62-59=3 degrees. Wind angle value will be: 185-62=123 degrees. We can now calculate TAS using formula (2):

$$TAS = \frac{434 - 29\cos(123^0)}{\cos(3^0)} = 450,05$$

Comparing the calculated TAS value (450 kt) with measured TAS value (446 kt – it can be seen on the display near GS value), we can conclude that discrepancy is quite small. Now we have to define all input values we need for IAS calculation. Temperature on the ground level in Kelvin will be 274,15 deg; on the flight level – 223,15 deg, air pressure on the flight level, according to height-pressure table, will be 185,47 mm hg. Hence, the calculated IAS will be:

$$IAS = \frac{450}{\sqrt{\dfrac{0,13065}{0,03925}}} = \frac{450}{1,82} = 247,25$$

At the same time IAS measured by ADS, was approximately 259 kt, as we can see on the right gauge on Fig.3. It means that discrepancy between measured and calculated value amounted 12 kt. In the same way several other experiments were conducted. All of them showed similar results: error didn't max 16 kt.

Are this error and described method in general acceptable? The crucial criteria is ability to keep safe IAS. Stall IAS of Airbus A-320, one of the most popular civil aircrafts worldwide, is 185 kt, and its maximum acceptable IAS is 350 kt [5]. Hence, safety gap is 350-185=165 kt. If flight crew or FMGS will aim to keep the mean speed – 276 kt, safety speed stock on each side will be 82 kt. This value is much larger that the largest error obtained during experiments.

The conclusions

Experiment and analysis of its results showed that described method of IAS measurements based on data from GNSS, magnetic compass and weather forecast is valid enough to provide safe flight in case of ADS incapacity. This method may be used for UAV operations as well – generally these aircrafts have smaller safe velocity gap, but they are being operated at low flight level, so influence of pressure difference will be insignificant.

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Main Factors to be Taken into Consideration When Planning a Route for Remotely Piloted Aircraft System in riga flight information region

Remotely Piloted Aircraft System (RPAS) consists of two main parts- Remotely Piloted Aircraft (RPA) and Remote Station. In order to be able to control the RPA, a specific control and command C2 link is required. In RPAS harmonization and integration process into civil aviation field, it is necessary to take into consideration current rules, which are applicable to manned aircraft as far as it is practicable and possible. Currently there are no definite requirements for technical equipment of such aircraft on international, European or Latvian scale; there are only general guidelines and suggestions. Detect and Avoid System DAA can be mentioned as one of the additional requirements for RPAS only. Each State shall itself establish definite legislation for use of remote aircraft, this way giving opportunity to possible airspace users to operate in a safe a legal manner.

Main Components of RPAS

Typically RPAS consists of two man parts- remotely piloted aircraft (RPA) and control station, which is located on the ground or in any other place and which is used to control and command the RPA. To enable cooperation between these two parts- the airborne and the ground-based- a reliable communication channel is needed. In air traffic control (ATC) communication system there are four different communications needed:

Voice communications with associated ATC service (from ATC to RPA pilots using RPA);

Voice communications with accosiated ATC service (from RPA to ATC center using RPA);

ATC data link (from ATC center to RPA pilot using RPA);

ATC data link (from RPA pilot to ATC center using RPA).

If there were no communications between the RPA and its pilot, it would not be possible for the whole RPAS system to operate. For this reason, it is essential to have a command and control (C2) channel, which would enable information flow between system components. C2 usually has the following information transfer capabilities:

Uplink information flow to RPA to be able to change RPA behavior and position;

Downlink information flow from RPA to be able to display status and position of the RPA;

DAA uplink information flow, which chooses and controls sensors, if necessary, and provides automatic reaction to outside conditions;

DAA downlink information, which is data from DAA sensors, connected with air traffic, weather conditions, ground obstacles, visual information of aerodromes, as well as infromation, which is needed for cautions regarding avoidance maneuvres, if needed.

Information needed to transfer RPA from one control station to another- uplink and downlink- if several control stations are used;

Information, which is needed for flight data recording- uplink and downlink.

A structure of C2 usually is described using terms RLOS and BRLOS. RLOS (Radio line-of-sight) is a communication range, where information transfer is committed in directly visible line, without using any additional equipment. Simple RLOS diagram is shown in figure 1.

Figure 1. RLOS communication operational diagram

BRLOS (Beyond Radio Line-of-Sight) C2 configuration is referred to any configuration, where transmitter and receiver are not in directly visibility range. In this case additional equipment is needed. It can be either satellite system, which can establish communications between more than one ground-based control stations, or appropriate ground-based equipment. Architecture of such case is shown in figure 2.

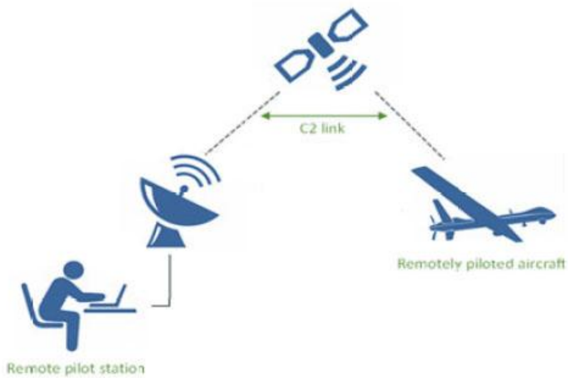

Figure 2. BRLOS Communication Operational Diagram

ICAO Communication Equipment Requirements

In terms of air traffic management a technical equipment of an aircraft can be divided in three main parts: communication, navigation and surveillance. According to International Civil Aviation Organization (ICAO) requirements, an aircraft shall be equipped with such equipment, which would enable it to:

- Commit two-way radio communications for the purpose of aerodrome control;
- Receive meteorological information at any time;
- Monitor aviation emergency frequency 121.5 MHz.

Communication Equipment

Communication equipment requirements depend on a type and class of airspace, where a flight is committed (airspace classification is done in accordance with ICAO Annex 2 “Rules of the Air” and other regional requirements). Required Communication Performance (RCP) is one of the criteria, which define accuracy and other parameters. RCP states, that:

- aircraft shall be equipped with such communication equipment as stated according to airspace type requirements;
- aircraft pilot or operator shall receive a permission from the appropriate air traffic services (ATS) authority to operate in particular airspace.

RCP type contains a number, which is assigned to the following communication characteristics:

- Transaction time- time, needed for operational communications, after which initiators could revert to alternate procedure;
- Continuity of service- probability, that operational communications could be committed on time;
- Availability- probability, that operational communications can be committed in the moment, when needed;
- Integrity- probability, that communications will be done without interference.

The main RCP requirements are shown in the table 1.

Table 1. Main RCP type requirements

RCP type	Transaction time	Continuity (probability/flight hours)	Availability (probability/flight hours)	Integrity (acceptable volume/flight hours)
RCP 10	10	0.995	0.99998	10^{-5}
RCP 60	60	0.99	0.9995	10^{-5}
RCP 120	120	0.99	0.9995	10^{-5}
RCP 240	240	0.99	0.9995	10^{-5}
RCP 400	400	0.99	0.999	10^{-5}

For instance, RCP10 value is used in cases, where minimum separation between two aircraft is 5 nautical miles NM, which means, that air traffic will allow intervals between two aircraft 5 NM or greater. RCP60 can be used in routine communications, routine data transfer, which is meant to reduce amount of voice communications. RCP120 value is used in 15 NM horizontal separation areas, but RCP 240 is used in areas, where lateral separation between two aircraft is defined 30 NM- both laterally and longitudinally. This case is designated as 30/30/ RCP 400 is used in cases, where minimum separation intervals are defined to exceed 30 NM, for example, communications using HF frequency band. RCP values are defined depending on requirements, which are described in ICAO PANS/ATM Doc4444 RTCA DO-290/EUROCAE ED-120, RTCA DO-284.

International Telecommunication Unit (ITU) has set a list of frequency ranges, which can be used by RPAS:

a) 960- 1 165 MHz for RLOS;
b) 1 545- 1 555/1 646.5- 1 656.5 MHz and 1 610- 1 626.5 MHz for BRLOS;
c) 5 030- 5 091 MHz for RLOS and BRLOS.

Navigation Equipment

Navigation equipment is used by the pilot to fly from one point or departure aerodrome to another- destination. Aircraft shall have such equipment, which would enable it to:

a) Operate in accordance with a valid operational flight plan;
b) Operate in accordance with ATC instructions, except cases, when flight is committed in accordance with visual flight rules (VFR), using ground based reference objects for navigation purposes, if appropriate ATS authority has not excluded also this case.

Operational actions, where Performance Based Navigation (PBN) criteria have been set, shall take into consideration the following additional requirements:

a) An aicraft shall have such equipment, which would enable it to operate in accordance with international PBN criteria;
b) An aircraft must receive a permission form appropriate ATS authority to operate.

Flights in parts of airspace, where in accordance with regional air navigation agreements minimum PBN (MPBN) requirements has been set, aircraft shall have equipment, which would enable:

a) The crew of an aircraft to receive and report reliable information about aircraft's heading in any point of its path at the time required;
b) To receive a permission from appropriate ATS authority about the MPBN use in its operational activities.

Navigation specifications are used by the country in order to establish and develop airworthiness and operational procedure requirements. Navigation specifications set requirements on RNAV (area navigation) system tolerance levels. It is done by analyzing:

- Accuracy, integrity, availability and continuity of service;
- Functional capabilities in RNAV system;
- What sensors shall be integrated into RNAV system;
- What requirements shall be set for crews.

Navigation specifications are either RNP specifications or RNAV specifications. RNP specifications include airborne equipment requirements, what operators check themselves, but RNAV does not include any specifications regarding aircraft crew.

ICAO Requirements regarding RPAS equipment

Unlike manned aircraft there are no strict ICAO rules regarding technical equipment for RPAS operation. ICAO Doc 10019 "Manual on Remotely Piloted Aircraft Systems" gives guidelines, but more detailed legislation shall be established by each ICAO contracting State itself, taking into consideration State's own specific requirements and situation. When considering the list of minimum equipment required the following issues shall be taken into consideration:

a) RPAS manufacturing state and its requirements;
b) RPAS manufacturer rules and specifications;
c) RPAS registration country's rules and practise;
d) International legislation in force.

When a new RPAS type is designed and manufactured, it would be necessary to get its Type Certificate (TC), which would show, that this particular type and its associated components comply with all rules which are applicable. Usually TC is given by the country, in which the RPAS is manufactured. TC includes also Instructions for Continuing Airworthiness (ICA) and Flight Manual (FM). Currently there are strict rules for manned aircraft FM, but regarding RPAS ICAO suggests considering the following issues:

a) Handling of RPA from one control station to another, if more than one is used;
b) Control and command link C2 specifications and procedures, as well as how to act in case of C2 link loss;
c) Termination of flight procedures applicable to RPAS only (security of RPA control station and C2 link).

According to ICAO Doc10019, RPAS technical equipment shall have the following functions:

a) RPAS shall have a system, which would be able to identify and inform the user about system error, which could negatively affect airworthiness of the system and its ability to continue operation;
b) Identification of critical technical equipment and its components in RPA and RPAS;
c) Ability to register and store information about incidents and accidents of RPAS and its critical failures.

Detect and Avoid System

"Detect and Avoid" (DAA) system is one of additional systems only for RPAS. It is defined as a system, which is able to see, detect or identify conflicting aircraft or other obstacles and able to make maneuvers to avoid collision. The purpose of the system is to guarantee safe operation of RPAS in the air and on the ground, promote their integration process into manned aviation. DAA system is needed to give

RPAS similar functions comparing to manned aircraft, whose pilots can use their vision, hearing, touch and other cognitive processes. RPAS can be equipped with different systems and DAA sensors can also be different depending on manufacturer and type of equipment. DAA system is considered to be necessary to reduce risk in the following situations:

a) Avoid collisions with other aircraft;
b) Avoid collisions with ground-based obstacles;
c) Avoid dangerous meteorological conditions (icing, thunderstorms, turbulence);
d) Avoid collisions with ground-based vehicles (aircraft, cars, sturctures, buildings, people on the ground).

DAA might have such functions:

a) Detect and avoid- ability of RPAS to make maneuvres to avoid possible collisions with obstacles by using manual or automated actions. If comparing to manned aircraft, it might operate in a similar manner as Airborne Collision Avoidance System (ACAS), which is integrated in autopilot system.
b) Detect and advise- ability of RPAS to give essential information and advice possible range of avoidance maneuvre to avoid danger. As an example in manned aircraft also here ACAS can be mentioned.
c) Detect and inform: ability of RPAS to give essential information, which the system might use to avoid possible collisions, to plan possible avoidance maneuver. As an example from manned aircraft weather radar and its associated displays can be used.

Technical Requirements for Operation in Riga FIR

Operational requirements for flights in Riga FIR are available in Aeronautical Publication of Latvia. It is stated, that all flights in controlled airspace of Riga FIR shall be equipped with operational secondary surveillance (SSR) transponder Mode A/C/S with 4096 identification codes (Mode A) and altitude display capabilities (Mode C). Radio telephony communications in terms of air traffic control voice communications are done in VHF frequency in aeronautical communication range, and all airspace users concerned must be able to monitor frequency 121.5 MHz as well. When operating in uncontrolled airspace, RPAS pilot shall establish communications with other airspace users on one frequency (usually it is air-to-air communication frequency 123.950 MHz) to inform others about its position and intentions, planned route. Aircraft navigation and communication equipment must comply with international requirements stated above.

In addition, when operating RPAS shall use only those frequencies, which are approved by appropriate official authorities.

Conclusion

Currently in Latvia there are no definite requirements for RPAS equipment, and there are no operational procedures established for such aircraft operation in controlled or uncontrolled airspace, for this reason, RPAS equipment must have the same capabilities as manned aircraft. Rapid growth of RPAS industry encourages the country to establish its own legislation, which would give opportunities for safe RPAS use in different field.

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UDC 629.78

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Concept of group debris cleaning using unmanned servicing spacecraft

A concept of an approach to the debris cleaning using a group of servicing spacecraft to provide reliable navigation and efficiency. Some of the results of mathematical modelling are provided.

Group debris cleaning

Despite the recognition of the global problem of combating contamination of near-Earth space, debris cleaning technology is in the initial stage of development. Thus as part of TeSeR program, which was presented in May 2016, the task was placed to create the prototype tools, which allow to safely remove any out of order spacecraft from orbit. The test phase should begin in 2018 [1].

Federal Space Agency ("Roskosmos") plans to launch a new spacecraft “Liquidator” into geostationary orbit of our planet in 2025, whose main task will be cleaning debris, consisting of out of order satellites, booster units and other left over parts from previous launches into space. Designing of the new spacecraft is scheduled to begin in 2018 [2].

US offer other countries to carry out joint massive cleaning of debris, after having developed the necessary technology [3].

The Navigation-ballistic provision (NBP) for servicing spacecraft (SC) occupies an important place in the process of cleaning of debris. During the design of NBP, the extensive scope of SSC application, as well as the tendency to the use of autonomous onboard systems on the base of satellite navigation should be taken into account.

In 2009 the European Space Agency estimated the number of near-Earth debris larger than 5 cm as 43 837 objects, about 20 % of which were on highly elliptical orbits [4].

The NBP for higher elliptical orbits for SC faces many problems. It is first of all the unstable radio navigation field. Therefore, significant time intervals may exist when there are no navigation satellites (NS) available for the use of SC.

There exist numerous approaches, which are based on changes in the composition and algorithmic support of onboard systems of SC, to solve this problem.

This paper proposes the concept of using a group of servicing SC to solve the problem of cleaning the debris in unstable radio navigation field.

Nowadays more and more attention is paid to the organization of group SC flights. Such SC groups may be used, for example, for forming large aperture antenna fields, sequential multi position recording of the Earth surface, etc. [5].

The concept of the group SC debris cleaning involves the following.

The group of servicing SC intended for the disposal of debris is centered in the chosen field of near-Earth space. The group should consist of at least four servicing SC. According to the terminology adopted in [5], each SC in the group may be a master or a follower. Each SC has its own satellite navigation equipment, means of communication with any other SC in the group, including the means to transmit its own coordinates, which are linked to the onboard time scale, as the master, or the receiving of them as a follower. Additionally, the format of the information about the coordinates during the transmission and reception has to be coordinated with the format of the navigation signal.

The orbits of the SC are selected and calculated in advance, in accordance with the debris disposal technology and orbits design theory [6, 7]. However, an additional requirement is imposed on the relative position of the SC in the group.

The position should be optimized to provide the navigation determination of SC group (with exchange of information) on longer sections of the orbital movement. To solve this problem, a methodology was developed, for example [8].

Conditions ensuring the navigation position determination in the group suggest that, at least two SC of the group must receive the information from four sources of navigation signals.

Possible options:

- One SC receives a signal from the three NS and signals broadcast from one other SC, which receive signals from sufficient number of NS for determining the position (option 1);

- One SC receives signals from two NS and signals broadcast from two other SC, which receive signals from sufficient number of NS for determining the position (option 2);

- One SC receives signals from one NS and signals broadcast from three other SC, which receive signals from sufficient number of NS for determining the position (option 3).

Mathematical modelling was used to test the concept.

The initial data are the coordinates of 6 NS, recorded with a navigation receiver at a fixed point in time, and given coordinates of the object.

Software complex provides:

- the generation of pseudo ranges with random error (normal distribution with set parameters - $m\xi, \sigma\xi$);

- the solution of the problem of determining the coordinates of the object on the one-step algorithm based on the method of least squares;

- obtaining the statistics of positioning errors by varying the number of satellites and standard deviations (SD) of errors during the generation of pseudo range.

Statistics were determined by averaging 1,000 iterations.

Table 1 shows the SD of spherical positioning error SP depending on the number of operating satellites (during which $m\xi := 0$ m, $\sigma\xi := 10$ m) and the geometrical dilution of precision GDOP, which correspond to the satellite configurations.

Table 1.

Results of mathematical modelling

Number of NS	SP, m	GDOP
4	65	6.6
5	26	2.7
6	22	2.35

In the case of broadcast of coordinates from the master SC to the follower SC, the corresponding pseudo ranges for navigation tasks are generated with a SD equal to SP.

Table 2 shows the SD of spherical error sp1, sp2, sp3 respectively for the three above specified options of the interaction of SC in the group.

Table 2.

Results of possible SC groups options modelling

SP, m	sp1, m	sp2, m	sp3, m
65	171	247	340
26	84	114	146
22	82	111	125

The results obtained in (Table 1, Table 2) reveal the following.

The efficiency of the supplement signal to follower SC depends substantially on GDOP of the navigation satellite constellation, which master SC uses.

By increasing the transmitted signals from 1 to 3 the follower SC navigation position determination error increases from 3 to 6 times compared with the master SC.

The obtained results do not deny the possibility of further development of the concept.

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Rules, requirements and procedures for private remote pilot training

Rules, requirements and procedures are developed for professional training of remote pilots on basis of pilot training, training of remote pilots on flight simulator and flights of remotely piloted aircraft in scientific and manufacture center of unmanned aviation in National Aviation University.

Formulation of the problem. Regulatory requirements for operation of remotely piloted aircraft systems, including requirements for remote pilot training are most actively developed in recent years all over the world [1, 3, 4, 5, 8]. Especially, this process is accelerated after the release of ICAO Circular No. 328 [7], which put a lot of questions to aviation community. Remote pilots – private, commercial, instructors, and test-pilots are trained in different countries with different success. But questions keep open about rules, requirements and procedures for remote pilot training.

Analysis of recent researches and publications. The Chicago Convention [6] demands minimum standards to ensure a safety of civil aviation. There are requirements of Joint Aviation Administration [2] for training of piloted aircraft pilots.

Statement of problem. Recent researches and publications [1-9] describe different aspects of rules, requirements and procedures for training both pilots of piloted aircraft and remote pilots but general rules, requirements and procedures for remote pilot training are absent.

Presentation of the main material. In National Aviation University on the basis of scientific and manufacture center of unmanned aviation it was conducted investigation of remote pilot training: theoretical training; training on flight simulator developed by school laboratory "Remotely Piloted Aircraft Systems" of Aeronavigation Institute; and flight training.

Rules. Modern remote pilot in one person represents a whole range of professions: pilot, navigator, flight engineer, operator of target payload, radio operator. Flight work is the most difficult type of human activity that identifies the difficulties of professional training. So it is actual a question of best adaptation of remote pilot to remotely piloted aircraft. Remote pilot now and in the future will remain a central element in a system "remote pilot — remotely piloted aircraft — environment".

Flight on any remotely piloted aircraft is accompanied by hazards, which apparently are not always evident but potentially exist. Reduction of safety risk is achieved by improvement of remotely piloted aircraft, psychophysiological qualities of remote pilot, rules, requirements and procedures of remote pilot training. The last leads to complication of equipment, increasing a number of devices, attention elements, and consequently, to increase an amount of information received by remote pilot, deficiency of time during making decisions in control process of remotely piloted aircraft.

First of all it is necessary to determine: a number and duration of stages of remote pilot training; goals and objectives of the stages; a hierarchy structure of stage goals and tasks; specifics of readiness; time intervals of target focus of training means; a dominant aim on functioning of training sub-systems; an activation of special motivation on necessary activity type; dynamics of pedagogical flow tension in accordance with goal system through the stages to achieve a training main goal; grades of training means; nature, content and methods of training in stages; time and content of professional readiness control in general and by stages (control points). All this are determined by dominant-motivational aim rule.

Such components of remote pilot training as: a logical link with various training aspects; an involvement in integration of required number of means to achieve the goal; a keeping in integration by necessary functioning facets of various training means; a strict determination of specific pedagogical processes in amount of time of their operation in space (directivity); and an integration of training system elements in stages taking into account human factors, are provided by spatio-temporal integration of training means. This rule assumes an integrative interaction of training means not only in linking interests of various sections of program, but mainly for formation of remote pilot high adaptive complex. Spatio-temporal integration is limited, on the one hand, by minimum number of system elements and, on the other hand, by remote pilot adaptive capacity. In case of extraordinary increase of element number (training means) at any stage the remote pilot may be outside his carrying capacity.

A quantitative characteristic improvement of ordering of model and its functioning, dynamics of ratio of various training means is determined by specialization rule. Rank dynamics of training means on stage is determined by specialization degree of specific training means.

Such components of remote pilot training as: a rhythmic load interchange of various nature; a total volume of rhythmically change load (tension); a contraction of loads in specialized and contrasting microcycles; and an interchange of specialized microcycles with a certain pattern depending on ratio of organization levels of body adaptive systems (in accordance with principles of dominant motivational aim, spatial-temporal integration of training means and so on), are included in variety direction rhythm rule.

Control of process intensity of remote pilot training by comparing model with actual training results and adjustment of adaptive body systems is provided by feedback rule. It is implemented through management subsystem that affects remote pilot indirectly, through main subsystems. Due to feedback existing between remote pilot and training model, an individual approach to remote pilot training is possible. Divergence of parameters of "remote pilot portrait" and his model is a control signal for changing of training process tension, correction of insufficiently developed professionally important qualities and adaptive body systems. Feedback takes into account peculiarities of adaptive body system organization in different individuals under influence of same information because the same information stream is learn by remote pilot not in a same degree. Part of useful information is not learned by remote pilot, and to avoid this it is necessary an additional influence on him for the purpose of learning of omitted valuable information. The backfeed between "remote pilot portrait" and his model must be carried out during an entire training process continuously.

So organization of remote pilot training is determined by rules: dominant-motivation aim; spatio-temporal integration; specialization; variety direction rhythm; and feedback.

Requirements. The process of professional training includes a range of means and types of training. For this reason it is necessary formation of professional knowledge, skills and abilities.

As for pilots of piloted aircraft knowledge of remote pilot should includes: physical nature and fulfillment techniques of flight elements, maneuvers and figures; characteristics of remotely piloted aircraft system operation; order of distribution and switching of attention during fulfillment of flight task elements; support guidelines and readings for determining of remotely piloted aircraft attitude; typical deviations and errors during flights and means of their prevention and elimination; orienteering rules, equipment utilization, safety measures and actions in special situations; operation peculiarities of remotely piloted aircraft and its systems.

As for pilots of piloted aircraft skills of remote pilot should include: actions by levers of remote pilot station during all flight phases; interchangeability of crew members, timely assistance to each other; and preparing for flight and sequence of remotely piloted aircraft equipment utilization in accordance with nature and conditions of flights.

As for pilots of piloted aircraft abilities of remote pilot should include: interpret and evaluate the readings in flight; assess flight conditions and timely take correct decisions; pilot a remotely piloted aircraft according to flight elements lean on flight simulator; actively, initiatively, independently and creatively act depending on created conditions; and while maneuvering determine a remotely piloted aircraft attitude.

The stated requirements allow modeling of such process in practice. It is necessary for this: to develop a target and input models of training process; to determine stages and period of professional improvement, their aims and training means types; to distribute information process means in accordance with principles of organizational level management by remote pilot training.

Along with the abilities, knowledge, and skills of remote pilots a target model should include requirements for stability degree of integration of motivational, emotional, intellectual, and psycho-physiological activity components ensuring a high level of professional performance in special situations. The target model should define a strategy to achieve professional training objectives and, above all, solving of problem associated with development of typical tasks of professional orientation that remote pilot must learn to perform as well as methods for assessing and monitoring the required level of their knowledge and skills.

Input student model gives description of his person and is based on assessment of level of both psychological and psychophysiological qualities, theoretical training. Input model parameters are estimated from results of medical examination, profession selection, exams on theoretical training and testing. The input student model parameters provide recommendations and basis of differential approach to initial process of remote pilot training.

Procedures. On average, students assume one incident every 5 to 6 flights. Analysis of accidents and incidents shows that shortcomings in remote pilot teaching method, errors in piloting technique and remotely piloted aircraft system operation, capacity for work violations, and remote pilot indiscipline determine an overall level of failure rate, and their causes are characterized by repeatability. This necessitates an improvement of remote pilot training.

The main reasons that leads to wrong action of remote pilots is: insufficient attention; improper distribution and switching of attention; disproportion of movements; insufficient development of fine muscular sense; load. In sufficient measure these psychophysiological qualities is possible to form by theoretical and simulator training. While organizing of remote pilot training process a system approach is effective and is expressed as follows: quick formation of professional skills; less distinct "physiological cost" of professional activity; quality and reliable performance of professional functions in special conditions; and improving a capacity for work and so on. Along with organizational principles needed to develop a system, there are specific procedural principles that allow close approach to professional training methods of remote pilot.

Specific patterns of implementation of professional knowledge, skills and abilities in operation process are based on principle of strict regulation and time limitation. In specific flight conditions, for example at failure of flight control and navigation devices and systems of remotely piloted aircraft system, remote pilot should perform his professional functions in strict time intervals on background of pronounced emotional arousal that leads to training process, basis of which should be strict regulation of temporary limitation of remote pilot activity in general and certain piloting operations.

Principle of additional psychological load on background of main activity determines a forming of attention reserves in the professional training process. Necessity for introduction of this principle is determined by presence in flight activity of periods of complications of flight conditions, a transition to manual control after flight in automatic mode, refusals of aviation instruments and systems of remotely piloted aircraft, performing very difficult tasks. A generalization of flight mode image is important factor of flight training, as a result of which remote pilot actions occur in shorter time intervals, releasing attention reserves. This gives an ability to perform additional work on remotely piloted aircraft control.

Principle of complex formation of psycho-physiological adaptation mechanisms first plans a training of individual professionally important qualities in all types of ground and flight training, and then their usage in various combinations by way of activity changing.

Principle of rhythmic increasing of physiological work supposes an alternation of physiological work on degree of neuropsychic body tension. The principle obliges after psychological load reducing to provide its increase to level that necessarily surpasses the previous load peak.

Thus, specific, didactic, organizational and procedural principles provide a focus approach to organization system of remote pilot training and development of formation methods of remote pilot professional training.

Conclusions

Developed rules, requirements and procedures are good basis for remote pilot professional training.

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Unmanned Aircraft Usage in The Municipal Air Transport of Ukraine

The article analyzes, systematization and coding types of drones on existing classifications. Showing prospects of municipal and unmanned aircraft, flight simulation group UAVs for aerial photography. Comparative analysis of the effectiveness of group flying UAVs for the intended purpose and use of UAVs in the municipal transport.

Introduction

Unmanned aircraft has several advantages, namely low operating cost, good concealment, resistance and flexibility, simplicity and availability of technology compared to manned aircraft and Unmanned Aerial Vehicles (UAV) can be used in cases where the use of manned aircraft is impractical, expensive or risky [1; 2]. The main advantage of using UAVs is tasks that involve risk to humans and efficiency in solving economic problems.

Obviously, the effectiveness of UAVs in monitoring forest fires, search and rescue operations in the processing of agricultural crops, relay communications and the movement of goods is much higher than in single UAV flights. In this sense, the use of UAVs is more appropriate: to relay communications in those places - where the antenna coverage cannot be set because of difficult terrain, agriculture, with aerial photography, moving cargo. Also, UAVs was used for military purposes since 1961 [1].

The disadvantages of unmanned aircraft include the limited capacity due to the small size UAV that can be compensated for the use of group flight [2]. In addition, the group of small and light UAV effectively interact appear more useful qualities: speed task, increasing the density of surface area when spraying crops, and so on [3].

UAV usage in municipal air transport

The advantage of an unmanned helicopter and multicopters is the ability to land at low speed. However unmanned helicopters is too expensive, and multicopters not yet able to fly long distances, and apply only to capture local facilities (separate buildings). [4]

Unmanned aircraft with flapping wings combines unmanned aircraft and helicopters type, namely the ability to fly in a straight plane and suspend flight over a particular asset, besides the advantages of the scheme are small size flying machine [20]. The main disadvantage of flapping wing UAV is: short duration of the flight, had studied the surface area (in the case of aerial photography), inability to move the load, and use in agriculture [20].

The Group UAV can minimize the above-mentioned disadvantages. Table 1 presented a comparative analysis of the effectiveness of different types of UAV flight in a group when the following tasks:

1. Aerial photography
2. Relay connection
3. Agricultural work
4. Moving cargo
5. Search and rescue works

Table 1

Comparative analysis of the types of UAV inappropriately using municipal services

UAV purpose	UAV type		
	Aircrafts	Multicopters	UAV with flapping wings
Aerial photography	+	+	+
Agricultural work	-	+	-
Relay connection	+	+	+
Moving cargo	+	+	-
Search and rescue works	+	+	+

Therefore, aerial photography, search and rescue operations can be carried out all types of UAVs, but search and rescue will have the advantage that they can stay on one place for a long time, that multicopters. When you move the cargo is the most effective type of UAV aircraft, as well as in agricultural work and relay communications [5]. For the work on UAV aerial advantage to manned aircraft are primarily cost significantly reducing the number of routine operations, but no human on board simplifies preparations [6].

According to Table 1 it is clear that the best option for use in municipal services is multicopters. Opportunities monitoring areas offered by unmanned aircraft, an extremely high: professional quadcopters can reach speeds up to 100 km / h, climb 500 meters record images as 4K and send it in HD-quality. Range of new mass UAV is 5 kilometers. Now actively being developed on the use of drones, equipped with thermal imagers for better search people in the forest park areas and the dark, and instant identification of sources of ignition.

Let's consider this on the example of Kyiv: the use of unmanned aircraft in the police. As noted above UAV flight distance is an average of about 5 km, so the range (R) Unmanned Aircraft will be 5 km, respectively area which will cover a UAV S = πR2 = 78,5 km2. Kyiv area 839 km2, so for simultaneous monitoring of the territory of the capital needed N = 839 / 78.5 = 11.

High speed with which the UAV can arrive at a given point regardless of road and weather conditions shows them as different devices for use in medical rescue and operational purposes. UAV medical devices are used in cases where you should not count on the prompt arrival of the ambulance. For example in Germany has tested UAV pacemaker, which is caused by using the application on a mobile device [7].

When rescue people in reservoirs using special drones that patrol the city around the clock beaches and have the ability to transfer several individual swimming facilities (meaning lifeline). [7] For example: a group of UAV patrols the area of the city: monitoring traffic congestion, accidents, fires, etc., The detection situation for threats to people's lives statement provides timely information to the MOE, and the place goes to another UAV (medical, life - depending on the situation).

Conclusions

Thus, analysis of the UAV groups inappropriately made it possible to generate input data for use in municipal transport (Table 1). Further research should be directed to the solution of practical problems of implementation of group management in driving UAV, which leads to more efficient use of UAVs, namely the possibility of adjusting the plan and optimization flight path based on data already obtained from other UAVs; increasing the probability of success of the task; a significant gain in time; simultaneous examination area and increase the area of simultaneous monitoring; the possibility of setting different tasks for multi-group members.

The main problem is avoiding collisions with ground UAV objects in urban conditions, so further studies should be sent for consideration to the problem.

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Distributed control system for remotely piloted aircraft

The article analyzes the problem of organization of integrated flying remotely piloted aircrafts. The structure of the distributed decision support system remotely piloted aircraft solutions. Developed a database of local DSS operators of remotely piloted aircraft system(s). For rational aggregating requests and increase the processing speed as a database as NoSQL solution.

Problem statement. Remotely piloted aircraft systems (RPAS) are a new component of the aviation system, one which ICAO, States and the aerospace industry are working to understand, define and ultimately integrate. These systems are based on cutting-edge developments in aerospace technologies, offering advancements which may open new and improved civil/commercial applications as well as improvements to the safety and efficiency of all civil aviation [1; 2].

Unmanned aircraft has several advantages, namely low operating cost, good concealment, resistance and flexibility, simplicity and availability of technology compared to manned aircraft and Unmanned Aerial Vehicles (UAV) can be used in cases where the use of manned aircraft is impractical, expensive or risky [1; 2; 3]. The main advantage of using UAVs is tasks that involve risk to humans and efficiency in solving economic problems.

The goal of ICAO in addressing unmanned aviation is to provide the fundamental international regulatory framework through Standards and Recommended Practices (SARPs), with supporting Procedures for Air Navigation Services and guidance material.

The article analyzes the problem of organization of integrated flying remotely piloted aircrafts. The structure of the distributed Decision Support System (DSS) remotely piloted aircraft (RPA) solutions. Developed a database of local DSS operators of RPAS. For rational aggregating requests and increase the processing speed as a database as NoSQL solution.

The purpose of the publication is development of the structure of distributed DSS for remotely piloted aircraft; development of a database of local DSS operators RPAS distributed within the DSS.

Main part. For planning and flight control UAV developed a Distributed Decision Support System (DDSS), which represents a complex system with complex interactions geographically distributed local DDSS operators of RPA. During the flight UAV's (RPA's) may be controled by RPAS. Remotely piloted aircraft controlled with remote piloting station (RPS) with the management and control line (C2). Together with other components such as the starter equipment and equipment for the return, if it is used, RPA, RPS and the line C2 constitute RPAS [1].

At any given time t_i k-RPA can be controlled from only one j-th RPS, if necessary, at time t_i+1 to be transmitted to the control (j + 1)th RPS for using DDSS

(Figure 1). This transfer flight control of the j-th RPS to (j + 1) -th RPS to be safe and effective, which is provided through the local DSS operators RPAS. According to the recommendations of the ICAO guidelines [1; 2] task system can perform one or more nodes (local DSS operators RPAS). With the formation of the database addresses issues related to the inclusion of RPA the existing regulatory framework of civil air navigation system; description and classification of UAVs and related components; rules of flight, such as instrument flight rules (IFR) and Visual Flight Rules (VFR) flights in the visual line of sight (VLOS) and beyond line of sight (BVLOS) [1].

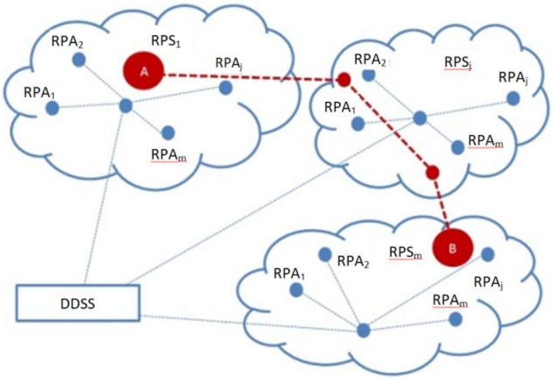

Fig.1 The structure of distributed RPS Mission Control UAVs

From the DDSS organization depends on its effectiveness [3]. In determining the structure of the system are the following objectives:

- study of problems that solves DSS;
- selection algorithm implementation problems;
- determine the levels and components in the system;
- distribution of tasks to nodes (levels);
- definition of technical means complex systems;
- relevant content and management database.

Mathematical model for selection of a DDSS to control, which minimizes the cost of the system with regard to costs for exchange of information between local DSS operators RPAS and solved at different levels and priorities of the costs of operating the system:

$$Z = \min\left[\sum_{i,j,k,i',j',k'} b_{ikji'k'l'} x_{ikj} x_{i'k'l'} + \sum_{j,l} C_{lj} x_{jl}\right],$$

$$\sum_{k,j} x_{ikj} = 1 \ , i = \overline{1, I}$$

$$\sum_{l,j} k_l x_{ij} + \sum_{i,k,j} k_{ik} x_{ikj} \leq k, \ k = \overline{1, K}$$

$$\sum_{i,k} m_{ik} x_{ikj} \leq \sum_l m_l x_{jl}, \ j = \overline{1, J}$$

where

$$b_{ikji'k'l'} = \begin{cases} a_{ikj}, \text{if } ik = i'k' \\ a_{iki'k'} \cdot y_{jj'}, \text{if } ik \neq i'k' \end{cases}$$

$$x_{ikj} = \begin{cases} 1, \text{k task , i mean in j node,} \\ 0, \text{otherwise,} \end{cases}$$

$$x_{jl} = \begin{cases} 1, \text{ in j node l} - \text{ RPS,} \\ 0, \text{therwise,} \end{cases}$$

$\{a_{ii'}\}$ - matrix communication of information between tasks i and i' with the level and priorities

$\{y_{jj'}\}$ - matrix expenses for the transfer of information between the RPS (nodes);

m_l – the characteristics RPS;

C_{lj} – RPA flight costs;

K_l – operating costs RPAS.

Indeed, UAV piloted by remote piloting station (RPS) using line management and control (C2). For piloting UAVs use RPS, which is both portable and multiple control station is located indoors or outdoors, be stationary or mobile (mounted on the vehicle / ship / aircraft). To coordinate interaction and exchange of information between remoted pilots developed database of local RPS NoSQL [4]. During developing a database of local RPS, UAV users, it was made UAS components analysis, UAV, RPS, C2, and so on. Taking into account the UAVs operating procedure that includes the purpose of the flight, flight rules, flight areas, functional level C2 lines and other standards (Figure 2 and figure 3).

Information block local DSS operators RPAS within a distributed DSS drawn up in accordance with the recommendations of ICAO [1; 2] Instructions for assembly applications for private use under the planning of flights contains the following components:

- characteristics of RPAS, RPA, RPS, communications, navigation, surveillance (conduct of the lines and control (C2), GNSS, ADS-B, etc.);
- certification RPAS, RPA, RPS;
- RPAS obligations of the operator;
- safety management;
- DAA;
- connection with the ATM;
- procedures manual landing planes, airports;
- RPA operating procedures, rules of operation, etc.

Unlike relational model [4], which stores logic business core application in different physical table in order to normalize, NoSQL storage with these entities operate as an integral of objects. So instead of creating a new table for each separate entity, we simply create objects of entities defined for these attributes.

```
{
        "id" : "EO707-11",
        "airCarrier" : "SWISS",
        "aircraftType" : {
                "manufacturer" : "BOEING",
                "bodyType" : "747",
                "engine" : "four-engined",
                "year" : "2006",
                "seats" : "605"
        },
        "payload" : 0.82
}
{
        "airCarrier" : "IBERIA",
        "aircraftType" : {
                "manufacturer" : "AIRBUS",
                "bodyType" : "A310",
                "engine" : "twin-engined",
                "year" : "1996",
                "seats" : "279"
        },
        "payload" : 0.76
}
{
        "id" : "AI908J-09",
        "airCarrier" : "IBERIA",
        "aircraftType" : {
                "manufacturer" : "AIRBUS",
                "bodyType" : "A310",
                "engine" : "twin-engined",
                "year" : "1996",
                "seats" : "279"
        },
        "payload" : 0.76
} ...
```

Fig.2 Fragment of data of NoSQL database of local RPS UAVs users

id	aircarrier	aircraft	payload
EO707-11	SWISS	747	0.82
-	IBERIA	A310	0.76
AI908J-09	IBERIA	A310	0.76
AI911J-13	IBERIA	A310	0.95
AI904K-05	IBERIA	A310	0.85
AI943N-12	IBERIA	A310	0.9
EO608-06	SWISS	747	0.89
EO611-08	SWISS	747	1
EO702-19	SWISS	747	0.74
EO702-21	SWISS	A380	0.8

airCarrier	manufacturer	bodyType	engine	year	seats
IBERIA	AIRBUS	A310	twin-engined	1996	279
SWISS	AIRBUS	A380	four-engined	2007	555
IBERIA	AIRBUS	A380	four-engined	2011	555
IBERIA	AIRBUS	A310	twin-engined	1996	279
SWISS	BOEING	747	four-engined	2003	605
SWISS	BOEING	747	four-engined	2006	605

```
// USE AGGREGATION
db.flight.aggregate([
    {$group:
     {
        _id:{
            "airCarrier":"$airCarrier"
        },
        averagePayload:{$avg:"$payload"}
     }
    }
])

// OUTPUT:
//{ "_id" : { "airCarrier" : "IBERIA" }, "averagePayload" : 0.844 }
//{ "_id" : { "airCarrier" : "SWISS" }, "averagePayload" : 0.85 }
```

Fig.3 Fragment of NoSQL database of local RPS UAVs users

Using this approach, the task, will ignore the specific objects and their attributes and will work with individual flows with a holistic entities. This allows you to use a standardized approach to consolidating all information flows in the subject area, and to identify for each use prioritize and rules RPAS and flights RPA [5; 6].

Conclusion

Global operational air traffic management concept that reflects the ICAO vision of a single coherent and based on global fashion mutually ANS systems should ensure collective consolidation to management of traffic. Consolidation of information flow plays an important role in air traffic management. In today's rapid development of aviation to the person receives a large amount of information from a variety of control systems. To make the right decision information which comes to air traffic controllers should be structured and consolidated information flows. There is a need to establish a system that will structure the information to collect and consolidate a disparate information flows and the output file turnkey solutions for air traffic management. To implement this system plays an important role choose Database. Analysis of existing solutions shows the need to use NoSQL database. These systems are capable of providing the required speed [5 - 7]. And thanks to a special approach to data aggregation becomes possible standardization of methods of consolidation flows.

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Unmanned Aircraft Systems of Ukraine: production and using

In the article analysis the problem of development and use unmanned aerial vehicles in Ukraine. Analyzed typical flight technical and operational characteristics, made conclusions about the prospects of development of the UAV. Formulated tactical and technical characteristics of aircraft. Conducted a brief overview of some of them.

Unmanned aerial vehicles (UAVS), also known as a drone, as an unmanned aircraft system (UAS), or by several other names, is an aircraft without a human pilot aboard and widely used in both military and in peaceful purposes. UAVS are able to conduct air reconnaissance and surveillance, transfer photos and video in real time. They can be carriers and targets, to operate in extreme conditions, including in areas that have undergone radiation, chemical or biological contamination in areas of disasters or intense fire countermeasures.

Multiple terms are used for unmanned aerial vehicles, which generally refer to the same concept. The term drone, more widely used by the public, was coined in reference to the resemblance of dumb-looking navigation and loud-and-regular motor sounds of old military unmanned aircraft to the male bee. The term has encountered strong opposition from aviation professionals and government regulators [8].

The term unmanned aircraft system (UAS) was adopted by the United States Department of Defense (DoD) and the United States Federal Aviation Administration in 2005 according to their Unmanned Aircraft System Roadmap 2005–2030.[5] The International Civil Aviation Organization (ICAO) and the British Civil Aviation Authority adopted this term, also used in the European Union's Single-European-Sky (SES) Air-Traffic-Management (ATM) Research (SESAR Joint Undertaking) roadmap for 2020 [3]. This term emphasizes the importance of elements other than the aircraft. It includes elements such as ground control stations, data links and other support equipment. A similar term is an unmanned-aircraft vehicle system (UAVS) remotely piloted aerial vehicle (RPAV), remotely piloted aircraft system (RPAS). Many similar terms are in use.

Unmanned technologies there since World War II. At first they were complex and expensive systems, which have only military purpose. Over the past two decades in this subject field was a real scientific and technological breakthrough. According to a leading international Association of unmanned systems UVS International, presently in development units are actively involved around hundreds of public and private enterprises in different countries [3]. Ukraine in this case is also no exception.

In Ukraine, created the necessary production and technological base that has rich experience in development, testing and production of drones. These models not only technical characteristics do not concede their world counterparts, but in many cases even surpass them.

Our country is one of the few countries that have a strong air design potential. The development of aviation industries can overcome the lag in building unmanned aircraft systems, competitive and take their place in the production and operation. One of the areas that allow to implement new ideas and professional expertise in the form of final products is the creation of small unmanned systems.

UAVs typically fall into one of six functional categories (although multi-role airframe platforms are becoming more prevalent): target and decoy – providing ground and aerial gunnery a target that simulates an enemy aircraft or missile; reconnaissance – providing battlefield intelligence; combat – providing attack capability for high-risk missions; logistics – delivering cargo; border control; research and development – improve UAV technologies; civil and commercial UAVs – agriculture, aerial photography, data collection [8].

The main advantage of UAVS, which recognize all experts is the lack of a the Board of the person, regardless of the complexity and danger of the tasks performed by UAVS, life pilots nothing threatening. UAV is able to act in the areas of biological, radioactive and chemical contamination. He does not need a complex system of life support crew. In a crisis situation the apparatus you can donate.

Depending on the management principles distinguish the following types of unmanned aerial systems: unmanned untethered; unmanned automatic; unmanned remotely-manned aircrafts (DPLA). In aviation after 2000 comes rapid expansion it is the last type of apparatus, and they said when taking the term «drone» or the abbreviation UAV [9, 1]. That is, the term «Remotely piloted vehicle», «AL», «UAV» meant exactly aircraft, which through communication channels managed by one or more pilots.

The crew of the UAV can also include Commander, operator of the sensors, the operator of fire weapons. UAV crews during long-term missions are changing, as generally, every 4 hours. Unmanned aerial vehicles, according to NATO standards, as well as aircraft with a pilot on board, divided into 3 classes: I - the full take-off weight of 150 kg, II - the full take-off weight of 600 kg, III - the full take-off mass of more than 600 kg. Class I is divided into categories: «micro» - up to 2 kg, «mini»- up to 15 kg, «small» - from 15 kg [9].

Ukrainian developments of UAVS, as at the beginning of the Russian armed aggression against Ukraine, Ukraine's armed forces have not had own modern unmanned aircraft. The existing armed with TU- 141 «swift» were morally obsolete. In desperate need of unmanned airplanes-scout First Nations meet the volunteers by adapting civilian vehicles to the requirements of military [4]. Were created, including Bat-1, PD-1 UAV «Fury». The latter was designed by Kiev NNP «Athlone AVIA» in 2014, his name came up with the most fighters who use this machine almost from the start of fighting in Donbass. The first battalion, who used «Fury» was «Donbass». In July 22, 2015 new unmanned aerial vehicles «Fury» officially taken by national Guard, as the Minister of the Interior Affairs of Ukraine Arsen Avakov reported [4]. These UAVS are also in service with the armed forces of Ukraine.

The Ukrainian state-owned defense company Ukroboronprom has built the country’s first military unmanned aerial vehicle (UAV) to bolster Ukraine’s combat against Russia-backed insurgents in the country’s east [7].

The first batch of three drones was supplied to the Ukrainian Armed Forces, Ukrobonoprom said in a statement. The BpAK-MP-1 UAV was built by the firm's subsidiary Meridian in cooperation with a research team from the Kiev Technical University. «The path from the design phase to production was just one year,» the statement said.

Yuriy Paschenko, the deputy director general of Ukroboronprom, said that the tactical version of the new drone, which will be fitted with combat capabilities, will made in late 2016 and supplied to the Ukrainian Armed Forces in the first quarter of 2017 [9].

In 2015 the students of Kyiv Polytechnic Institute were created by unmanned aircraft complexes of the Spectator. Production of JSC established Meridian named S.P. Korolev, incorporated DC «Ukroboronprom» [3]. Also, to date the only UAV container start class micro, which passes the stage of flight and ground test is a UAV «Sokol-2», which is a joint development of the NTUU «KPI» and SE «DKKB», «Luch». An experimental sample of the UAV was presented to the largest in the Middle East and North Africa, the international exhibition of armaments and defence technologies «IDEX-2001» [3] and received the highest award in one of the seven nominations.

On the basis of the National Aviation University was created Center of unmanned aircraft «Virazh» [5], which is actively engaged in the development, tests and launch aircraft of different classifications. Among these BPS m-10-1 and m-10-2 «Eye», two-engine aircraft m-B5 «Sky Patrol», a multipurpose unmanned aerial complex m-6-3 «Skylark» etc.

Among domestic developer BpAK is worth noting [2, p. 38]: Institute of problems of physical modeling National Aerospace University «Kharkiv Aviation Institute», who created a series of BpAK with relatively high characteristics («Stork», «Snipe», «Peregrine Falcon», «Golden Eagle»); CB «Rise», LLC «Uavia» Chuhuyiv aircraft repair plant, RPI «Ukrtehno-Atom».

In January 2016 Secretary Oleksandr Turchynov stated about production shock unmanned vehicles at SE «Antonov» [6]. The main function of the new tactical Multipurpose unmanned air complex is intelligence. However, it will be able to carry a small combat load and hit the ground targets. In particular, it arms should be able to destroy heavy armor, for example, tank [6].

Conclusions

As a result of the research shows that the existing in Ukraine UAVS of different types largely reflect the concept of their operational use in the right situation, but there are still a number of issues that require fundamental research:

- theoretical-experimental search for optimal aerodynamics outline that best meets the geometric, massive and operational restrictions;
- improvement of efficiency coefficient of electric power installation the application of more efficient sources of electric energy;
- theoretical-experimental work on complete devices;
- implementation of the regulatory framework created, certification, registration and use of BpAK;

- creation of a system of technical support, repair and modernization of BpAK;
- deployment of a system of training of operators-pilots and engineering-technical composition;

Delineated areas solve problems require complex approach taking into account and using advanced achievements in the field of air crafting , newest technology, navigation and radio electronics.

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Automated system of definition the field of view of camera of unmanned aerial vehicle

Developed a prototype system to determine the field of view of camera drones, to work in real time. This paper described an algorithm for determining the field of vision of the camera, submitted described by structure of the system and requirements for her.

Introduction

The technological development improved methods of intelligence, in particular with unmanned aerial vehicle (UAV), this allows you to safely monitor the location and movement of enemy, collect information of them. Human losses reduced when use observations with UAV, but it create new tasks: processing digital images and video in on-line, creating secure channel, creating system of object recognition and watch for them.

The result of digital aerial photography is digital terrain picture, and elements of the exterior orientation in the moment when photo was taken: $(X_{UAV}, Y_{UAV}, Z_{UAV})$– coordinates UAV and (ψ, ϕ, θ) − angles relative to the axes [1].

Statement of the problem

We received data in a form:

$$(\text{photo}, X_{UAV}, Y_{UAV}, Z_{UAV}, \psi, \phi, \theta),$$

where photo – digital image, $(X_{UAV}, Y_{UAV}, Z_{UAV})$ – coordinates UAV in system SK-63[2], (ψ, ϕ, θ) – angles relative to the axes in the moment when photo was taken.

Must to do:

1) suggest a method based on the analysis of know methods, if will be need they will improved for definition the field of view of camera;
2) develop an algorithm for determining the coordinates of the field of vision of camera and conducting test on data aerial photography;
3) implement the prototype system that can be installed on board the UAV and passing flight test.

Description of the prototype system

The system must satisfy the following requirements:

1) small size and weight;
2) low cost price;
3) resistance to violations of exploitation;
4) high resolution and wide viewing angle camera;
5) high speed work.

The first requirement is the small size of the system. Since the system is to be integrated on board small unmanned aircraft. The weight of the system is important for this type of flying vehicles, so it should also be considered.

The cost of such a system should be low for several reasons:

- possibility of damage during use;
- loss during use;
- possibility of launching into production.

The system put forward one of the requirements as stress resistance, such as to work on board unmanned aircraft, work in weather with high humidity, rapid changes in temperature.

Specifications for the camera require separate investigation because the size of the matrix and the focal length of the camera affects the accuracy of the coordinate object, quality of recognition and the system speed of work.

Our prototype of system consists of three main elements (Fig.1):

1) camera;
2) board computer;
3) navigational equipment.

Data exchange occurs through low-level protocols exchange information it is through ttyUSB. Interaction with the navigation board is using its own software, the adoption of processing and transmitting data to the main program for further use. Interaction with the camera going through the library OpenCV, by using the library get data from the camera and transmit to the main program for further processing.

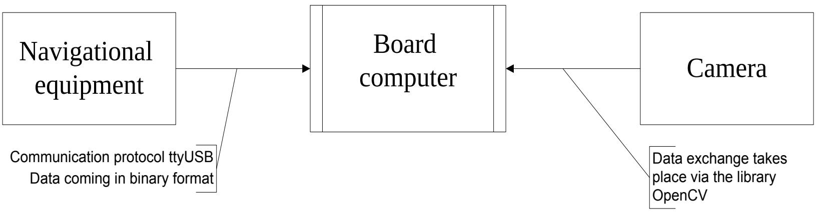

Fig.1. Diagram interaction between system modules

The algorithm for determining the coordinates of the field vision camera unmanned aerial vehicle described in [4]. The input data for the algorithm is the location of the UAV, its angles relative to the ground and the physical parameters of the camera. We showed the work algorithm of the system described and presented algorithm (Fig. 2).

The software tool implemented in C ++, to OS Linux, and using libraries OpenCV. Data transfer implemented between devices by USB-port.

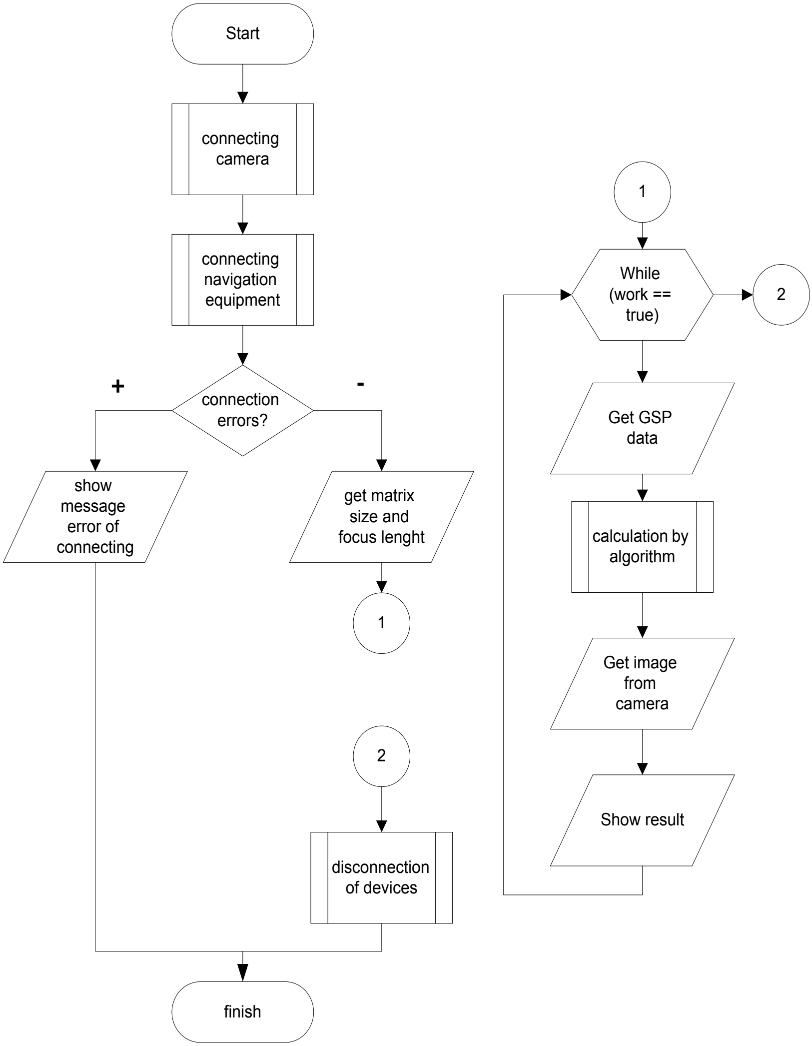

Fig. 2. The algorithm of the system work

Conclusions

The developed against of the system that implements the task of determining the coordinates of the field of vision of the camera and the object for which observed.

Further research aimed at testing the developed prototype and recognition of technical requirements for camera which should be installed in this system.

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Modern trends and issues of the development and improve the accuracy of navigation systems for UAVs

Equipping the armed forces of various complexes with UAVs assumes the character of a steady trend. The development of modern and advanced technologies allows carrying out of different functions for unmanned aerial vehicles, which in the past were not available or perform for other forces and assets. These developments of unmanned aerial systems are not possible without the development and improve the accuracy of the navigation systems.

Navigation systems for unmanned aerial vehicles.

Modern unmanned aerial vehicles (UAVs) have a lot of shapes, sizes, configurations and characteristics. Historically, the first UAVs was simple remotely piloted flying vehicles, but the more relevant use of autonomous systems.

Generally UAVs used for military and special purposes, but also has been actively used in civilian aims such as security and firefighting, as well as non-military work related to the protection of strategic assets such as pipelines, territorial waters, difficult to reach and protected areas, etc [1].

On-board of the UAVs has installed various modern navigation systems. However, the most widely used systems are based on satellite navigation systems and inertial navigation sensors like MEMS (micro-electromechanical system), because they provide the required level of accuracy with low weight and dimensions [2].

To the modern on-board navigating systems for UAVs must meet high requirements of globality, regardless of weather conditions, underlying the total plant cover that surrounds them, buildings, time of day and season, continuity, sufficient bandwidth, high noise immunity, regardless of height above the ground and other conditions of the object of navigation and so on.

Huge perspectives in the development of mini and micro UAVs are opened in because of the development nanotechnology and biotechnology. Projects nano-drones, although existing still only in the minds of its creators take into account the creating miniature systems capable of flying in flocks or swarms above the enemy, especially in urban areas, controlling his every move and every word [3].

In general, sensors what included in the GPS/INS system was consisted of three 1-axis vibration gyroscopes, one 3-axis accelerometer, one GPS receiver with multiple antennas and DSP processor with I/O and memory like Figure 1.

Despite all the benefits of the use unmanned aviation in the interests of groups of ground forces, this process has some limitations. Large-scale use by all sides of UAVs, according to military experts, can disrupt the process of control airspace over the area of conflict. Difficulties of interspecific and the more at the interagency coordination of fly drones repeatedly increased with presence of enemy UAVs [4].

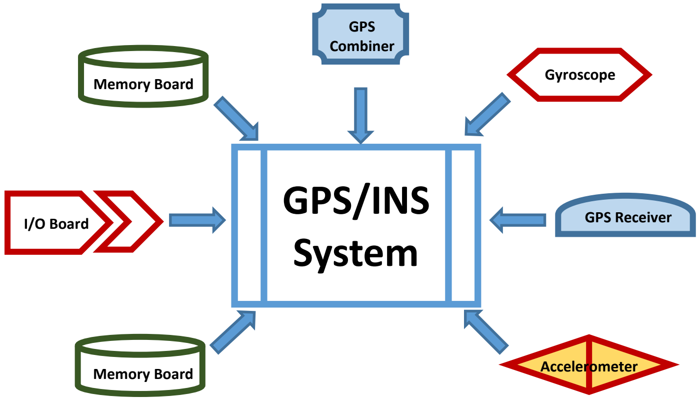

Figure 1. Hardware Structure GPS/INS System

Types and features of the integrated navigation systems.

INS/GPS integration architectures are defined as separate, loosely and tightly coupled, deeply integrated configurations [5]. The benefits of increasingly tight coupling in the navigation systems introduce in table №1. Widely used methods for combining navigation measuring devices are based on mutual compensation and filtering their errors [6].

Table 2.

Cumulative benefits of increasingly tight coupling in the navigation systems

Coupling Level	Benefits
Uncoupled INS to GPS	- Position, velocity, acceleration, attitude, and attitude rate information - Redundant systems A drift-free GPS - A high-bandwidth INS
Loosely coupled	- More rapid GPS acquisition - In-flight calibration and alignment Better inertial instrument calibration and alignment - Better attitude estimates - Longer operation after jamming
Tightly coupled	- Better navigation performance better instrument calibration - Reliable tracking under high dynamics reduced tracking loop bandwidth (jamming resistance) - Optimum use of however many SVs available
Deeply integrated	- Advantages the single filter removes the problem of the “cascade” filters switching, compactness requirements reduction of power consumption. - Disadvantages the state vector contains up to 40 components (that is why the filter is difficult to realize).

For navigation and coordination of UAVs and use them for flight control, satellite navigation system used GPS in combination with an inertial system. Often the precision of one inertial system based on gyroscopes to estimate coordinates is not enough. So when carried out of aerial intelligence and obtained photos, for example, when are tanks on the ground, need add to them the precise geographic location.

Therefore, the presence of GPS signals is a necessary condition for the execution of tasks unmanned aerial vehicles now. Absence or deliberate suppression of satellite system signals cause problems with accurately determine of their location and as a result to perform flight on a given route. In the case of using inertial systems with extremely low accuracy in UAVs (especially for short-range UAVs) the absence of corrective signals from GPS can lead to "disorder" inertial systems and UAVs crash. Today, the suppression of GPS signals is considered as the main method of struggle against UAVs.

But along with this, use of UAVs raises several serious problems related is mainly with safety operation of unmanned aerial systems, and in particular the problems of information security. Threats emanating from remotely piloted UAVs when they are used together in a single airspace with traditional aircraft also have an information aspect as the interception control of the "drones" and can be made for the purpose of malicious attacks on other aircraft or ground targets [7].

Use of the high precise inertial navigation systems (INS) has not fully solved this problem for the following reasons:

1) Such systems are expensive (from 30-50 thousand dollars);

2) Weight of the "high accuracy" inertial system on laser or fiber optic gyroscopes is near 8 kg and making them difficult for using in small and medium UAVs;

3) Principal constraint of INS is growth of determination the coordinate errors over the time of autonomous work. Precision of autonomous work for modern INS is about 1 nautical mile per hour of flight (for high accuracy systems) that does not allow for precision determination coordinates of target.

Combination of mechanical-electronic and digital systems with modern navigation systems for UAVs allows obtaining high accuracy of determination the coordinates with high economic performance and optimal overall dimensions of the final integrated navigation system.

This requires measuring the state of UAV, coordinates of location, their speed, altitude, vertical speed, orientation angles and angular velocities and accelerations. Having in its composition triads of inertial sensors (micromechanical gyroscopes and accelerometers), barometric altimeter, triaxial magnetometer and using the complex of data from these sensors with the data of GPS module, the system produces a complete navigation solution on the coordinates and orientation angles.

Challenges and problems of development navigation systems for UAVs.

The success of the mission depends on UAVs for reliable operation of all onboard systems. Severability and independence from the human factors and resistance to external influences are decisive factors for the success of the mission of UAVs [8]. So for counteracting and neutralizing UAV use all available tools.

Currently, the "jammers" for satellite navigation receivers are already in service with several countries. Every year an increasing number of companies that produces such "jammers". Nowadays hard to imagine military operations, which were not applied least the transmitter obstacles of satellite navigation systems.

Automatic UAVs systems, equipped with a fully automatic control system requires minimal preparation of ground staff, thus solve the problem of using UAVs at large distances from the place of home base, without contact with the ground station, in all weather conditions. They are easy to use, portable, rapidly deployed and does not require ground infrastructure. Can be argued that high performance of UAVs equipped with the highly precise navigation system and a fully automatic control system reduces operating costs and staff requirements.

The development of UAVs constrain by several problems, the most important of which is provide data transfer between aerial vehicle and ground control center in the necessary speed and without distortion, and the stability and security of data channels. The world market trading of UAVs is constantly expanding and competition was very hard on it. After all, UAVs is need continuous expanding the scope of use, improving design and control system, increased range and flight duration [9]. Despite these issues of UAVs is very perspective type of technology.

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UDC 004.9

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UAV flight mechanics

Described the basics of UAV motion control system. The problems in stabilization of PID controller. Provided comparisons of transfer characteristics for PI and PID controllers.

The flight of multicopter is due to the rotation of the pairs of rotors in opposite directions, in the case quadcopters - two couples. Unlike traditional helicopters, all four rotors work together to create a vertical thrust and weight lifting apparatus in the air. The movement of the quadcopter is controlled by varying the relative thrust of each rotor. This design creates a more stable platform than helicopters with one rotor.

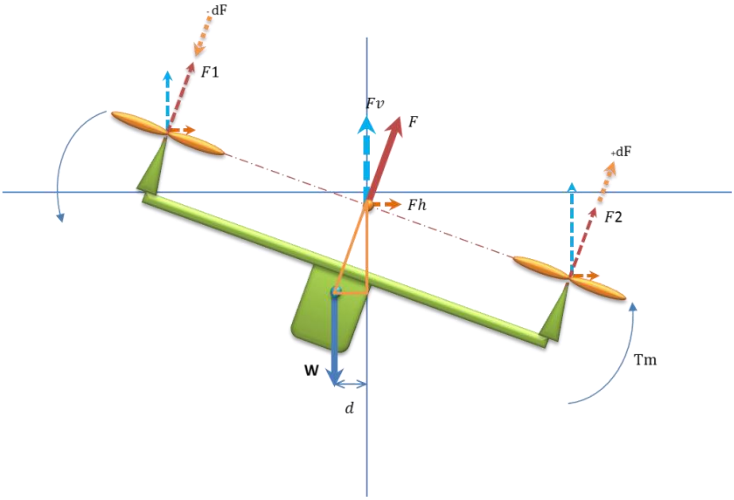

Fig. 1 – Turning the quadcopter by changing thrust of one rotor

Helicopters uses two rotors, one main rotor, which provides lift and shift pitch and roll, and one stabilizer – the tail rotor [1]. Tail rotor used to stabilize the aircraft on the twisting torque of the main rotor. Quadcopters and other multicopters based on four or more rotors which act together to tilt the entire apparatus and perform changes in pitch and roll. Motors controlled by onboard flight controller - through the analysis of the current state of orientation using one or more sensors and auxiliary control. The steeper the angle of the device causes the faster going in this direction, but too steep an angle can cause accidents.

From a technical point of view, this raises an interesting and difficult task of balancing (maintaining a stable position and vertical orientation) by continuously adjusting the speed of rotation on each rotor. Since the realization of these adjustments in real time is an extremely difficult task for a human, its work translates into created complex system of regulation – the «PID controller».

As the multicopter, because of its design has resistance to external influences, the flight stabilization system occurs in three corners of his center: roll, pitch and yaw (Fig. 2). However, human reaction speed is not sufficient for effectively stabilization, so in practice used automatic stabilization system based on sensors installed on the quadcopter, such as accelerometers and gyroscopes.

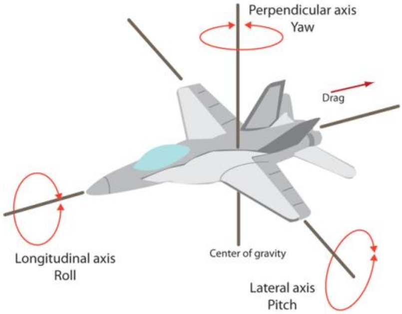

Fig. 2 – Angles of the aircraft compared to the center

Since the yaw angle is not critical for the maintenance of aircraft in the air, the main task is to stabilize the device in roll and pitch.

First of all, it should be noted that the accelerometer is not able to track uniform rotation in the plane perpendicular vector of $\vec{g}$.

If we assume that the actual acceleration of the device small in comparison with the acceleration of free fall $\vec{g}$, it is possible to determine the angles of pitch and roll, only by according to indications of the accelerometer. However, practical studies have shown that the natural noisiness of the accelerometer, in conjunction with vibration from the rotation of the propellers and self acceleration of multicopter, which does not allow to determine the angles required for stabilization accuracy. If use a filter with sufficient strength to smooth the signal, the sensor output delay occurs, and prevents timely response for change the position of the aircraft. Moreover, with a strong smoothing, information is lost at a relatively small changes of angle.

Thus, to solve the problem of stabilization uses a combination of accelerometer and gyroscope [2].

To represent rotations convenient to use quaternions – four component vectors. We denote $Q_g(t)$ for representing rotation, calculated at time t accordingly to indications at gyroscope, and $Q_a(t)$ – rotation calculated in the same moment according to indications at accelerometer.

To correct the error indications of gyroscope integration, needs to take a weighted sum of the quaternion:

$$Q(t) = \alpha Q_a(t) + (1 - \alpha) Q_g(t) \tag{1}$$

Where α – correction factor (usually takes values from 0.005 to 0.1).

Getting the angles of orientation of the device (yaw, roll and pitch) using quaternion orientations:

$$\psi = arctg\left(\frac{1-2Q_y^2-2Q_z^2}{2Q_yQ_w-2Q_xQ_z}\right) \tag{2}$$

$$\gamma = arctg\left(2Q_xQ_y - 2Q_zQ_w\right) \tag{3}$$

$$\theta = arctg\left(\frac{1-2Q_x^2-2Q_z^2}{2Q_xQ_w-2Q_yQ_z}\right) \tag{4}$$

Where Q_w, Q_x, Q_y, Q_z – four components of quaternion; the obtained values – rotation angles of machine: roll, pitch and yaw, respectively.

After the controling program obtain the angles of roll and pitch, it is necessary to apply the correction to the power of each engine to eliminate possible deviations. For this purpose, typically uses PID or PD controllers.

In total there are not so many types of regulators that are used to control the technical process, especially – the aircraft flight. A total of three, namely, P, PI, PID, there are other types but their usage is the exception, rather than rule. All the controllers are different in their characteristics and complexity of implementation. Shortly about the advantages and disadvantages in the usage of each of them:

– Proportional controller (P-controller). Principle of action – producing a control effect on the control object, proportionally to the value of error. Advantages: ease of implementation and configuration. Disadvantages: can not provide stable maintenance parameter – or rather can not provide achievement of a given parameter.

Used in devices where simplicity is required, but there is no need for great precision. In industry is rarely used due to the fact that in more or less complex devices to implement other, more precise controller is easy. Actually used in simple devices with limited functionality with no software control (microcontrollers, microprocessors, etc.).

– Proportional-integral controller (PI-controller). It is one of the most versatile regulators. In fact, PI controller – is a P controller with an additional integral component. I-component, which complements the algorithm, first of all needs to eliminate static error, which is characteristic of a proportional controller. In fact, an integral part is cumulative and thus allows that the PI controller takes into time previous history of changes in the input variable. Advantages: ease of implementation. Disadvantages: output to a target value is prolonged (over time).

It is used in many industrial applications where is necessary accurately hold the parameter which does not change its value instantly, even with the instantaneous change in external environment. For example the temperature can not change instantly because there are the heat capacity, moreover, also the sensor itself can not instantaneously change its temperature. Pressure fluids also can not change instantaneously, so using the PI regulators, for example, for the maintenance of pressure is justified.

– Proportional-integral-derivative controller (PID controller). The most optimal of this three types of regulators, so it widely used. In fact, this is evolution of the PI controller. The proportional component generates a signal which counteracts the deviation of the controlled variable at a given time (the ideology of pure P controller). Integral component accumulates the resultant value, leveling thus lack the P controller – the presence of static errors. D-component, which, as it predicts a deviation from the objectives and monitors speed deviations, so it the fastest in this algorithm. In fact, it is an advantage and a disadvantage at the same time. It is necessary to consider when choosing the law of regulation.

Advantages: best transfer characteristic, excellent speed and accuracy of regulation in comparison with P- and PI- regulators.

Disadvantages: difficult to implement and configure. Modern PID controllers implemented using computer processors. The yield on a given parameter is prolonged (at time).

PID controller, considering in terms of stabilizing the UAV – is algorithm, based on the deviation from the value, which should stabilize, and gives an amendment to the relevant rotors. Assuming the deviation from the required value at time t equal to $e\ (t)$, then the following formula expresses the necessary correction, where $K_I,\ K_I,\ K_D$ – proportional, integral and differential coefficients respectively:

$$u(t) = P + I + D = K_P \cdot e(t) + K_I \int_0^t e(\tau)d\tau + K_D \frac{d}{dt} e(t) \tag{5}$$

In the case of PD (proportional-differential) regulator, component I is reset, and the previous formula becomes:

$$u(t) = P + D = K_P \cdot e(t) + K_I + K_D \frac{d}{dt} e(t) \tag{6}$$

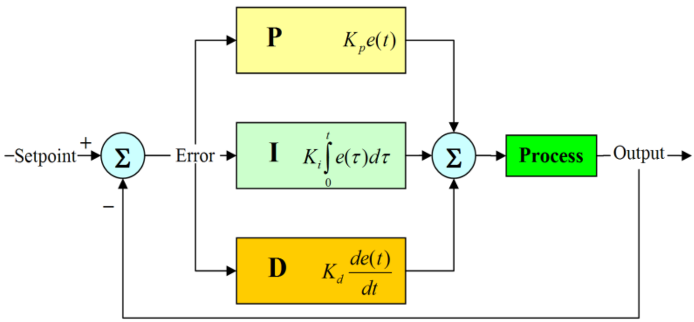

Figure 3 – Functional diagram of the PID regulator

Accelerometer and gyroscope are located on the machine such that their axes are the same direction as multicopter own axes. Thus, the reconstructed deviation angles represent the position stability. Since the task is stabilization of roll and pitch, it can be considered to be independent tasks. It is convenient to represent the angles in the form of two-dimensional (or three-dimensional, with 3 angles) vector, and all operations on the calculation of corrections carried out in the form of a vector.

In order to quadcopter did not lose height, the amount of thrust of the rotors screws should be kept at an arbitrary inclination. Consider the case of one axis. If denote the time t at the total power for the motors at axis $M\ (t)$, and $P_1(t)$ with $P_2(t)$ – the powers that must be issued for two rotors at each axis respectively, the acquired form designs next formulas:

$$P_1(t) = \sqrt{\frac{M^2(t)+u(t)}{2}} \tag{7}$$

$$P_2(t) = \sqrt{\frac{M^2(t)-u(t)}{2}} \tag{8}$$

Square root arises from the physical law according to which the lift screw is proportional to the square of the angular velocity. We can check, that with this choice of lifting, power force saved:

$$P_1^2(t) + P_2^2(t) = \frac{M^2(t)+u(t)}{2} + \frac{M^2(t)-u(t)}{2} = M^2(t) \tag{9}$$

Despite the development of modern theory of automatic control methods, and based on them results like P, PI and PID controllers, which are often used in robotics, in terms of control the behavior of the aircraft and stabilization, disadvantages of these controllers are well known:

– Control systems that are based on PI, PD, PID for solving the problem of flight stabilization quadcopters do not provide the required quality due to the fact that the calculation of their parameters requires an accurate mathematical model of the control object and disturbance, which is very difficult to obtain.

– Aligning the device takes some time to stabilize due to the slowness of the process of calculating the D-component.

– Also, disadvantage of this method is poor quality of regulation and the limited region of stability with some drift of the object parameters and delayed action on the disturbances of the system input (noised data from the sensors).

As a result of disturbances and significant increasing in deviation of the controlled variable (the orientation of the device) with an increasing in the gain or delay, gain of the system should change (it is constant and given in experimental way). At the same time the formation of proportional, integral and differential impacts of the regulator remains the same as in steady and in transient conditions, leading to a deterioration in the quality of regulation, the appearance of oscillations and unstable work.

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Ways of improving flight characteristics of normal design UAV of "battlefield" class

Activity of the Scientific and Production Center of Unmanned Aviation 'Virazh' (SPCUV 'Virazh') is focused on designing and development of modern competitive unmanned aviation technology industrial mass production in order to use it for the economical benefits.

One of the most common today unmanned aerial vehicles (UAV) is a unit "battlefield" class. Requirements stipulated observance of the starting weight of 5 kg, flight duration 2 h and the distance from the starting point up to 30 km. Taking into account current practice of similar design and application of small vehicles can say that most of their configuration layout and aerodynamic solutions adopted from radio controlled avia-models, mostly gliders of sports classes F3 and F5. There are some places and direct "tracing" of well-known sports models, to which external "boxes" are attached for the payload. At this stage it seems appropriate, since priority is rapid and probably the cheapest market saturation by unmanned aircraft technology. In these circumstances, the paths of improvement are few and they concern primarily to benefit through the use of best power batteries, more efficient power plants and the application of progressive technological solutions in the design.

However, market development is associated with increased competition, which will involve improvement of all important parts of the UAV board, including the general configuration layout of the circuit and its aerodynamic perfection.

It should be noted that the concept of "battlefield" UAV is based on the fact that it must be a kind of "truck" that is carrier of payload observation type that requires smooth flying under winds of 15 m/s, in terms of elevation 300 – 1000 m which is known to be characterized by high turbulence. So design property, its aerodynamics and inertial characteristics should ensure minimal deviation from the set values of the yaw, roll and pitch as well as the minimum level of "shaking" from the effects of turbulence.

If the requirements for the heading and pitch can be artificially "pulled" by automatic, it is much more difficult to adhere in the turbulent atmosphere of responses from the aircraft with sports wing of a large area as well as compliance to a minimum oscillations along the axis of the OY. It is known that an adequate solution of this problem is an increase of the specific load per unit area. Actually, against the background of this forecast will appropriate to specify the ways in which developers probably will continue to move.

Firstly is the application of appropriate a wing lifting, so called "freight" profiles. Unlike sports models profiles in which the profile aerodynamic quality is 60-70 units for UAV required profiles, which have aerodynamic quality at 150-160 units. These profiles are of very complex configuration and require high quality manufacturing, but the obvious advantage covers technological difficulties. One of these profiles is a series of profiles Wortmann FX-60-160 (177). Achieved value high quality due to the receipt of acceptable cruise Cy coefficient for angles of attack near zero. The increase in the relative thickness of up to 16-18% and increases wing stall characteristics.

Secondly much of the harmful resistances occur in the transition area between wing and fuselage. Using advanced "fillet" especially in the middle wing design can be achieved by reducing the interference component of the resistance by 5-8%. In fact, it is the movement towards so-called integrated configuration layout of UAV.

By - third reduction of harmful resistance of interference nature of the tail unit. The problem solved by the application of "V" - like tail unit, value of which is 25-30% lower than the others.

Fourth, carefully hiding in hoods and fairings the drag parts that are in the airflow.

In - fifth winglets application - specific tips to reduce inductive component of wing resistance.

The mentioned above measures provided to obtain from UAV – middle wing of normal design OKO-2/UA-Beta, which is designed in SPCUA "VIRAZH" NAU collaborative with the UA-by Technology (m. Kyiv), aerodynamic quality at 20-22 units. Cruising speed UAV was 18 m/s and load per unit area was between 13-15 kg/m2 for the take-off mass 4,95 kg. Wingspan of UAV OKO-2/UA-Beta is only 2.2 m, wing area 0,37 m2. Battery power consumption obtained on level of 3,5 W × h/km, which is 15% lower than famous "battlefield" UAV Bird-Eye-400. The specified consumption providing UAV flight duration of OKO-2/UA-Beta within 115 - 118 min and length of the route about 80 km.

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Automatic wing leading edge airplane aerodynamic diagnostics system in flight condition

A new approach of leading edge diagnosis based on optic fiber injection into the composite materials is proposed. The result of semi-natural modeling the system components is provided.

Neural network methods for solving problems of adaptive control system UAV (CS UAV)

The problem of adaptation is one of the central problems in the modern theory and practice of automatic control. Building adaptive systems, allowing for optimal (quasi-optimal) management of complex technical objects in a very small a priori information about the characteristics of the controlled object and the environment, it is one of the biggest challenges for theorists and development of control systems.

Intensive study of adaptive control systems related to the design of autopilots, the development of automatic control theory, associated with great achievements in mathematics, physics, mechanics and engineering, was an important factor for the development of adaptive control systems and, above all, to the flight control systems of various aircraft.

To solve the problems of the adaptive control systems using adaptive management techniques are more interested in multilayer neural networks (MNN) direct or multi-layer perceptrons (MLP). When designing multilayer neural networks MNN neurons are combined in layers, each of which processes the signal vector of the previous layer (or input vector). The minimum implementation is a two-layer network consisting of input, hidden and output layers. When calculating the layers of the input layer is usually not considered, as it serves only to distribute the input signals for neurons of a subsequent layer.

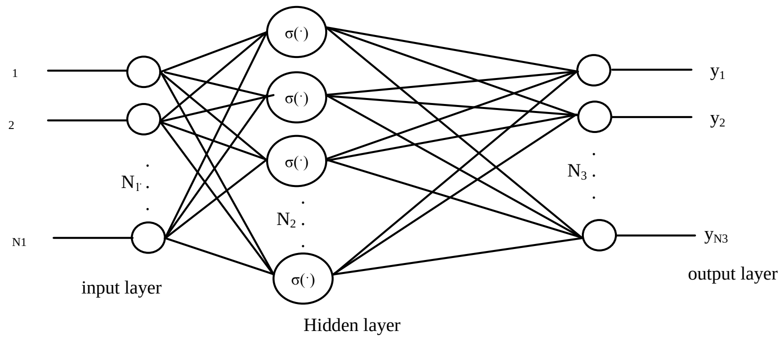

Fig. 1. Multilayer neural networks . Method of dynamic inversion (DI)[1-4]

The method of DI is to transform the nonlinear system to linear form time invariant. Then, in order to obtain a control system with the desired characteristics in the design of the controller used linear control theory methods.

This approach is used, for example, to solve the problems arising in the soup when flying UAV drone at high angles of attack. Algorithms of the flight control system of the UAV are synthesized based on the concept of dynamic inversion (DI) using a fixed linearized model of aircraft dynamics (linear model of one of the aircraft flight modes). In this case, the regulator must be added to compensate for the adaptive element inversion error in the CS in real time. To eliminate errors in the inversion of multi-layer systems are well suited NN.

In [4] the use of DI and the NN as an adaptive element in the structure of the aircraft flight control system.

Fig. 2 illustrates a dynamic process of approximation of inversion

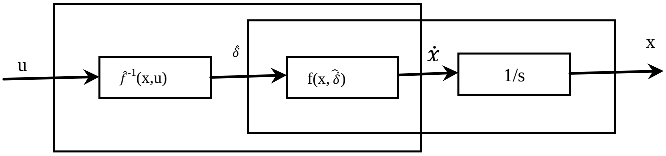

Fig. 2. Approximate inversion model

In the ideal case, the inversion and accurate design pseudo management and can apply a linear time-invariant theory of management, satisfying the requirements of sustainability and quality of the flight control system. If the inversion is based on the approximate (linearized) model aircraft, the flight control system must be supplemented by an element of compensation inversion errors.

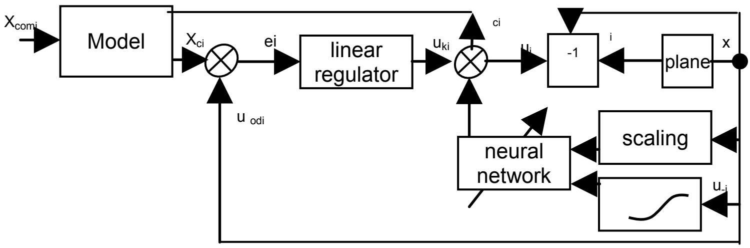

Fig. 3. A block diagram of the adaptive control

Figure 3 shows the adaptive control architecture using a DI process. It is obvious that all state variables and all variables pseudo control u_, NN are input signals in each control channel.

Linear and non-linear neural network.

Various NN differ in their architecture: the structure of connections between neurons, the number of layers of neurons activation function, learning algorithms. From this viewpoint, among the known NN can distinguish static and dynamic network monolayer and multilayer web [7,8].

When using two types of NN differ for the formation of adaptive management:

- Linear NN Weighted [2-4]

General view of the National Assembly of the linear circuit shown in Fig. 4.

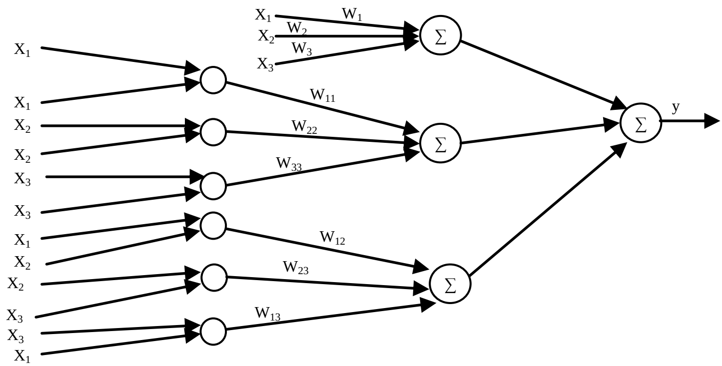

Fig. 4. Linear NN Weighted

- Nonlinear NN Weighted [2,5-6]

Nonlinear NN is widely used in practice. The structure of this National Assembly is made up of a multilayer neural network (MNN) with one hidden layer and sigmoid activation functions. This network has the possibility of approximating any function.

One of the most common activation functions are used in the MNN is a nonlinear function with saturation, the so-called logistic function or sigmoid (t. E. The function of B-shaped form).

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Fourier transform

The term 'pseudo-periodicity' means that the signal is not precisely periodic like a fixed frequency sine or square wave. The shape of the signal is slowly changing as the spoken word progresses. But there is strong similarity between successive short segments, of which there are about 11, 8 and 25 respectively in the three time domain speech graphs shown above.

The discrete time Fourier transform (DTFT).

The discrete time Fourier transform (DTFT) of a suitably bandlimited signal x^a (t), whose analogue Fourier transform is $X_a(j\Omega)$, then The DTFT provides a convenient means of computing $X_a(j\omega)$ by a summation rather than an integral.

Increasing the number of time-domain samples from 64 to 128 gives us more points in the frequency-domain and then we can read the frequencies and amplitudes more accurately.

But it is not always possible to take more time-domain samples. Why? The signal may not be 'stationary' i.e. its spectrum may be gradually changing and the change may be too much over 128 samples.

Sticking with N=64, consider what happens if the frequency of one of the sine-waves, the higher one say, is changed slightly. First we observe that it was π/2, corresponding to *fs*/4, which coincides exactly with 16π/32, one of the frequency domain sampling points, i.e. the one with k=16. What happens if we decrease the frequency of this sine wave from 16π/32 to .15.5π/32 ≈1.522.

The first difficulty enforces 'windowing' or restricting the sequence {x[n]} to a finite block of non-zero samples; say for n in the range 0 to N-1. The resulting windowed sequence:

The second difficulty means that 'frequency-domain sampling' must be used.

It is normal, because of the inverse DTFT formula, to consider for Ω in the range -π to π. For real signals, it would be sufficient to consider values of $X(e^{j\Omega})$ only in the range $0 \le \omega \le \pi$.

There are applications where we need to apply the DTFT to complex signals, and in such cases we then need to know for Ω in the range -π to π. However, because the spectrum repeats at frequency intervals of 2π as illustrated below, equivalent information is obtained if we evaluate for Ω in the range 0 to 2π instead of -π to = π.

Taking M equally spaced frequency-domain samples in the range $0 \le \Omega \le 2\pi$ produces the finite sequence of complex numbers.

This is trouble! Now we don't get the correct amplitude for the sinusoid at 1.522 which does not correspond to one of the frequency sampling points. There is a 35% error in amplitude reading.

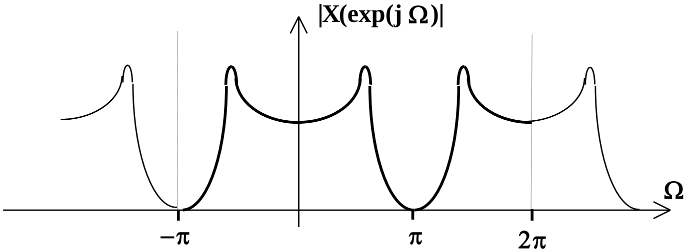

Fig. 1. DTF

How can we overcome this problem? If we could increase N from 64, this would improve matters and in this case would solve the problem entirely as 1.522 would coincide with one of the new freq sampling points created by doubling N. However, this solution may not be possible as we may only have 64 samples available. The signal may be rapidly changing (non-stationary) and it may be just about possible to consider it quasi-stationary for N=64 but not for N=128.

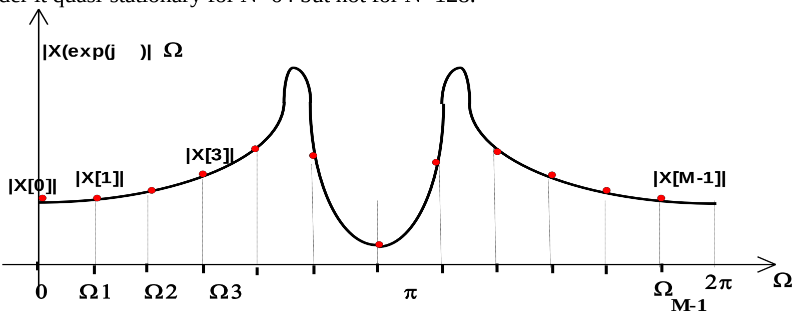

Fig. 2. Frequency-domain sampling

The imposition of windowing and frequency-domain sampling on the DTFT produces the following equation:

$$X(e^{j\omega k}) = \sum_{n=0}^{N-1} x[n] e^{-j\omega_k n} \quad \text{where } \omega_k = 2\pi k / M$$

which is usefully evaluated for k = 0, 1, 2, ..., M-1, so that Ω_k goes from 0 to 2π. The larger M, the easier it is to draw smooth and accurate spectral graphs. However, it is often important to evaluate just sufficient samples to obtain an unambiguous spectral representation of a signal quickly. It may be shown that just N frequency-domain samples are sufficient for this purpose since, in this case, an inverse transform exists to recover the original time-domain signal from the N samples of its DTFT spectrum. With fewer than N frequency-domain samples we cannot be guaranteed a way of getting back the original N time-domain samples. Computing more than N frequency-domain samples has advantages for drawing graphs, as mentioned earlier, but this would be at the cost of slowing down the computation, which for some applications is undesirable. When M = N, the complex sequence defined by Equation 3 becomes the Discrete Fourier Transform (DFT) of the sequence. DFT may be defined as the transformation:

The similarity between equations and is exploited by computer programs able to perform the DFT or its inverse using essentially the same code. Such a program, which implements these equations in a direct manner, is given as a 'C' program in Table 1. This program is very slow, however, and it is possible to speed it up by Fast Fourier Transform (FFT) techniques. Such a technique, programmed in ‘C’, is presented in Table 2. It is quite interesting to study how the improvement of speed is achieved by using 'FFT' techniques to implement the DFT. This may be found in most DSP textbooks, but is outside the syllabus of this section. In this section we are more interested in how to use the DFT and interpret its results than in how it is programmed efficiently. To further illustrate the direct DFT program, a MATLAB version is presented in Table 3. This uses the ability of MATLAB to define and manipulate complex numbers, but is complicated slightly by the fact that all MATLAB arrays start with index 1. Therefore instead of storing sample x[0] in array element x(0) as we may wish, we must store it in x(1). This direct DFT MATLAB program is of academic interest only as MATLAB has an efficient fft procedure in its 'signal processing tool-box'. To illustrate its use, Table 4 is a MATLAB program which reads music from a 'wav' file, splits it up into 512 sample sections and performs a DFT analysis on each section.

Given {x[n]}0,N-1 the DFT (or FFT) gives us {X[k]}0,N-1 with N complex spectral samples from 0 to *fs*. (where f_S is the sampling frequency). When {x[n]} is real, we need only to plot magnitudes of X[k] for k=0 to N/2. When N=512, k=N/2 = 256 corresponds to *fs*/2.

It is usual to define signal blocks starting from n=0, but, unfortunately, MATLAB arrays cannot start from zero. If the signal is $\{x[n]\}_{0,N-1}$ we may wish to store this in a MATLAB array called x. Or we may prefer to adopt a different name, such as ‘array_for_x’, for the array. A shorter name may be better. These notes often use the same name for the signal and array. To circumvent the lack of a MATLAB array element with index zero, we store x[0] in x(1), x[1] in x(2), and so on. In general, x[n] is stored as x(1+n). Similarly {X[k]}0,N-1 are stored as X(1) ... X(N).

We now demonstrate the use of the DFT (or FFT) to spectrally analyse segments of signals containing and/or cosine waves.

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The Wavelet Transform

The Discrete Wavelet Transform (DWT) generates a matrix which is now widely used for image compression instead of the FT since it is able to localise preserve photographic detail such that many of the coefficients may be ignored (tantamount to filtering) and yet the reconstruction remains effective.

The Haar Transform to get that Wavelet feel.

The Discrete Fourier Transform (DFT) may be thought of in general terms as a matrix multiplication in which the original vector x_k is decomposed into a series of coefficients X_n . Both k and n are integers which range over the same value N.

Let $\phi(x)$ be some mother function.

The $\phi(2x)$ is the same function compressed by a factor of 2. Binary compression can therefore be denoted as $\phi_j = \phi(2^j x)$.

Likewise $\phi(2x-1)$ is our compressed function translated by 1. Multiple translation and compression of the mother function can therefore be denoted as $\phi_{jk} = \phi(2^j x - k)$

We do ***not*** choose $\phi(x)$ arbitrarily but impose two conditions.

$\phi(x) = \sum_k c_k \phi(2x-k)$ or more generally $\phi(2^{j-1}x) = \sum_k c_k^j \phi(2^j x - k)$. That is it lends itself to a fractal like summing behaviour. $\int \phi(x)dx = 1$, the normalisation condition. This leads to $\sum_k c_k = 2$.

Alas, life is not easy and there is much confusion in the literature at this point. If you accept this as is then you will **NOT** get coefficients which produce a reversible transform. Since this is desirable in physics we need to do what Numerical Recipes suggests and force $\sum_k c_k^2 = 1$. This means reducing the coefficients by a further factor $1/\sqrt{2}$. The reason lies buried deep in matrix inversion.

$$\begin{pmatrix} x_0 \\ . \\ . \\ x_{N-1} \end{pmatrix} = \begin{pmatrix} . & . & . & . \\ . & W_{kn} & . & . \\ . & . & . & . \\ . & . & . & . \end{pmatrix} \begin{pmatrix} X_0 \\ . \\ . \\ X_{N-1} \end{pmatrix}$$

In the above we may derive the transformed coefficients X_n by inverting the matrix. Here are two examples, our friend Haar and the "top hat"

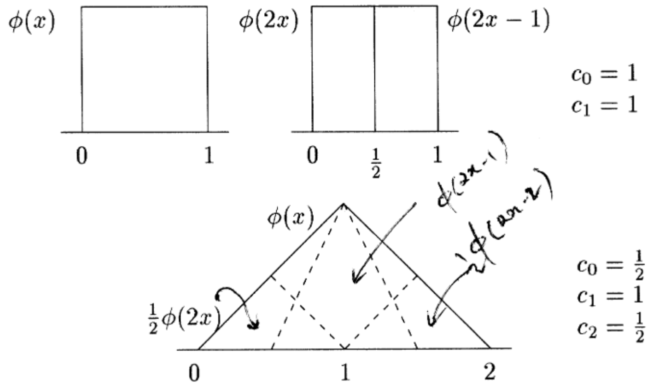

Fig. 1. Haar

Again a $1/\sqrt{2}$ multiplication factor ensures reversibility of the transform

Ingrid Daubechies invented a four coefficient fractal which is not a simple mother function shape as above, but instead must be constructed by working backwards from the coefficients. They are:

$$c_0 = \tfrac{1}{4}(1+\sqrt{3}), c_1 = \tfrac{1}{4}(3+\sqrt{3}), c_2 = \tfrac{1}{4}(3-\sqrt{3}), c_3 = \tfrac{1}{4}(1-\sqrt{3}).$$

The form of W_{kn} has many possibilities but physically we would like the option of forward and backward transforms ie., an inverse ought to exist.

The Discrete Wavelet Transform (DWT) generates a matrix W_{kn} which is now widely used for image compression instead of the FT since it is able to localise preserve photographic detail such that many of the coefficients may be ignored (tantamount to filtering) and yet the reconstruction remains effective.

For certain types of problems the filtering may be much more aggressive than corresponding FT coefficient filtering. (see "Numerical Recipes in C", Prentice Hall, 2nd Ed. 1992, chapter 13).

Filter banks satisfying this condition are called biorthogonal. Moreover, the analysis and synthesis filter impulse responses of all two-band, real-coefficient, perfect reconstruction filter banks are subject to the biorthogonality constraint.

One solution that satisfies the biorthogonality requirement of and used in the development of the fast wavelet transform are called orthonormal. It require

which defines orthonormality for perfect reconstruction filter banks. The relationship of the four filter is

DWT's are particularly effective in analysing waveforms which have spikes or pulses buried in noise.

The noise may be more effectively removed than with FT filtering and the shape of the pulses preserved. Conservation of Energy similar to a Parseval theorem would also be nice.

Suppose for simplicity we assume an input vector x_k with $0 < k < 7$. This is readily decomposed into an obvious basis set as shown.

Other basis systems are of course possible (remember your QM and spinors?). In 1910 Haar proposed the following decomposition.

$$(x_k) = a_0 \begin{pmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{pmatrix} + a_1 \begin{pmatrix} 1 \\ 1 \\ 1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \end{pmatrix} + a_2 \begin{pmatrix} 1 \\ 1 \\ -1 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} + a_3 \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ -1 \\ -1 \end{pmatrix} + a_4 \begin{pmatrix} 1 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} + a_5 \begin{pmatrix} 0 \\ 0 \\ 1 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} + a_6 \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ -1 \\ 0 \\ 0 \end{pmatrix} + a_7 \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ -1 \end{pmatrix}$$

or $x_n = H_{nk} a_k$ with the columns of H being simply the above basis vectors and the a_k obtained by matrix inversion of H.

These basis vectors have characteristic “shapes” when drawn on their side as shown in the figure on the next page and it is these shapes which show the essential features of what DWT decomposition does.

A mother or scaling function at the start with a non-zero average. This will normally be normalised to 1.

Wavelet functions with zero average which are both compressed and translated. It is this compression and translation which finds peaks or pulses well.

The wavelet functions are orthogonal. You can see this directly by multiplying any two together.

The wavelet functions have compact support which means they are all localised. This is unlike the FT in which the basis functions $\exp(-2\pi nk/N)$ are continuous.

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Hidden Markov model

The articles that follow focus on the terms that define the applications, how the technology works, who the major players will be in the future, and how these players envision many of the applications evolving. These articles are meant to present a comprehensive view on the technology which we will then bring to a focus during class.

The theory behind Hidden Markov Model (HMM).

Now that the computer generates a list of phonemes, what happens next? Obviously these phonemes have to be converted into words and perhaps even the words into sentences. How this occurs can be very complicated indeed, especially for systems designed for speaker-independent, continuous dictation.

However, the most common method is to use a Hidden Markov Model (HMM). The theory behind HMMs is complicated, but a brief look at simple Markov Models will help you gain an understanding of how they work.

Basically, think of a Markov Model (in a speech recognition context) as a chain of phonenes that represent a word. The chain can branch, and if it does, is statistically balanced. For example:

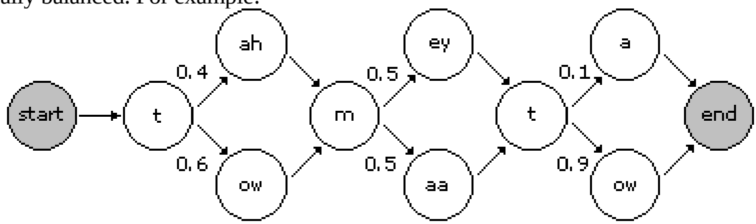

Fig. 1. Markov Model

Note that this Markov Model represents both the American English and the (real) English methods of saying the word "tomato". In this case, the model is slightly biased towards the English pronounciation. This idea can be extended up to the level of sentences, and can greatly improve recognition. For example:

Recognize speech

Wreck a nice beach

These two phrases are *surprisingly* similar, yet have wildly different meanings. A program using a Markov Model at the sentence level might be able to ascertain which of these two phrases the speaker was actually using through statistical analysis using the phrase that preceded it.

The first commercial applications of computer aided voice recognition came in the medical and legal fields. Physicians and attorneys used to dictate notes on a case to an answering service and a secretary would type the report. As the power of the computer hardware and software improved, the speech recognition capabilities of the computer became sufficient to transcribe these dictations. Rather than having someone re-type the entire report, a human was merely needed to proofread the document after the computer constructed a rough draft. Soon the necessity for a human proofreader will vanish as the technology becomes even more powerful. The need for an accurate and efficient method of transcription provided the impetus for today's commercial voice recognition software.

There are three major players in the end-user commercial application of speech recognition; IBM, Lernaut and Hauspie, and Dragon Systems. These three companies provide software packages that convert audible words into digital data that the computer applications can transform into usable data. IBM's ViaVoice, L&H's VoiceXPress, and Dragon System's Naturally Speaking are very similar products that are comparable in price, ease-of-use, and features. The deluxe version of these programs costs about $150 and has a vocabulary of over 200,000 words. They will convert voice data into usable data for most popular software applications and have customized interfaces for the Microsoft suite of applications. These programs are programmed to recognize and correctly interpret dates, currency and numbers. The user can control the operations of the computer (such as opening and closing files and browsing the Web) through voice commands and macros. The software will also read text and numbers to the user in a human voice. All of these voice recognition programs require an intense training session (from 15 minutes to an hour) to learn the specific patterns of an individual's voice. As computer processor speeds have improved, so has the accuracy and speed of these voice recognition software applications.

The ultimate objective for developing SR technologies is to create a system through which humans can speak to a machine in the same way they would converse with another human being. Essentially, we will speak in a natural language to the humanized computer system, without regard to perfect syntax or grammar.

Syntactic and Symantec Analysis: This process is much more complex than Keywording. As the speaker inputs audible data, the VR program parses the noise and computes what is believed (by the system) to be what the user inputs. This technique requires an extensive set of algorithms, rules, and definitions. For instance, when the word "two" is spoken into the system, the program can predict that "2" is intended (instead of "too" or "to"). The computer may determine the appropriate meaning of this homonym by analyzing the syntax, semantics, and sentence structure. This method is best applied to word processing and data entry.

The commercial programs available today require a "training session" with each user, which may last over an hour. During this time, not only does the user have to learn how to speak to the machine, but the computer also needs to become accustomed to the user's voice. This may be a constraint on productivity because of the lost hours, but this also presents another problem. This new problem lies in the fact that systems will need to learn to understand multiple users in a short time (or instantly). For instance, when we go to the McDonald's drive-thru window and order a burger with ketchup, we will expect the computer system to recognize our verbal input immediately. It would not be fast food if we had to train the Speech Recognition program for half an hour!

Another limitation to the use of current SR tools is that there are nearly unlimited variables comprising the noise of voice. For example, when we answer a phone call just as we wake from sleep, our voice sounds different than after we cheered all night at a basketball game. Additionally, background noise poses limiting factors on the effectiveness of SR technology. It is relatively easy for the computer to filter background noise when we are speaking in a quiet office, but if we were to say the same phrase on a busy street the SR systems will be confused.

The current commercial SR products do not have the capability to be used on a wide-scale basis. Depending on the application of this technology, it may or may not be an appropriate time to adopt these SR systems. For instance, the SR technology may be effectively implemented to reduce costs in call centers. However, SR technology is perhaps not at a level suitable to increase the productivity of office tasks. With the rate the SR software applications are developing, it will soon be beneficial to employ Speech Recognition technology in everyday functions.

Another important technology associated with SR is the ability for the program to understand fluid speech versus unnatural speech with pauses between each word. This ability marks the difference between Continuous Speech systems and Discrete Speech systems. While Discrete Speech systems are not conducive to natural human speech, they are highly accurate. On the other hand, as expected, the Continuous Speech model that is closer to a human's natural talking has a lower accuracy rate.

Several companies have developed and distributed "Speech Engines." These "engines" are essentially databanks of all possible words, phrases, syllables, phonemes, etc. through which the SR programs search to find a reasonable result. Each speech engine offered by each different developer operates on a different principle. For instance, the Microsoft Speech Recognition Engines use either an "acoustic model" or a "dictation language model." Other companies have their own specifications.

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Linear predictive coding using voice excited vocoder

The speech signal is filtered to no more than one half the system sampling frequency and then A/D conversion is performed. The speech is processed on a frame by frame basis where the analysis frame length can be variable. For each frame a pitch period estimation is made along with a voicing decision. A linear predictive coefficient analysis is performed to obtain an inverse model of the speech spectrum A (z). In addition a gain parameter G, representing some function of the speech energy is computed.

Linear predictive coding (LPC) of speech.

At the receiver, the transmitted parameters are decoded into quantized versions of the coefficient analysis and pitch estimation parameters. An excitation signal for synthesis is then constructed from the transmitted pitch and voicing parameters. The excitation signal then drives a synthesis filter 1/A (z) corresponding to the analysis model A (z). The digital samples s^(n) are then passed through an D/A converter and low pass filtered to generate the synthetic speech s(t). Either before or after synthesis, the gain is used to match the synthetic speech energy to the actual speech energy. The digital samples are the converted to an analog signal and passed through a filter similar to the one at the input of the system.

The linear predictive coding (LPC) method for speech analysis and synthesis is based on modeling the Vocal tract as a linear All-Pole (IIR) filter having the system transfer function:

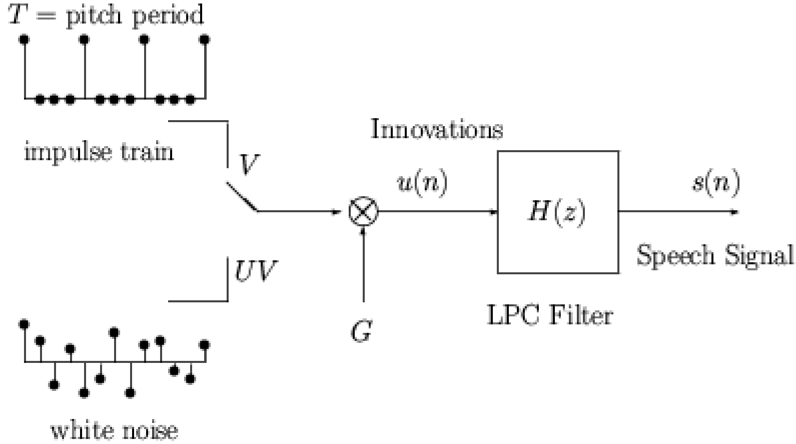

Fig. 1. Method for speech analysis and synthesis is based on modeling the Vocal tract as a linear All-Pole

Where p is the number of poles, G is the filter Gain, and a[k] are the parameters that determine the poles. There are two mutually exclusive ways excitation functions to model voiced and unvoiced speech sounds. For a short time-basis analysis, voiced speech is considered periodic with a fundamental frequency of Fo, and a pitch period of 1/Fo, which depends on the speaker.

Hence, Voiced speech is generated by exciting the all pole filter model by a periodic impulse train.

On the other hand, unvoiced sounds are generated by exciting the all-pole filter by the output of a random noise generator.

The fundamental difference between these two types of speech sounds comes from the way they are produced.

The vibrations of the vocal cords produce voiced sounds. The rate at which the vocal cords vibrate dictates the pitch of the sound. On the other hand, unvoiced sounds do not rely on the vibration of the vocal cords. The unvoiced sounds are created by the constriction of the vocal tract. The vocal cords remain open and the constrictions of the vocal tract force air out to produce the unvoiced sounds

Given a short segment of a speech signal, lets say about 20 ms or 160 samples at a sampling rate 8 KHz, the speech encoder at the transmitter must determine the proper excitation function, the pitch period for voiced speech, the gain, and the coefficients ap[k]. The block diagram below describes the encoder/decoder for the Linear Predictive Coding.

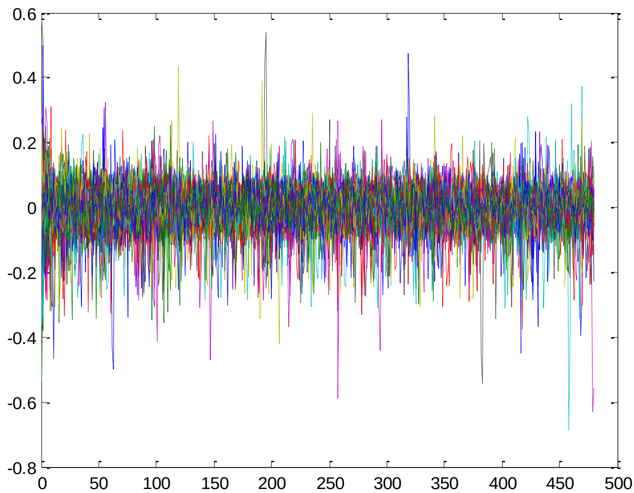

Fig. 3. DCT concentrates most of the energy

The parameters of the model are determined adaptively from the data and modeled into a binary sequence and transmitted to the receiver.

At the receiver point, the speech signal is the synthesized from the model and excitation signal.

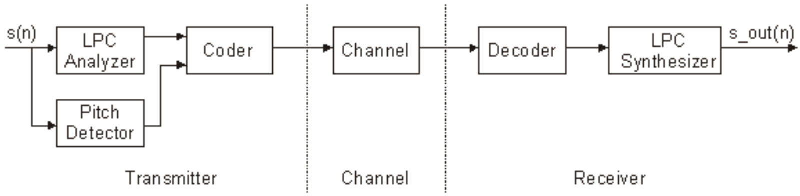

Fig. 3. Linear Predictive Coding

To achieve a high compression rate ,the discrete cosine transform (DCT) of the residual signal could be employed. The DCT concentrates most of the energy of the signal in the first few coefficients. Thus one way to compress the signal is to transfer only the coefficients, which contain most of the energy.

Typically the pitch period requires 6 bits, the gain parameters are represented in 5 bits after the dynamic range is compressed logrithmaticaly, and the prediction coefficients require 8-10 bits normally for accuracy reasons. This is very important in LPC because any small changes in the prediction coefficients result in large change in the pole positions of the filter model, which cause instability in the model. This is overcome by using the PARACOR method.

To achieve a high compression rate ,the discrete cosine transform (DCT) of the residual signal could be employed. The DCT concentrates most of the energy of the signal in the first few coefficients. Thus one way to compress the signal is to transfer only the coefficients, which contain most of the energy.

Once the LPC coefficients are competed, we can determine weather the input speech frame is voiced, and if so, what the pitch is.

If the speech frame is decided to be voiced, an impulse train is employed to represent it, with nonzero taps occurring every pitch period. A pitch-detecting algorithm is used in order to determine to correct pitch period / frequency. The autocorrelation function is used to estimate the pitch period as . However, if the frame is unvoiced, then white noise is used to represent it and a pitch period of T=0 is transmitted.

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Speech Recognition Technology and Applications

Speech recognition (SR) is an emerging technology that will impact the convergence of the telephony, television and computing industries. SR technology has been available for many years. However, it has not been practical due to the high cost of applications and computing resources and the lack of common standards to integrate SR technology with software applications.

Speech Recognition.

Speech recognition (SR) is an emerging technology that will impact the convergence of the telephony, television and computing industries. SR technology has been available for many years. However, it has not been practical due to the high cost of applications and computing resources and the lack of common standards to integrate SR technology with software applications.

The business community has not yet fully embraced SR -- the voice-to-text (dictation) applications only generated $48 million of revenue in the US during 1996. According to William Meisel, of the "Speech Recognition Update" newsletter, business has not yet moved to SR technology due to:

- quality - ability to understand spoken words, ability to discern between like words (to, too, two)
- cost of applications and computing resources
- lack of integration between SR software, operating systems, and applications.

However, these concerns are being addressed. The SR area should experience significant growth and have a substantial impact on business and society over the next 10 - 20 years, particularly in telephony (call center management, voice mail, PDAs) and voice-to-text (VTT) applications.

Speech recognition is an enabling technology that may radically change the interface between humans and computers (and other devices having computational abilities). The current interface with these devices is the keyboard/keypad and mouse. However, SR is a complex technological challenge. In order to achieve SR a computer must perform the following functions:

- recognize the sentence that is being spoken
- break the sentence down into individual words
- interpret the meaning of the words

act on the interpretation in an appropriate manner (i.e., deliver information back to the user). It takes the average human 10 plus years to develop the rudimentary elements of this task!

SR requires a software application "engine" with logic built in to decipher and act on the spoken word. Numerous engines exist; follow this link to see a list of engines and their capabilities. There are three main development weaknesses with most available SR engines:

1. Inability to decipher conversational speech. Most engines are capable of interpreting words that are spoken clearly with a specific cadence in an environment free of significant background interference/noise. This weakness requires users to develop SR "computing skills". The user needs to learn the language of the specific SR engine. Work is being done at Stanford University's Applied Speech Technology Laboratory to develop Conversational Speech Recognition (CSR). Conversational means that the engine is able to interpret a user's skills and ask appropriate questions to ensure that the correct commands are being executed. In essence, CSR adapts to the user instead of making the user adapt to it.
2. Lack of standards for quick and economical application development. The Speech Recognition Programming Interface Committee (SRAPI) is working with a consortium of technology firms to develop standards that will bring the capabilities of SR into mainstream acceptance and use.
3. Ability to interpret the context of the speaker is a critical limitation of current technology. It is difficult to program an engine to recognize and interpret speaker context. Victor Zue at MIT is working to improve this situation by developing engines that can operate within the context of specified content domains. An article describing Zue's work and the limitations that context impose on SR applications can be found in the Economist.

The implications of this technology will be far ranging once the cost of computing resources become reasonable, standards are developed, and competent SR engines are developed. For the most part, the conditions mentioned above have already been met. Costs have been reduced - SR products can now be run on existing Pentium level PCs. Standards have developed but still need improvement - click here for a discussion of standards. Numerous engines have been developed with a broad range of capability. These advancements have resulted in products like: Interactive Voice Response systems (IVRs) including call center activities and voice mail systems. Cyber Voice Incorporated is one of many firms that are using SR technology to improve customer call center operations. Voice-to-text (VTT) applications that take dictation of words and numbers and automatically insert them into word processors/spreadsheets and are used to perform common computing commands. IBM and other software providers offer applications with similar features. A list of other commercially available SR applications shows the potential of SR technology.

- VTT increases efficiency of workers that perform extensive typing or data entry activities (both numbers and words can be dictated). This could be particularly beneficial in legal, medical and insurance environments where large amounts of dictation and transcription occur.
- VTT SR applications have the ability to prevent repetitive strain disorders caused by keyboards. It eliminates the need to type or use a mouse. However, anecdotal incidents of voice disorders caused by the use of SR are already surfacing in the media.

- VTT can be used to assist individuals with disabilities in performing a broader range of jobs in the work environment.
- Interactive voice response systems have many benefits in the management of call centers by reducing staffing costs and by screening phone calls and apportioning calls to the correct/appropriate service provider (computer or human).

Potential Future Applications

- Speech driven web browsers: The user interface changes from keyboard/mouse to speech. This allows greater access to the net because a telephone can serve as the interface. Users could theoretically get voice mail and email using this functionality. Email could be read to them via voice synthesizing software (text-to-voice or TTV) which is already commercially viable.
- SR servers on the internet: A customer may be exploring the internet and see an advertisement that interests her. A simple click on a button gives her an internet connection to a SR application on the company's server which determines her need and funnels her call to the appropriate service provider (computer or human)!
- Speech driven desktop telephony: Telephone user simply says "call home", "conference in Jeff" and the computer-telephone integrated device executes the command. Wildfire Home Page
- Personal Digital Assistants (PDAs) with SR Capability: Devices would not have SR capability locally (due to computing power) but could be used as an interface (via wireless telephone service) between the user and a remote server with SR capability. A talking, handheld, and "thin client" PDA!

SR Appliances: A washing machine user would simply tell the appliance "start a cold cycle". The SR computing power would reside a central (home) PC, or the internet, which is connected to the appliance and executes the command for it and other home appliances. The central PC, or internet, resource is required because the cost of installing the computing power and software on each individual appliance would be uneconomical.

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Automatic speech recognition

Speech recognition is the analysis side of the subject of machine speech processing. The synthesis side might be called speech production. These two taken together allow computers to work with spoken language. My study concentrates on isolated word speech recognition. Speech recognition, in humans, is thousands of years old. On our planet it could be traced backed millions of years to the dinosaurs.

Speech recognition DTW.

The concept of a machine than can recognize the human voice has long been an accepted feature in Science Fiction. From 'Star Trek' to George Orwell's '1984' - *"Actually he was not used to writing by hand. Apart from very short notes, it was usual to dictate everything into the speakwriter."* - it has been commonly assumed that one day it will be possible to converse naturally with an advanced computer-based system. Indeed in his book 'The Road Ahead', Bill Gates (co-founder of Microsoft Corp.) hails ASR as one of the most important innovations for future computer operating systems.

From a technological perspective it is possible to distinguish between two broad types of ASR: 'direct voice input' (DVI) and 'large vocabulary continuous speech recognition' (LVCSR).

DVI devices are primarily aimed at voice command-and-control, whereas LVCSR systems are used for form filling or voice-based document creation. In both cases the underlying technology is more or less the same.

DVI systems are typically configured for small to medium sized vocabularies (up to several thousand words) and might employ word or phrase spotting techniques. Also, DVI systems are usually required to respond immediately to a voice command. LVCSR systems involve vocabularies of perhaps hundreds of thousands of words, and are typically configured to transcribe continuous speech.

Also, LVCSR need not be performed in real-time - for example, at least one vendor has offered a telephone-based dictation service in which the transcribed document is e-mailed back to the user.

From an application viewpoint, the benefits of using ASR derive from providing an extra communication channel in hands-busy eyes-busy human-machine interaction (HMI), or simply from the fact that talking can be faster than typing. Also, whilst speaking to a machine cannot be described as natural, it can nevertheless be considered intuitive; as one ASR advertisement declared *"you have been learning since birth the only skill needed to use our system"*.

ASR products have existed in the marketplace since the 1970s.

However, early systems were expensive hardware devices that could only recognize a few isolated words (i.e. words with pauses between them), and needed to be trained by users repeating each of the vocabulary words several times.

The 1980s and 90s witnessed a substantial improvement in ASR algorithms and products, and the technology developed to the point where, in the late 1990s, software for desktop dictation became available 'off-the-shelf' for only a few tens of dollars. As a consequence, the markets for ASR systems have now grown to include:

- large vocabulary dictation - for RSI sufferers and quadriplegics, and for formal document preparation in legal or medical services
- interactive voice response - for callers who do not have tone pads, for the automation of call centers, and for access to information services such as stock market quotes
- telecom assistants - for repertory dialing and personal management systems
- process and factory management - for stocktaking, measurement and quality control

The progress in ASR has been fuelled by a number of key developments, not least the relentless increase in the power of desktop computing.

Also R&D has been greatly stimulated by the introduction of competitive public system evaluations, particularly those sponsored by the US Defense Advanced Research Projects Agency (DARPA). However, scientifically, the key step has been the introduction of statistical techniques for modeling speech patterns coupled with the availability of vast quantities of recorded speech data for training the models.

The main breakthrough in ASR has been the discovery that recognition can be viewed as an integrated search process, and this first appeared in the 1970s with the introduction of a powerful mathematical search technique known as 'dynamic programming' (DP) or 'Viterbi search'.

Initially DP was used to implement non-linear time alignment in a whole-word template-based approach, and this became known as 'dynamic time warping' (DTW).

DTW-based systems were quite successful, and could even be configured to recognize connected words.

However another significant step came in the late 1980s when pattern matching was replaced by 'hidden Markov modeling'.

This not only allowed systems to be configured for large numbers of users – providing so-called 'speaker independent' systems – but 'sub-word HMMs' enabled the recognition of words that had not been encountered in the training material.

A hidden Markov model (HMM) is a stochastic generative process that is particularly well suited to modeling time-varying patterns such as speech.

HMMs represent speech as a sequence of observation vectors derived from a probabilistic function of a first-order Markov chain.

Model 'states' are identified with an output probability distribution that describes pronunciation variations, and states are connected by probabilistic 'transitions' that capture durational structure. An HMM can thus be used as a 'maximum likelihood classifier' to compute the probability of a sequence of words given a sequence of acoustic observations.

Figure 1 illustrates a contemporary ASR system. Incoming speech is subject to some form of front-end signal processing - usually 'cepstral' analysis – that outputs a sequence of acoustic vectors. Using Viterbi search, this sequence is compared with an integrated network of HMM states in order to find the path that corresponds to the most likely explanation of the observations. The path reveals the recognized sequence of words.

The key to this approach is the process for compiling the HMM network. Two sets of training corpora are involved; one consisting of many hours of annotated speech material, and another comprising several million words of text. The first is used to estimate the parameters of the 'acoustic model' – an inventory of context-sensitive sub-word HMMs such as 'diphones' or 'triphones' – and the second is used to estimate the parameters of an n-gram 'language model'. Each word in the target vocabulary is then expressed in terms of a sequence of phonetic sub-word units, and compiled into a network together with the language model and non-speech HMMs (to accommodate noise).

This mainstream approach to ASR is not without its detractors. It is difficult to construct such a system to exhibit accurate discriminatory behavior. As a result, a handful of researchers have investigated 'artificial neural networks' (ANNs), particularly for sub-word modeling.

However, such systems have not outperformed HMMs on benchmark tests. A more general criticism – primarily leveled at the dominance of the DARPA-sponsored evaluations – has been concerned with the inadvertant suppression of scientific diversity (Bourlard *et al*, 1996).

Participation in such prestige activities not only commits a large research effort, thereby severely reducing the opportunity for lateral thinking, but also discourages any short-term risk that the resultant performance might be worse.

Finally, a comprehensive comparison between ASR and HSR accuracy was performed in 1997.

Richard Lippmann presented comparative word error rates for a range of tasks and conditions. The results indicated that ASR currently performs about an order-of-magnitude worse than a human listener.

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A Comparison of MPEG-1, MP3, MPEG-2

The MPEG codecs evolved as the needs of the industry and the readily available technology changed with time. MPEG-1 was developed with the intention of distributing audio on a CD medium, coupled with the video portion of this codec it provided VHS quality audio and video distributable on CDs. MPEG-2 audio's main feature involved the ability to encode multiple audio channels as well as improved encoding-noise reduction algorithms. This variation catered to the surge in surround sound becoming a standard in cinemas and also home theatres.

Advanced Audio Coding.

The Advanced Audio Coding (AAC) revision of this particular variation offers such high-quality encoding that it remains practically untouched even in the newest MPEG-4 standard, which mainly involves improvements in video encoding technology.

MPEG-4 has the advantage of featuring a simple math structure, enabling rapid encoding/decoding, as well as a Low Delay (LD) version that enables high quality audio over a narrow bandwidth. Perhaps the most widely known revision is the MP3, or MPEG-1 Layer 3, which is used throughout various industries to distribute high-quality low bit rate stereo sound.

The intention of this research and comparative study is to determine where the efficiencies of each standard lies despite overlapping abilities.

Each codec is geared towards a different audience and so, despite backwards compatibility, older codecs may actually provide more efficient encoding for a given application.

MPEG-4 in its new innovations and attempts to encompass all applications of its codec "ancestors" may lead to providing telephony or even music delivery service over very low bandwidth communication channels.

Project Accomplishments:

MPEG-1: This standard consists of three layers of increasing complexity, delay, and quality/performance. The higher layers are incorporated through the use of the lower layers as a platform.

MPEG-1 supports four modes: mono, stereo, dual (two separate channels), and joint stereo.

MPEG-2: MPEG-2 creates a lifelike sound for audio related applications. This includes video conferencing, electronic cinema, multimedia services, multilingual channels, channels for hearing impaired and visually impaired, etc. This standard is the second phase of MPEG that supports 2 multi-channel audio coding standards.

MPEG-4: MPEG-4 is the one of the most recent iterations, combining all previous MPEG standards into one standard that covers a multitude of applications. It achieves higher quality versus bit-rate while sparing the computational complexity of

MP3. Also through optimized code, load delay encoding and decoding of audio is possible. High fidelity audio is capable of being transmitted via a narrow bandwidth.

Three core coders are used either individually or in tandem to achieve high coding efficiency for a higher bit-rate:

The Low-Delay component of the codec opens this format to new applications such as IP phone and other real time voice communications. At very low bit rates it substitutes sounds rather than trying to reproduce them.

The file sizes for each bit rate did not vary with each codec but this was not the case with quality. The newer the codec, the better the quality at a given bit rate, while certain codec such as MP3 and MPEG-4 LTP scaled up much more rapidly than other codecs.

It was also found that during waveform comparison MP3 formats experienced a 50msec delay from the original waveform while MPEG-1 layers I & II only experienced about a 10msec delay. MPEG4 waveforms could not be compared in the same fashion since software could not be obtained that read these files accurately.

The computational load or complexity of these encoding/decoding schemes will also be explored in order to show how certain codecs, being mathematically "simple", are cheaper to implement in hardware.

This will be shown through sample compressions of music and speech samples, while monitoring processor and memory usage, as well as encoding duration.

Project Plan:

- Subrati & Caliendo – Researching & analyzing MPEG-1/2/4 codec structures
- Caliendo – Explore the effects and improvements made by AAC
- Subrati – Obtain comparison tools/software that can be used to test the performance of each codec
- Caliendo – Further in depth analysis of encoding structure of codec, dealing with the basic technology, such as signal processing and psychoacoustics, behind it.
- Subrati – Establish set of benchmarks to perform
- Caliendo – Perform
- Subrati & Caliendo - Quality comparison of the performance of each codec with the use of music files, voice files, etc.
- Subrati – Through previous comparison have a definite idea of weaknesses/strengths for certain applications of each codec
- Caliendo – Identify new applications made possible through codec improvements.
- Caliendo – Prepare presentation
- Uses a hybrid filter bank, in which the 32 sub band signals are subdivided by using a DCT block transform.
- Utilizes an analysis by synthesis approach (the process of scaling, quantization, and coding of data is performed within two nested iteration loops), pre-echo control, and non-uniform quantization with entropy coding.
- Also has a buffer technique, known as bit reservoir, which preserves additional bit rate by ensuring that the decoder buffer neither overflows or underflows when a bit stream is presented at a constant rate.
- *Software:* AVI2MP, LAMEwin32, NERO MPEG-4 AAC Encoder, GOLDWAVE sound editor.

- We used two sample music files originally in PCM 16-bit 44.1 kHz stereo format and one recorded voice sample having the format PCM 8-bit 44.1 kHz. These were all coded at various constant bit rates using the five codecs mentioned above. The bit rates, relative file sizes, encoding times, and quality ratings are all available in Appendix A.
- The file sizes for each bit rate did not vary with each codec but this was not the case with quality. The newer the codec, the better the quality at a given bit rate, while certain codec such as MP3 and MPEG-4 LTP scaled up much more rapidly than other codecs. It was also found that during waveform comparison MP3 formats experienced a 50msec delay from the original waveform while MPEG-1 layers I & II only experienced about a 10msec delay. MPEG4 waveforms could not be compared in the same fashion since software could not be obtained that read these files accurately

Data obtained through both research and actual encoding of sound samples provided somewhat expected results of various factors such as quality, file size, etc. As expected, with constant bitrate encoding, the file sizes regardless of codec were the same for each sample.

Quality steadily increased when compared to bitrate, achieving much higher quality at each bitrate when using a newer codec. The encode times were understandable as well. There are very few freeware MPEG1 – Layer I & II encoders, as well as MPEG4 encoders. The former is an older codec and the latter is so new and its parameters are not yet set in stone due to licensing bickering, that few are willing to release actual encoders.

MPEG1 – Layer III however is widespread, has been developed by countless people, and so its encoder has gone through countless refinements over the years. An Excel spreadsheet with all of this data, as well as screenshots of certain waveforms has been included in a zip file. (Note: The file name S2-M1L1064… means sample 1, mpeg1 layer 1 at 64kbps. All samples were encoded at 44.1Khz)

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Important issues of teaching English to aviation personnel

In this article the author defines the most important directions in the process of teaching English to aviation personnel. On the basis of analyzed literature some important ideas about the methods, forms and principals of teaching have been presented. Social, cultural, educational aspects that need our consideration while teaching aviation personnel have been highlighted.

Nowadays no one doubts the importance of correct communication between a pilot and air traffic control for the flight safety. Miscommunications may broadly be applied to a range of verbal communications problems ranging from misunderstandings, such as those due to ambiguity, cultural differences, language structure, and so on, to more technical problems, such as microphone “clipping” and over-transmitting of another’s radio signal. Studies indicate that miscommunication is a pervasive problem in air traffic control and, although infrequent when considered as a percentage of daily transactions, nevertheless, has been a causal factor in numerous fatal accidents.

The facts about verbal communication come from many different fields of science. The study of verbal miscommunications in the air traffic system is part of the rapidly expanding field of human factors. Strengthening flight safety requires deep investigations into the nature of reasons that lead to accidents in aviation. The researches of many scientists are devoted to the aim to synthesize the knowledge from three fields - aviation human factors, language and communications, and aviation law. It allows them to develop educational resources for air traffic control instructors and team leaders.

Despite all measures designed to ensure safety, many accidents still occur due to pilot error. S. Roscoe insists that the term "pilot error" covers a variety of ergonomic disadvantages. Sh. Uplinger explains that misunderstandings in communication in the air traffic control has serious consequences, and believes that the number of accidents will increase until there will not be organized control of human errors and as well as misunderstanding in communication [2, p. 1].

"Coordination of crew and command of the English language" – are two of the four security questions, which are listed by the National Council transport service. Reports on incidents, accidents, study human resources provide enough evidence that communicative practice is closely linked to safety. Communication can determine the success or failure in achieving goals. When goals are important and involve high interest rates, the question of effective communication is crucial. We must remember that in the aviation industry the stakes are very high.

One feature of the aviation industry is the fact that the norms and standards for air industry developed in English, which requires continuous training of aviation personnel. Modern pilots must be competent to handle and manage large volume of incoming information. These verbal instructions are given in English. Although some pilots insist that aviation English is not a problem for them, other pilots recognize that technical language is difficult to study. The received information comes in the form of guidelines that require clarification and simplification where possible. The information comes in the form of technological terms, aviation items, which should be discussed in the target language (English) in the international arena. Misunderstanding and false information should be minimized and not reach the pilots because of the low level of knowledge and understanding. [2, p. 9].

There is no doubt that the acquisition and use of language skills is a complex process, which involves the study of grammar, pronunciation, intonation and peculiarities of usage. The nuances of information transmission depend on such subtleties as pauses, hesitation, light variations in phraseology. Attention should be given to stereotypical use of the message format of confirmation which lacks understanding, minor inaccuracies in replays, messages, and other signs of insecurity or lack of confidence on the listener's and the speaker's side.

Researchers K. Ericsson and H. Simon singled out a class of important communication characteristics - the accent, tone, pitch, pause and intonation in the English language. In their opinion, the most important is the stress which makes the difference in meaning of the two words (insult, permit). Tone is important in English that it combines the emphasis for the characteristic intonation of a specific proposal for approval, questions, or exclamation. Such patterns are very strong and even a declarative sentence becomes a question if pronounced with a rising tone *The aircraft is taxiing?* [1, c. 29].

These characteristics of aviation English require a special approach to the training of those, on knowledge of which the lives of many people depend. So K. Graham (University of Limerick, Ireland) investigated linguistic characteristics of aviation English and came to the conclusion that "approach, in which the student is in the center of educational process in any courses for the teaching of English for specific purposes". She insists that courses of English for special purposes should have a circular design, not linear one. It is important that airline staff and pilots are very motivated, and especially anxious to attend courses that give them the opportunity to "speak up". This process is important for self-expression, it gives the opportunity to benefit from speaking the target language.

Besides, we should bear in mind that training should be based on action learning through performance and practice. Listening should be provided an important place, students must learn to listen carefully to each other. Written English should be used too. And it is vital that students should be encouraged to introduce issues for discussion. Through discussions, the instructor should emphasize the positive features of students' work. It allows the teacher to indicate the success of the students, even their slow progress, because language learning is a slow process that cannot be accelerated.

Even intensive courses require time for better learning. Students ' questions to each other, to the teacher foster teamwork in class. Every student has many opportunities to perform. Asking questions is very important in the practice of hearing. If the student does not hear or does not understand his or her interlocutor, he must be involved in future issues with a greater amount of information.

Instructors and students must constantly explore aviation material for a clear and constructive understanding.

K. Graham also says that aviation English must fulfill a broader function than the usual English for students of regular courses. Aviation English needs to give pilots the skills of social interaction in English-speaking countries and to prepare pilots for retraining and continuous professional development using the English language. The researcher insists that the knowledge of the structure and functions of English is more important than just learning specific terms. Pilots say that aviation personnel from different countries have different pronunciation and technical vocabulary can be confusing even for native speakers. Therefore, even in a familiar environment aviation English can be a problem.

We should note that the airlines employ pilots from different countries, and socio-linguistic competence in many cases is more important than knowledge of aviation terms. It is unlikely that the pilots will act in contrast to their cultural roots and background, so it is important to learn new values, which corresponds to standard procedures in the flight operations and communications. Training should not be confined to knowledge and skills "transmission" activities. It should be a constructive experience in which the pilot “rebuilds” targeted training in their cultural context. According to this philosophy of constructivism lessons should be conducted. Socio-cultural aspect needs to be in the center of the classroom. The study of the culture of the target (English) language is important in order to make this language meaningful for activities in the aircraft industry.

Another aspect that requires attention of educators is the fact that the English language is changing rapidly due to the growing changes in society, technological progress, and other languages that contribute to these changes. Science, medicine, advertising are major factors of changes in the English language. This means that educator should be well informed about the appearance of new terms in the aviation industry and to introduce them in his courses. Technological terms and nomenclature of aircraft must be discussed in English, which provides an explanation of the complex issues of the standards and regulations of the aviation industry. An interesting fact is that even pilots whose native language is English will recognize that some recommendations are challenging for them. Updating the content of training of air personnel combined with the explanations and a simplified delivery of information on aviation English is the main prerequisite of safety.

However, we should remember that lexical terms for pilots - native English speakers is only part of aviation English (*take-off, land, runway, airborne*). There is sub technical vocabulary with lexical units that do not always relate to aviation English, but is part of the technical vocabulary (*valve, illuminate, rudder*). These technical terms are especially important for understanding instructions and aviation documents. Often learners of the courses in aviation English language have a good command of special terminology according to their profession, but have an insufficient level of knowledge of sub-technical vocabulary, and it greatly reduces the effectiveness of professional activity.

We consider important to pay attention to another aspect. During the preparation aviation personnel teachers often hear their opinions that general English is not required for their work, and that the study of terminology and phraseology will be sufficient to carry out professional duties. We agree with researchers who insist on the need of courses of “pre- aviation” English that would be basis for further learning or “hybrid” courses of general English and aviation vocabulary. English derivatives in aviation can be explained to aviation personnel only after they get profound knowledge of general English language. Thus general or plain English is crucial to mastering professional knowledge for pilots [2, p.9].

Also we should remember that there is a definite overlapping "between the various forms of aviation English, between aviation English and other variants of technical English, between aviation English and General English". But teachers for air personnel must be aware of the great need for student-centered approach respectively to different levels and interests of a course participants. The instructor should find what each student needs to know and then provide the opportunity for students to learn it.

Teachers need to keep in mind that pilots are interested in information technologies, and have good computer skills, and these skills help teachers to use ICT in the educational process. This allows them to give a new unconventional approach to the study of aviation English.

Besides, according to the principles of adult learning the educator must take into account the previous professional and life experiences of his students. It is noted that past experience can lead to positive or negative attitudes in learning. Biographical information of the students is valuable for learning dynamics in the group and helps teachers to better know students, to further development of an individual approach in training. It must be remembered that adult education instructors play the role of facilitators.

Conclusion.

Thus, training of aviation personnel should be provided on the basis of andragogical principals: taking into consideration professional and life experience, the use of student-centered approach, the use of previously acquired knowledge and skills for effective educational process. Constant modernization of the content of education and ICT provision is important. Linguistic aspect of such training should provide the profound knowledge of general English with further extension by acquisition terms and phraseological units.

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Linguistic redundancy phenomenon in radiotelephony communication between a pilot and ATC

The paper sets out the notion of linguistic redundancy and reveals its functions in RTF communication from the point of view of flight safety. The attempt is made to find out with the help of what stylistic devices linguistic redundancy is expressed in pilot-ATCO communication.

Radio communication between a pilot and an air traffic controller can be defined as a specific professional communication aiming at the exchange of information for the purpose of flight safety incidents and accidents prevention and increase of flight operations efficiency. It is obvious that in order to implement the above mentioned goals first and foremost important requirements to an exchange between a pilot and ATC are brevity of phrases, highly informative and unambiguous messages with at least good readability (the latter characteristic is in many ways dependent on technical support of radiotelephony).Simply put, the main priority is to transmit the necessary information within the shortest period of time possible and in the most efficient and understandable manner possible. These professional standards are maintained with the use of standard words and phrases and quite often with the help of repetition of certain key patterns and words which is known as linguistic redundancy.

Before getting down to how exactly linguistic redundancy functions in radiotelephony communication let`s have a closer look at the term "redundancy" itself. It is worth mentioning that there is more than one meaning of this notion. "In grammar, redundancy generally refers to any feature of a language that is not needed in order to identify a linguistic unit (features that are not redundant are said to be distinctive). In generative grammar, redundancy refers to any language feature that can be predicted on the basis of other language features. In common usage, redundancy refers to the repetition of the same idea or item of information within a phrase, clause, or sentence."[6]

As it can be inferred from the given definitions redundancy is thought of as an inessential feature, which doesn`t matter much or as some sort of predictability and finally as information which is mentioned more than once. In relation to radiotelephony communication the concept of linguistic redundancy comprises the last two features: repetition of some constructions is used due to the standards of transmitting messages between a pilot and ATC, so the reiteration of such lexical units such as, for instance, a callsign is expected and, therefore, is predictable and, of course, some lexical unit which while transmitting a message is mentioned twice or for more times doesn`t add anything new to what is said before.

Despite the fact that it doesn`t supplement anything new to the denotational information of a message, it is worth noting that linguistic redundancy is a phenomenon which is peculiar both to plain English and when using RTF. Studies indicate that the use of linguistic redundancy in pilot and ATC communication is 96

%, while the index of its usage in spoken languages all over the world is approximately the same and ranges between70-80% [1, 99]. The high percentage of linguistic redundancy use in both of these discourses shows how important it is due to fulfilling essential functions. In case of colloquial language linguistic redundancy contributes to its expressiveness and acts as a carrier of pragmatic aspect – it helps to render emotions, speaker`s attitude to what is said, to express an order, to take time to figure out what to say next, to emphasize a particular idea etc. In radiotelephony communication linguistic redundancy functions are connected with receiving a feedback from a pilot or ATC. Thus, linguistic redundancy is more than important. Taking into account the physical context in which radiotelephony takes place (such its features as special and time remoteness, the absence of visual contact, mimics and gestures, indirectness) redundancy performs a number of functions directly contributing to flight safety. We are going to consider each of them in more detail.

As a means of giving clear instructions by ATC. In this case it can be observed the usage of parallel syntax. – the reiteration of the structure of several successive sentences[2, 41] which is one form of linguistic redundancy. In RTF communication it is almost always combined with lexical repetition, so syntactical parallelism is a component of practically all exchanges between a pilot and ATC.

It is well known that the main duty of ATC is to control the traffic in the airspace guiding pilots. To accomplish this and in order to make the instructions clear and easy to interpret in the speech of ATCO the dominant form of making utterances is a predicative construction in the imperative mood. This grammar form is usually repeated for several times as a part of a single transmission. Responding to the controller`s reply a pilot usually uses elliptical sentences, repeating the parts of a sentence too and confirming that the instructions were received and understood.

ATC: SVK314, **descent** flight level 110 and **maintain** present heading.

Pilot: Roger, **descending** flight level 110 and **maintaining** present heading, SVK314 [8].

As an "interlocutor" identification and a communication establishment marker. In order to establish communication in an exchange between a pilot and ATCO words and phrases denoting the callsign of an aircraft and the name of an aeronautical station are used – they are repeated. In accordance with the radiotelephony procedures when establishing communication before transmitting a message a pilot has to address an aeronautical station saying its name which is the location and the type of services being provided. Then, a pilot names the callsign for his aircraft. In response a controller names the callsign of the aircraft and his name[1]. This is the way how linguistic redundancy in the form of repeated lexical units indicates that communication has been established.

Pilot - **Metro Ground, Big Jet 345,** request taxi

ATC - **Big Jet 345**, **Metro Ground**, taxi to holding point A1, hold short of Runway 18 [3, 3]

From the point of view of the language (more in terms of stylistics) and the way it is used in this example we are dealing with lexical repetition in the form of antimetabole as the phrase is repeated in reverse order which is combined with syntactical repetition.

During further exchange of messages between a pilot and ATCO the name of the aeronautical station addressed is usually omitted[1], because a controller is a participant of a dialogue that is known and identified with a low probability of confusion – this is the only facility which gives advisory and instructions for each stage of a flight.

However, the callsign of an aircraft is an obligatory unit to be mentioned. It indicates who is going to follow the given instructions. This procedure is intended for reduction of the risk of transmitting a message to a wrong receiver as ATCO usually has to deal with several aircraft simultaneously.

Pilot – **Metro Tower**, **Big Jet 345,** approaching holding point C1

ATC – **Big Jet 345**, **Metro Tower**, line up runway 27

Pilot – Lining up runway 27,**Big Jet 345**

ATC – **Big Jet 345**, runway 27, cleared for take-off

Pilot – Cleared for take-off, **Big Jet 345 [3, 8]**

From the point of view of stylistics the exchange is an example of framing combined with syntactic repetition. Besides contributing to the identification of who is given the instructions, in the pilot`s replies it also performs the function of a marker of where his message is finished.

A check of mutual understanding between a pilot and ATCO. This function of linguistic redundancy in RTF communication is meant to check whether a speech act has achieved its intended purpose. In other words it helps to insure if a message was understood correctly. In terms of standard phraseology there is a specific request READ BACK requiring a receiver to reconstruct the whole message or its part exactly as it is received in order to confirm that the reception is correct. 'Any safety related message or part of message transmitted by voice must always be read-back. Taxi, level, heading and speed instructions, airways/route clearances, approach clearances, runway in use, all clearances affecting any runway, SSR operating instructions, altimeter settings, VDF information, type of radar service, transition levels, frequency changes should always be read-back in full. Checking the accuracy of a read-back is far easier if the information is read back in the same order as given. Omissions are more difficult to pick up than incorrect data' [3, 11]. Therefore, for controllers it is essential to listen for pilots` read back to find discrepancies, if there are any to correct them in order to ascertain that the transmitted information has been understood and acknowledged correctly. For pilots it is required to read back the information in order of its receiving and, of course, it is crucial to listen for and to comply with ATC correction. In this case, linguistic redundancy in the form of lexical repetition is intended for emphasizing the key information needed to ensure safety.

Pilot: "Speedbird 188 requesting clearance to London Heathrow via track WHISKEY, Flight Level 380, Mach .83. Estimating COLOR at 0246z"

ATC: "**Speedbird 188 cleared to London Heathrow via COLOR, Track WHISKEY, FL380, Mach .83, cross COLOR latest at 0248z**"

Pilot: "**Speedbird 188 cleared to London Heathrow via COLOR, Track WHISKEY, FL380, Mach .83, crossing COLOR latest at 0248z**, TMI 068"

ATC: "Speedbird 188, your readback is correct, return to previous frequency." [7]

From the point of view of stylistics the highlighted in bold part of the exchange is successive repetition combined with syntactical parallelism.

As a way out of unintelligible transmission or failure to understand the message. The request for repetition (linguistic redundancy) in this case is usually made with the help of the phrase SAY AGAIN. Responding to a request, before transmitting the message for the second time a calling station should use the phrase I SAY AGAIN to draw the caller`s attention and to clarify what kind of information is going to be transmitted. Specific standard phraseology in this case is used for the purpose of making the transmission concise and universally understandable. Thus, it is done for the economy of efforts of communication partners. In most cases it is done with help of framing combined with syntactical parallelism.

Control: **VIM 418, due to traffic, fly heading 030, climb 12,000 feet, QNH 1000**

Pilot: Control, message garbled, please **say again**, VIM 418

Control: **I say again, VIM 418, due to traffic, fly heading 030, climb 12,000 feet, QNH 1000 [5, 4]**

However, obtaining more specific information can also be done without sticking to standard phraseology.

ATC: … One estimate **Aer Lingus 712.**

Pilot: One who**? Aer Lingus 712?[1]**

Syntactic parallelism is also used when a pilot or ATC experience communication failure, for instance, when one of the communication partners does not get responses from their interlocutor.

ATC: Station calling Bournemouth, **stand by.**

ATC: Station calling Bournemouth, **say again** your call sign.

ATC: Station calling Bournemouth, **try again [1].**

Conclusions. Linguistic redundancy is a phenomenon which in the most general terms can be defined as repetition of a message using the same lexical units or syntactic parallelism. As RTF communication between a pilot and ATC is highly standardized, we believe that despite a small number of the exchange examples analyzed in the paper it is possible to assume that the most common figures of lexical repetition are framing successive repetition and antimetabole. We also can conclude that linguistic redundancy is vital for maintaining flight safety standards as it acts as a carrier of essential information both for a pilot and ATCO. It is commonly used by ATCO to give instruction to pilots, as a check of mutual understanding between a pilot and ATCO, as an "interlocutor" identification, a communication establishment marker and as a way out of unintelligible transmission or failure to understand the message. So the term "redundancy" should be applied to pilot ATCO communication very tentatively, because without the usage of this phenomenon the number of communication errors leading to flight accidents and incidents would be bigger.

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Lingua-cognitive aspects of professional communication (based on aviation English)

Aspects of professional communication in terms of both the professional community of experts in the world picture, and linguistic tools are considered on the material of aviation English.

The effectiveness of the complex dynamic safety system is largely determined by mutual awareness of pilots and controllers.

The ever-changing information about the traffic situation, fuel, alarms, weather conditions, the state of the runway, arrival time, direction of the landing, requirements of the operations manual, etc. are the basis for decision-making.

The crew of the aircraft flying the vessel and navigating at any moment can receive and transmit operational information. On board the aircraft special devices record the communication of the crew during the flight with time recording [1, p. 199].

Professional communication is carried out within the professional sphere (aviation) in the course of professional work between professionals: pilots and controllers. The content of messages is the sole responsibility of the participants of communication.

We consider communication of aviation specialists with each other in the process of real activity as the dialogue of "initiated" who have implicit knowledge (intra-specific) of skills, a certain vision of the world, different in the way of perception of reality and processing of the information received from the outside world within a specific profession.

This professional vision of the world and the system of ideas of the professional members of the community behind it relate primarily to the professional (scientific and professional knowledge and experience) and pragmatics of specialists’ communication.

An expert has knowledge of the world and above all of the subject area where he is a professional and his personal behavioral experience is organized, systematized, structured and form a stable structure which is the professional view of the world.

In addition, "... there are as many images of the world as men, and one of the factors typifying these images, their greater or less resemblance to different people as the subject of labor is just professional and labor activities. This activity leads to possession and membership in a professional community with its characteristic mode of life "[2, p. 41].

Special (professional) world view is based on the professional knowledge and skills, based on the reality and the specific professional field and is independent of the subjective perception by individuals, international, does not depend on the language in which the given fragment of the world is described.

This article discusses the professional communication in the aviation industry, aviation specialists' communication during work activities as an autonomous branch of the communication, different in the content, objectives, forms and linguistic means of implementation of speech activity from other professional communications.

Aviation communication takes place in a "here and now", in a concrete form of manifestation of reality - its reality that determines the choice of means and content of communication.

The message / text based on the fact is realized in the discourse. Since the reality in which actual communication is carried out, is always special, thus it links the text and discourse. It seems that stated by Yu.E. Prokhorov understanding of communication and its components allows one to understand more accurately the issues of communication in the professional sphere. Describing the content and structure of communication Yu.E. Prokhorov identifies three interrelated components that are in constant interaction and mutual influence: the introvertive figure which is the text, the extrovertive figure which is the reality of the communication situation. "... The actual communication includes three distinct, but not indissoluble components: the very shape of reality, in which and from which it is carried out and two figures: the text which provides its content-language basis (since the text in all its manifestations belongs to the language) and the discourse which provides content-verbal basis (actual verbal and usually non-verbal components) of interaction of participants in communication. ... All three components are in dynamic interaction: the reality change entails a change of the text and discourse ... the realization of another discourse in communication makes its participants turn to other texts and different assessment of figures of reality [3, p. 34-35]. Text, discourse, reality make the content and structure of communication and, in general, can be represented realistically, latent, and quasi and virtually.

According to Yu.E. Prokhorov's definition, extrovertive communication figure is the discourse: "a set of verbal forms of practice organization and design of the content of communication of representatives of a certain socio-cultural community "[3, p. 34]. Yu.S. Stepanov focuses on such characteristic features of discourse. Discourse exists primarily and mainly in texts, but those ones behind which there is a special grammar, special vocabulary, special rules of usage and syntax, special semantics and eventually a special world [4, p. 676].

Another component of communication is the text as a verbal and cogitative product with a thematic structure and communicative community, it is determined as follows: "The introvertive communication figure is the text: a set of rules of linguistic and extralinguistic organization of the content of the communication of representatives of this linguistic-cultural community" [3, p. 34].

The text as a complex sign exists in the unity of the three parts: the semantics, pragmatics, syntactic.

During aviation communication a lot of speech fragments including the variety of them from their verbal organization perspectives are created, and at the same time there is a tendency to stabilize and secure expressions.

Aviation LSP specificity is related to the specificity of the very subject area. High informative value is provided:

- by richness of the terminological vocabulary, the ability to allocate the basic information;
- thingness, objectivity, completeness and uniqueness of statements; use of established terms preventing possible ambiguous interpretations; not allowed dual interpretation of information;
- logical sequence, presentation explicative, restraint, accuracy and clarity of statements;
- brevity, conciseness;
- a tendency to regularity and automatism.

Strengthening the normative principle presupposes the use of the most appropriate language and speech forms:

- formalization and standardization of language resources, the use of lexicalized units, clichés, stereotypes;
- caution in the choice of linguistic means, special use of word order;
- neutral use of language means.

The third component of communication which is a figure of reality is described as follows: "Material communication figure is the reality which is the totality of the material conditions of fulfillment of this communication of the representatives of the lingua-cultural community" [3, p.35].

The reality is a subject area in which the communication is realized and can be represented by a variety of specific forms.

Communicative competence of a professional understood as knowledge and skills necessary to comprehend another person's meanings and generating its own professionally significant meanings, further, is comprised of professional competence in the field of the reality figure or existential competence, competence in the field of professional texts and competence in the field of professional discourse.

Taking into account that "science as knowledge is sole and indivisible for states and peoples", and between any two languages there is a fundamental asymmetry, the meaning of the translation must be equivalent to the meaning of the original text and express the meaning with adequate cross-language correspondences. [5, p. 192].

Perception and understanding in professional communication are determined by the presence of a commonality of the professional view of the world. Therefore, proper meanings making the specific professional view of the world should be studied firstly. Communicative teaching method, which offers the best approximation to the real process of learning to communicate in the target language in a particular form of professional speech activity is productive.

Conclusions.

Thus, the components of professional communication on the basis of which specialists communicate in the professional environment is considered. Professional communication in the framework of the professional aviation world view different in the content, form, language means, goals and objectives. Accounting regularities of aircraft communication building helps to optimize the process of professional communication.

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A new approach to aviation English training

A new approach to Aviation English Training is essential today as education may be becoming increasingly out of step with the way that students use technology today for socializing, working and learning. Furthermore high education should not fail to face student's expectations. Considering learners' abilities to use digital technologies language learning depends on computer technologies either.

Specialists of the international air transport community realize that the advantages of our worldwide network depend strongly on the availability of qualified and competent personal [1]. All aviation personal training is under International Civil Aviation Organization (ICAO) control besides training is provided in accordance with its recommendations. ICAO suggests the implementation of the new ICAO Aviation Training Policy through Global Aviation Training (GAT) Office which introduces five ways to improve aviation personal training to provide their professionalism and competence. The first suggestion says that education should be proven effective over years with a stable success rate. Secondly, training should be reviewed regularly, ideally after each course. Teachers should be specially trained as teaching is a profession. It takes years to become a teacher. They need to be specially educated. And yet, in many professions, including aviation, it's common to have the best pilot or air traffic controller (ATC) in the classroom to train students. But it is not an effective way. A teacher cannot control traffic, so why we should expect ATC provide training in class. He as teacher should be specially trained. Last point means that teacher-students' relation are necessary to take into account [2]. Individual training should be provided.

Furthermore, we observe the existence of generation difference. The current Generation has other needs and expectations which are essential to consider while providing training. Changes are either forced by the development of innovation technology. However, aviation has always been a very dynamic environment which never changes; language learning depends on the use of technology. Computer-based training (CBT) or Internet-based training (IBT) materials can provide a rich source of flexible and effective learning activities [2]. Thus educational institutions should be ready to satisfy the learners' expectations. Accessibility, rapid feedback and ease of use are all features of learners' daily experience with digital technologies which are changing their expectations of education [4].

A series of surveys and reports have showed the result how people are using technologies. Much of the research which was engaged into the survey of how young people use computers and social software has been hold in the USA. However, a number of studies around this question have also been taken in the UK [4].

The main aim of the net usage by young people is for studying: 57 per cent use the net for completing homework, saying that it provides more information than books. 15 per cent of students use it for learning that is ‘not school’. 40 per cent use it to stay in touch with friends, 9 per cent for entertainment such as YouTube [3].

The great interest of current generation to innovations requires teaching and learning be provided in accordance to it just to satisfy students’ expectations. So, Aviation English training should be organized via information technologies.

Different Internet resources like Air crash investigations and others are essential in listening and vocabulary comprehensive skills building. Their usage decreases the time required in class and a visual experience of qualified Aviation English example increases improvement of communication skills. There is only necessity to choose an appropriate quality of audio and video media which could make Aviation English training easier, more interesting and effective. Besides, the duration of training is individually dependent. However, it is not possible to penetrate into high education practical training we can increase or decrease the number of classes in a way of individual homework. In accordance with students’ progress in studying we have to ask them to train at home more or less through watching video and writing reports, film review, or doing presentations based on topic discussed in class.

Another example of CBT is On-line presentation which is the internet video resource identified as an interactive authentic teaching tool. The tool has advantages similar to the ones specific for on-line presentation clips. It is a flexible teaching medium. The more interested and engaged students are, and the more interactive each learning session is, the more students will enjoy, learn from and retain information from the lesson [4].

Training is also effective if it is monitored and feedbacked regularly. Besides monitoring individual student’s performance within the training curriculum, providers should also have the means of assessing the effectiveness and efficiency of their own training process in terms of goals reached and time spent. This assessment includes monitoring the performance of their trainers and way they are perceived by students, and student-trainer administrator communication, as well as the reliability of any soft ware and hardware used.

Training activities of Aviation English should be complex. They have to provide their trainees with rich vocabulary, great possibility of communication skills development.

Talking about next approach to Aviation English training is *Blended learning* which refers to the combination of computer-based and classroom learning in order to make a training program efficient and effective. Practically, technology is used to provide learning and prepare the teacher-led learning. This means that CBT is used combining with practical classroom lessons led by a qualified teacher in order to put into practice the oral communication and interaction skills that are the main ICAO language requirements [2].

Individual CBT can prepare a student for classroom activities by removing a large part of the repetitive and lengthy information and listening processes from classroom time, resulting in the student having the raw materials of communication upon entering the classroom and teachers would be able to use the time in class in a better more effective way.

CBT is also effective for individual training to correct individual mistakes and improve personal skills which were found during the classes. Thus, there should be a cooperation and interaction between home and class training. This is a great task for Aviation English teachers to complete the material and divide it for home, individual and class training to provide successful learning.

A lesson should be planned to supply the subject content, language communication skills development and be pointed to routine and non-routine situations[6]. The interaction between individual self-study via CBT and IBT and teacher-led classes should be combined.

Moreover, teachers should be ready in need to modify the topic of class, methods of teaching, style and content of their class to face the current aviation language training requirements, English level, specific objectives and learning individuality of particular groups. The teacher of Aviation English should be particularly responsive to the needs of each group and person. This is especially important for students who are going to pass test; they will respond positively to An individual approach in their language training.

Aviation professionals have to be assessed in six different language skill areas, including pronunciation, vocabulary, listening comprehension and grammatical structure. However, the final focus of Operational Level 4 is on communicative proficiency: fluency and interactions, which incorporate the use of the other four foundation skills. It may be equally acceptable for the four “foundation” skills to be taught in a conventional way or integrated into essentially oral interactive tasks. However, the ultimate goal of the aviation English training process should be very definitely focused on communicative activities that develop fluency and bring into play individual and group interaction [2].

Teachers of Aviation English should implement a big number of free activities, which are not dependent on text which was read. The success of a class training can be measured by the percentage of time students spend speaking with a purpose. The use of pair, team and group activities will increase each student’s active participation.

Pilots and controllers respond orally much more than to textual input. If aviation English training mirrors these working habits in its language activities, then it will supply more suitable preparation for the actual working conditions.

Teacher of Aviation English should demonstrate the appropriate elements for students in class and they will use the language immediately in the context routine and non-standard aviation situations as clear air turbulence, level separation, missed approaches, ILS, security checks, and aerodrome layouts.

These activities make up the training classes more effective if training materials are designed so that there are multiple ways in which they can be delivered. A modular design, alternative lesson plans and alternative applications of the same course would provide teachers with greater flexibility in order to respond to specific requirements [2]. Oral communicative training methods would provide the development of speaking and listening skills. The training materials allow a high degree of student interactivity by ensuring interaction between all members of the class[5].

A major driver of changing pedagogies has been an increased understanding of the skills and knowledge required of young people both for employment and for engagement in civil aviation community.

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European requirements for aviation engineer's training in the UK

The article deals with international regulations which are implemented in aviation engineer`s training in the United Kingdom through different national authorities. The main document that standardized this issue is considered to be EASA Part 66, Part 147, and the main body that is authorized to provide compliance with international standards is the UK Civil Aviation Authority (CAA)

Aviation industry is based on implementation of regulations and standards issued by specific international organizations. Safety being a primary concern in aviation, all its spheres from specialists training to airport management are strictly adhered to the standards in every civilized country. Many international organizations are dedicated to regulate certain fields in aviation. The most significant and influential among them are ICAO, EASA, EUROCONTROL etc. Moreover, each country, which is the member of abovementioned organizations, should have an authority that would implement regulations in its national aviation industry.

The European Aviation Safety Agency (EASA) is the organization that regulates all aviation activity within Europe and it delegates authority for implementation of its regulations to National Aviation Authorities; in Britain it is called the UK Civil Aviation Authority (CAA).

The organization issues a range of licenses, permits and approvals to individuals and organizations throughout the aviation industry. The following individuals in UK are due to be certified:

- Aircraft owners
- Air traffic controllers
- Cabin crew
- Engineers
- Private pilots
- Professional pilots. [5]

As we can see, in order to assure safety within the industry, engineering personnel are licensed in the same way as pilots and air traffic controllers. If suitably licensed an engineer can certify the work that has been carried out on an aircraft and return it to service.

To go with Part-66 on the issuing of licenses is the larger area of setting up and gaining approval for a training school for aircraft mechanics and technicians. Part-147 governs the larger situation of establishing such a training organization. To obtain approval to be an aeronautical training organization, an organization must write, submit and keep updated a Maintenance Training Organization Exposition (MTOE). To support their MTOE they must have a documented set of procedures. Thirdly the organization must have a compliance matrix to show how they meet the requirements of Part-147.

There are two basic routes to an EASA license: the self-starter route and the EASA Part-147 approved course route:

- To complete the self-starter route one need to study for the EASA examinations associated with the category of license you are seeking and then sit the exams at an approved EASA examination center. To gain the knowledge needed to take the examinations, a candidate can self study or complete short courses or distance learning courses. If a person follows this route, he or she will need to gain five years of maintenance experience on the appropriate category of aircraft in addition to passing all of the examinations before it is possible to apply for a license.
- The EASA Part-147 approved course route. Part-147 approved courses are typically of two to three years duration. However, once you have completed the course, you only need to obtain two years' maintenance experience before applying to the CAA for your B License. Another benefit of this route is that the EASA assessment will normally be part of the course and based on the material you are taught. Also, when you are trying to get a job to obtain the required work experience, you are applying from a position of strength, having completed a worldwide, industry-recognized course. [4]

There are several categories of license which cover different levels and disciplines. Category A (Line Maintenance Certifying Mechanic [LMCM]): Basic A category License + Task Training (Level depends on Task Complexity) + Company Certification Authorization for specific Tasks ("A category A aircraft maintenance license permits the holder to issue certificates of release to service following minor scheduled line maintenance and simple defect rectification within the limits of tasks specifically endorsed on the authorisation. The certification privileges shall be restricted to work that the license holder has personally performed in a Part-145 organization"),

Category B1 (Mechanical) and/or B2(Avionics) (Line Maintenance Certifying Technician [LMCT]): Basic B1/B2 category License + Type Training (i.e. Line and Base Maintenance I.A.W. Part-66 Appendix III Level III) + Company Certification Authorization ("a category B1 aircraft maintenance license shall permit the holder to issue certificates of release to service following maintenance, including aircraft structure, powerplant and mechanical and electrical systems. Replacement of avionic line replaceable units, requiring simple tests to prove their serviceability, shall also be included in the privileges. Category B1 shall automatically include the appropriate 'A' subcategory", a Category B2 aircraft maintenance license shall permit the holder to issue certificates of release to service following maintenance on avionic and electrical systems").

Category C (Base Maintenance Certifying Engineer [BMCE]): Basic C category license + Type Training (Line & Base Maintenance i.a.w. Part-66 Appendix III, Level III for the first Type Rating and Part-66 Level I training for subsequent Aircraft Types of similar technology, otherwise Level III training) + Company Certification Authorization ("a category C aircraft maintenance license shall permit the holder to issue certificates of release to service following base maintenance on aircraft. The privileges apply to the aircraft in its entirety in a Part-145 organization").

Aircraft Engineering bachelor's course is taught in a number of UK's institutions such as Kingston University, Newcastle Aviation Academy, Newcastle College, KLM UK Engineering Technical College, International Centre for Aerospace Training (ICAT) Cardiff and Vale College. [1] The training is regulated by the requirements of EASA Part-147, its content being accredited by the Royal Aeronautical Society and by Institution of Mechanical Engineering. The Royal Aeronautical Society is an organization that is aimed to:

- Promote the highest professional standards in all aerospace disciplines
- Provide specialist information & act as a central forum for the exchange of ideas
- Play a leading role in influencing opinion on aerospace matters.[3]

Institution of Mechanical Engineering accredits academic engineering programmes for universities, as it aims at encouraging professional registration and long-term career development for mechanical engineers, aviation engineers included. [2]

Conclusions

All things considered, professional training of aviation engineers in the United Kingdom complies with EASA regulation with the help of several authorities and organizations and is promoted in British society by means of accreditation by recognized institutions such as Institution of Mechanical Engineering.

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Culture and linguistic education as important security factors in civil aviation

> *If people believe that can change their destiny, they are likely to focus their attention on the future and see the world as a game with positive sum. They will give the high level of priority to education, follow work ethic, make savings, and show entrepreneurship skills and so on. However, if the vast majority in a society does not share these views, the chances of progress and evolution substantially reduce. A society that is not oriented to the future is not innovative in its core.*

The problem of education is not a problem of an abstract state, but the problem of society, government and citizens themselves. Unfortunately, sometimes the interests of the government and citizens or society do not coincide. So if a citizen needs education as a tool to increase his well-being, the government in general, and some of its members in particular, are not necessarily interested in the same thing. Educated citizens are better professionals; they are more aware of their rights and duties, more responsible and adequately evaluate governmental actions, so they can better control them and propose changes. And this can directly affect the prosperity and security of the officials. So, in our opinion, the main contradiction is that the government and citizens may have completely opposite interests in spreading of education and growth of competence. Knowledge and ignorance in this case are not the abstract concepts, but quite specific factors that can increase or decrease the rental cost of a governmental working place. A rise of competence among citizens proportionally reduces the ability of governmental officials to abuse their power and enrich them, avoiding the established laws and regulations.

Adam Smith in his famous work "The Theory of Moral Sentiments" in 1789, investigating the development of society, wrote on this question: "... but that, in the great chess-board of human society, every single piece has a principle of motion of its own, altogether different from that which the legislature might choose to impress upon it. If those two principles coincide and act in the same direction, the game of human society will go on easily and harmoniously, and is very likely to be happy and successful. If they are opposite or different, the game will go on miserably, and the society must be at all times in the highest degree of disorder"[1].

Therefore, the real opportunity for school development lies in the establishment of new productive public relations. So far, the cooperation with parents, local communities and businesses is usually temporary and therefore it is not effective enough.

Under current conditions, the state cannot provide the qualitative education. Therefore, the community and local councils should have the appropriate legal basis

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[1]Smith A. The theory of Moral Sentiments, p.219.
https://www.ibiblio.org/ml/libri/s/SmithA_MoralSentiments_p.pdf

for the establishment of schools funds, foundation of secondary education institutions, right to impose targeted educational taxes and to collect charitable contributions. The fact is that because of insufficient funding educational process in many schools simply degrades.

Thus, the necessary amendments to the laws, government regulations, decisions of councils, orders and other regulations could be written and approved very quickly. Talented entrepreneurs, intellectuals, patriots, those who think about the country's fate, the fate of the children have to lead educational councils in schools, districts and cities.

The researches of citizens and NGOs found out that the main cause of reforms' inefficiency in Ukraine is the lack of understanding at the society level and at the level of administrative elites, that any successful transformation is only possible with the introduction of completely new rules of interaction for all the main actors of the state system. The main drivers of change have to become conscious changes in political, economic, legal and law enforcement systems, as well as in science and education. It is possible to create a higher level of interaction in these systems if we change at once all the basic elements and how they interact.

In practice, we cannot only change the economic model, leaving intact the legal system, which in Ukraine is beyond the society control, and therefore it works for itself, rather than enforcing the uniform laws for all citizens. If we study the experience of western social and economic institutions and their interaction rules more carefully and apply best practices in Ukraine, it can have a positive effect of self-organization and self-development, if there are political changes in the country. If the citizens take active part in these processes, science, education, economy will start working better, supporting and encouraging each other.

Today the politics remains an integral part or rather a manifestation of big business or oligarchy, with its own law enforcement system. Under these circumstances, medium and small businesses, that are the foundation of civil society in the developed countries, are largely kept in the background. However, neither science nor education have a real request from the society and base for its development.

Charles Bourdieu believed that "cultural capital [consists of] forms of knowledge, skills, education and the benefits that a person has and which enable [him or her] a higher status in a society. By sharing with their children knowledge and traditions that are needed in the current educational system to succeed, parents provide them with cultural capital"[2] which is very important security factor in modern society.

After many years of research and observation M. Hrondona elaborated the theory of economic development, which is a form of the cultural characteristics' typology, that make it possible to compare cultures, encouraging the economic development (high level of cultural capital) and cultures that oppose it (low cultural capital). He believes that two ideal value systems can be constructed: one includes only the values that promote economic development, and the second – only those which oppose it.

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[2] See more. The Cultural Capital: https://en.wikipedia.org/wiki/Cultural_capital

The country is modern if it has many values from the first system; it is as much traditional as it is close to the second set. Neither one nor the other value system really exists in its pure form, and no country fits completely into either category. However, some countries are close to having all the values that favor economic development, while others are close to the opposite extreme point. The actual value system is not only mixed, it also changes. If it moves toward the pole of favorable value scale, chances that the country will develop increase. If on the contrarily it shifts in the opposite direction, chances for the country's economic development accordingly reduce"[3]. This typology according to Harrison[4] is based on the answer to one fundamental question: does the culture encourage the belief that people can influence on their own destiny, or does it support the "golden rule"[5]?

If people believe that can change their destiny, they are likely to focus their attention on the future and see the world as a game with positive sum. They will give the high level of priority to education, follow work ethic, make savings, and show entrepreneurship skills and so on. At the same time they have to follow a fairly strict code of ethics, honor virtues, obey the laws, identify themselves with society, form social capital etc. However, if the vast majority in a society does not share these views, the chances of progress and evolution substantially reduce. A society that is not oriented to the future is not innovative in its core. Also, if moral standards are selective, so that people act according to the principle: for friends – everything, and for all the others – there is a law, there are no doubts about the degradation of legal system in the long term.

Changes in culture, as well as democracy or market economy, cannot be imposed from outside. Progress turns out to be stable only when it is fueled from within a society. An important factor is the openness of a country and its people to ideological, political, technological and institutional changes that have made other societies successful. Till public awareness and such a society through education have not reached a certain critical level, till there is no sufficient accumulation of new knowledge and moral values, any external pressure will cause only increased resistance. According to the Canadian researcher Daniel Latouch, "it is impossible to achieve change in culture until the majority beliefs that there is "something wrong" with the culture and till there is a systematic discussion in society of how to change the situation. In order for culture to matter, first we must realize that it needs to change"[6]. The recent events in Ukraine, in our opinion, are a good illustration of this thesis.

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[3] Mariano Grondona, “A Cultural Typology of Economic Development,” in Lawrence E. Harrison and Samuel P. Huntington, eds., Culture Matters: How Values Shape Human Progress (New York: Basic Books, 2000), pp. 44—55.

[4] Lawrence Harrison. Jews, Confucians and Protestants: Cultural Capital and the End of Multiculturalism. Rowman & Littlefield Publishers, 2012, pp.16-18.

[5] ‘Do unto others as you would have them do unto you’. See more: http://www.iep.utm.edu/goldrule/

[6] Daniel Latouch, Cultire and the Pursuit of Success, in Lawrence Harrison and Peter Berger, eds., Developing Cultures: Case Studies (New York and London: Routledge, 2006), p. 446.

However, let us note that changes in culture and "development" as it is now understood are inextricably linked[7]. For the changes to happen it is necessary to develop and implement a well-coordinated program, which primarily would include good parenting, education and its modernization, media, real participation of the citizens in local government, religion and its reform, changes in business culture and political leadership, conscious support of democracy and market economy.

The traditional models of education are passed from generation to generation, and this is mainly because the new generation of parents in educational approaches mainly relies on their own partly forgotten experience, on how their parents educated themselves. Actually, the traditional parenting is often the source, from which the child learns values, gets directions and adopts beliefs, which often interfere with the development and progress of the individual and society. According to researchers, parents can teach their children values that would lead them to democracy, social justice and prosperity[8].

Conclusions.

To educate children in the spirit of democratic ethics, it is necessary for the family to show that person himself is responsible for his future and can change his course of life. In order to do this, children should have feeling that they also have the right and opportunity to affect the family. Therefore, to raise children that can effectively control their destiny, it is important to consult with them, find out their opinion, listen to their advice or consider their preferences. It is no accident that psychologists call the parents who use such a model of upbringing, authoritative-democratic.

Important for disseminating of certain values and attitudes in wider social strata are speeches and behavior of public people, first of all, political leaders. That is why politicians while carrying out their political activities should understand how their public behavior, political program, public speeches affect members of society and strength the declared values. In addition, it is important that leaders take part in educational activities for the population regarding the declared progressive values and their importance for achieving the goal. For example, their personal honesty and well-being correlates with the welfare of the society. Constant dialogue with the media is also important; it should emphasize the need of dissemination of the values that lead the society towards development and progress. An important role here plays new "positive mythology" based on successful examples from the past of the region or the state in general, information about successful steps of the neighbors who once successfully overcome similar problems.

[7] Ralf Dahrendorf . Modern social conflict. Essay about freedom policy. - M. , 2002, p. 257 .

[8] Lawrence Harrison. Jews, Confucians and Protestants: Cultural Capital and the End of Multiculturalism. Rowman & Littlefield Publishers, 2012, p. 28.

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The problem of formation professional qualities aviation specialists to learn English

The article examined the problem of formation of professional qualities aviation specialists to learn English. Reveals the current state of aviation specialists to learn English. One of the most important components of training highly qualified specialists are training to foreign language professional communication. Language and future profession of aviation specialist - are inseparable, because motivation is studying professionally oriented English language is a prerequisite for theoretical training of aviation professionals.

Civil aviation sector in the last decade has undergone significant changes in aircraft building, their improvement and modernization. Airplanes have become more automated, which in turn leads to an improvement of the pilots, but along with this and increased requirements for psychological and physiological qualities of aviation specialists, because the main point while operating an aircraft is the identity of the pilot.

The present days demands as personal knowledge in language training, physical and psychophysiological training of flight personnel. These requirements also stipulated unfavorable influence on the body of the pilot during the flight, a huge flow of information coming into the flight, the acute shortage of time for decision-making, increased mental stress associated with responsibility for the decision. The current state of psychological readiness of cadets to flying activity demonstrates the lack of effectiveness of its formation in high school, because one of the goals of higher education institutions that train aviation specialists, is to improve the quality of training of flight personnel, improvement of physical and physiological capabilities of civil aviation professionals. The role in solving this problem given language training [1].

The current level of aviation places new, higher requirements for training. Radio communications on international air routes is carried out in English. Effective oral communication is important for safety. Voice message - the only means of communication between the pilot and controller at a distance, although the main standard message also transmitted electronically.

Communication skills of pilots and controllers are rated on a scale of ICAO, which includes six levels of English, each of which is measured by the above six figures.

Scale Evaluation of English include:

- 6 - professional;
- 5 - advanced;
- 4 - Working (operating);
- 3 - the level below the average;

- 2 - basic skills;
- 1 - a level lower than the original.

Designated scale ICAO Level 4 English language becomes the minimum in the performance and service international flights. The problem of ownership "free aviation English" among pilots and controllers non-English speaking countries is quite acute when, why it concerns not only Ukraine. ICAO strengthens the responsibility of aircraft operators for the knowledge and skills of staff.

Consequently, the seriousness of such changes require reform of vocational training aviation specialists study in terms of general and professionally oriented English language radiotelephone.

Characteristics professionally oriented English language is one of the indicators of the level of education and competence aviation specialist. Majority of cadets of flying higher education establishments connects you foreign language-teaching profession with a future, the desire to become competent and competitive specialist in the aviation industry [2].

For aviation specialists English study mechanism is the content of the relevant documents; language acquisition is not seen as supportive of education, and as an integrated component of all aviation training. Aviation specialist function is that it should be able to describe, to request, confirm and clarify information through communication skills [3].

Language is an imperfect way. Sometimes there are unforeseen difficulties understanding related to incorrect interpretation, using unnecessary words and lexical and grammatical structures. Radio communication "Air-Land" needs special attention because it determines the safety of flights. With the understanding of basic linguistic principles and rules of use lexical and grammatical structures of radio operators in maintaining radio communications in English increases the motivation to use standard vocabulary, grammar, more attentive to the intonation, diction, pace of speech, helping improve the quality of communications [4].

Foreign language program provides the students the ability to use linguistic system to communicate according to the situation.

Conclusions

The motivation to take up professionally oriented English urgent and requires constant studying it. One of the most important components of training highly qualified specialists are training to foreign language professional communication. Mastering the fourth level of English proficiency on a scale ICAO is a requirement in the aviation service. Language and future profession of aviation specialist - are inseparable, because motivation is studying professionally oriented English language is a prerequisite for theoretical training of aviation professionals [3].

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Collision risk modeling of the airborne aircraft with obstacles in adjoining aerodrome area

The problem of risk modeling of collision /dangerous closing-in by an airborne aircraft with obstacles, located in adjoining aerodrome area, is considered.

Today the development of cities' infrastructure leads to construction of new multistoried buildings. The high cost of modern living and commercial space in big cities requires of construction of multistoried buildings with twenty and more number of floors and the height more then sixty meters.

On the one hand, the building construction is positive unceasing process of cities' frame development, due to which, the new working places are created, the profit of small- and medium-size business is raised and the financial budget of the cities and country is grown up.

On the other hand, the construction of multistoried buildings may create or increase collision risk with high buildings by airborne aircrafts, which perform operation in adjoining aerodrome area, which is situated within the city.

The general building plan of city Kyiv provides the construction of near six hundreds of new buildings, many of which may create the collision risk for aircrafts, flying to or from international airport “Kyiv” (Zhulyany).

Thus, the problem of approval the building process on certain area adjoining to international airport “Kyiv” (Zhulyany) is appeared, in case if the height of buildings obliges to identify them as “obstacles”, which create some risk of aircrafts collision/dangerous closing-in.

This is the term “obstacle” definition, taken from document ICAO Standards and Recommended Practices (SARPS) [1]:

“Obstacle – all fixed (whether temporary or permanent) and mobile objects, or parts thereof, that: a) are located on an area intended for the surface movement of aircraft; or b) extend above a defined surface intended to protect aircraft in flight; or c) stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.”

Therefore the multistoried buildings are considered as “obstacles”, in case of they cross certain obstacles limitation surfaces, defined for the aerodrome with the aim of providing safety operations (with acceptable risk level).

In case of exceeding of certain obstacles limitation surfaces by multistoried buildings the collision risk for the airborne aircraft is created. This risk may be realized in accident with big economical losses due to destruction of aircrafts or building parts. More probably, that the aircraft's collision with the obstacle will lead to the accident with many human losses, not only passengers but strangers as well, that were occasionally near the obstacle.

In the same time, the prohibition of construction of multistoried buildings in all areas around the aerodrome will lead to ungrounded restriction of development speed of cities' infrastructure and decreasing the profit from this kind of business, which is undesirable as well.

In accordance with SARPS ICAO document [1] recommendation, p. 4.2.20 "New objects or extensions of existing objects should not be permitted above the conical surface and the inner horizontal surface except when, in the opinion of the appropriate authority, an object would be shielded by an existing immovable object, or after aeronautical study it is determined that the object would not adversely affect the safety or significantly affect the regularity of operations of airplanes."

The goal of aeronautical study in this case is modeling the aircraft's collision risk with either existing or planned to be constructed obstacles in the adjoined aerodrome (aerodromes) area; risk estimation and assessment and design of technical-organizational arrangements, directed to reducing risk level up to acceptable or minimum level.

If the aeronautical study proves that collision risk level for the airborne aircraft with the building which is planned to be constructed within adjoined aerodrome area is lower then acceptable risk level, such a conclusion may be used as a ground for consideration the expediency of construction this building.

Contrary, if the aeronautical study proves that collision risk level in this case is equal or more then acceptable, the construction of the building, which is due to its height considered as an obstacle, is unallowable.

Taken into account the importance and urgency of described problem, the necessity of design and approval by State authority of Manual of collision/dangerous closing-in risk estimation (management) of the airborne aircraft with the obstacles during performing operations in aerodrome adjoined area (Manual further) arises.

The Manual must be based on modern normative documents requirements [1-4], detailed analysis of technological processes of operation performing on the aerodrome for corresponding scenarios creation, which may create risk, analysis of geometrical sizes and location of the building for creation the geometric obstacle model and mathematical methods of risk modeling.

The problem of aircraft's collision risk modeling has scientific research character and must be solved on the basis of systemic scientific approach in accordance with requirements of all Ukrainian and international normative documents in series following stages.

Stage 1. Analysis of geometrical sizes and location of potential obstacle relatively to runway thresholds and axis (initial data is geographic coordinates and general plan of building construction).

Stage 2. Analysis of forms and geometric sizes of obstacle limitation surfaces in aerodrome area, in compliance with requirements [1]. Making the conclusion that the building is extending above the certain obstacle limitation surface thus it must be considered as an "obstacle" for aircrafts operations.

Stage 3. Analysis of types and trajectories of aircrafts' approaches and take-offs on the aerodrome's runway.

The types of aerodrome operations are analyzed and individual characteristics of the aerodrome are taken into account, such as distances available, displaced thresholds, types and states of air navigation, lighting and meteorological equipment, climatic characteristics of the aerodrome, aerodrome traffic density, and so on, in accordance with Aeronautical Information Publication (AIP).

Stage 4. Analysis of aerodrome operating minima parameters for all types of approaches and take-offs for aircrafts, serviced by the aerodrome (in accordance with AIP).

Stage 5. Design and analysis of scenarios of collisions/dangerous closing in of the aircraft with the obstacle during take-off, final approach and missed approach. The definition of minimal obstacle clearance height for buildings constructed or planned to be constructed in adjoined aerodrome area (in accordance with requirements of document [2]).

Stage 6. Design and analysis of scenarios of collisions/dangerous closing in of the aircraft with the obstacle during extended take-off, interrupted approach and missed approach with critical engine failure and aircraft's control systems failure. The definition of minimal obstacle clearance height for buildings constructed or planned to be constructed in adjoined aerodrome area (in accordance with requirements of document [2]).

Stage 7. Design of geometric model of the obstacle ("needle", "wall" or combination of them) and presentation of the model relatively to runway threshold and axis (in accordance with requirements of document [3]).

Stage 8. Design of mathematical models for collision/dangerous closing-in risk estimation.

With consideration of individual characteristics of the aerodrome and possible scenarios, which probably will create collision risk with the obstacle, the mathematical models for risks estimation are designed.

General principle of obstacle collision risk modeling is presented in document [3]. Risk of aircraft collision/dangerous closing-in with obstacle arises in case of aircraft's deviation in vertical and lateral direction towards the area where obstacle is located.

Having the geometrical model of the obstacle, presented in coordinates relatively to runway threshold and axis from the aircraft approach (take-off) direction (Fig. 1), the general mathematical model of risk collision with the obstacle may be presented as follows [3]

$$R(O_k) = \int_0^{z_k} \int_{y_{1_k}}^{y_{2_k}} f_{x_k}(y;z)dydz \,, \tag{1}$$

where $R(O_k)$ - aircraft's collision risk with *k* obstacle; $f_{x_k}(y;z)$ – two-dimensional density distribution function of aircraft's deviation in lateral (coordinate y) and vertical (coordinate z) planes on the distance *x* from the obstacle. Taking into account that the analysis of statistical aircrafts' deviations proved, that they are independent random events, the relation (1) may be presented as follows

$$R(O_k) = \int_{y_{1_k}}^{y_{2_k}} g_x(y)dy \cdot \int_0^{z_k} h_x(z)dz \tag{2}$$

where $g_x(y)dy$ та $h_x(z)dz$ – density distribution functions of aircraft's deviation in correspondently lateral and vertical planes on the distance *x* from the obstacle.

In the document [3] there are examples of collision risk, calculated by specially designed computer program, but it is emphasized that such a calculation may be used only for instrument piloting stage, as far as density distribution functions of aircraft deviation are defined only for this stage (2). On visual piloting stage during final approach or take-off the aircraft's deviation as most probable because critical engine failure or the failure of aircraft's control systems, or, because of, environmental factors influence, e.g. strong cross wind, which can't be parried by aircraft's pilots. As far as it is difficult to define the density distribution functions of aircrafts deviations due to influence of many factors, it's not possible to use programs, suggested in document [3]. In this case the Fault Tree Analysis for modeling the risk of aircraft collision with obstacle is one of the most acceptable.

The general risk $R(O)$ of aircraft's collision/dangerous closing-in with number of obstacles, situated comparatively close to each other is defined as [3]

$$\begin{aligned} R(O) &= 1 - P(\overline{O}) = 1 - P(\overline{O}_1 \cdot \overline{O}_2 \cdot \ldots \cdot \overline{O}_k \cdot \ldots \cdot \overline{O}_n) = \\ &= 1 - P(\overline{O}_1) \cdot P(\overline{O}_2 / \overline{O}_1) \cdot \ldots \cdot P(\overline{O}_n / \overline{O}_{n-1} \cdot \ldots \cdot \overline{O}_k \cdot \ldots \cdot \overline{O}_1) \end{aligned} \quad (3)$$

where $P(\overline{O}_n / \overline{O}_{n-1} \cdot \ldots \cdot \overline{O}_k \cdot \ldots \cdot \overline{O}_1)$ - conditional probability of absence of collision with *n* obstacles under the condition that it was no collision with the obstacle before.

It is possible to avoid the conditional probabilities, making the correction of collision probabilities by shading of one obstacles by the others – $P(O_k^*)$. Then for collision risk definition for certain operation e.g. missed approach – $R(O)_{ma}$ –, the probability of collision should be multiplied by the coefficient, which represents the average number of missed approaches on the aerodrome – K_{ma}. The relation (3) then will be changed as

$$R(O)_{ma} = \left[1 - \prod_{k=1}^{n} \left[1 - P(O_k^*) \right] \right] \cdot K_{ma} \quad (4)$$

Using described approach (4) it is possible to calculate total risk from many obstacles in one area and risk augmentation, in case of construction of new building, which is identified as an obstacle in this area.

In accordance with designed mathematical model and initial data the risk levels and risk indices of aircraft's collision/dangerous closing-in with the obstacle are estimated (in accordance with document [4]).

Stage 9. Assessment of risk of aircraft's collision/dangerous closing-in with the obstacles. Conclusion about risk acceptability (in accordance with documents [3, 4]).

Stage 10. Working out of recommendations for building company of procedures and/or technical solutions for collision risk reduction (day marking and night highlighting of the obstacle, in accordance with document [1] requirements).

Stage 11. Analysis of necessity and expediency of limitations in aerodrome flight procedures because of presence the obstacle. Assessment of potential influence of the obstacle to flight safety and regularity levels on the aerodrome.

Stage 12. Estimation of total risk of collision/dangerous closing-in of the aircraft with obstacles in case of many obstacles in some area.

Stage 13. Estimation of risk augmentation in case of construction of new building, which is considered as an obstacle in the certain area.

Following of all stages forms the general methodology of collision/dangerous closing-in risk management, because all parts of risk management strategy are fulfilled: risk's estimation, assessment, prognostication and providing or reducing up to acceptable or minimum levels.

Accounting basic aerodrome's peculiarities, certain location and geometrical sizes of the obstacle makes impossible the total unification of aeronautical study. In any special case of collision risk modeling and dangerous scenarios design the individual approach is required and the unique problem of scientific-research character must be solved.

Conclusions

Design and approval by aviation authority the Manual of collision/dangerous closing-in risk estimation (management) of the airborne aircraft with the obstacles (existing and planning) during performing operations in aerodrome adjoined area lets estimate, asses and prognosticate the collision risk level.

Using of the Manual permits, also, to define the total collision/dangerous closing-in risk with many obstacles, situated in some area and estimating risk augmentation because of constructing the new building (obstacle).

Collision/dangerous closing-in risk management for sure will make the positive influence both, flight safety levels and economical measures of cities, where aerodromes are situated.

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The Travelling Salesman Problem in the engineering education programming curriculum

The paper explains shortly the famous Traveling Salesman Problem, develops GUI MATLAB-program for its solution by "Brute-force algorithm" and suggests to include this in standard curriculum of Programming for students in aeronavigation area.

Mastering complex algorithms and their programming realization became an important part of modern education on each engineering specialties. There are two motivations for this: students get a powerful tool that facilitates learning almost all other disciplines, and master the instrument for developing computer programs for their future professional practice. Educators are obliged to look for new benchmarks and appropriate computerized platforms to allow their learning computer science as effective as possible. We find it not effective the common approach to learn particular popular languages that start from the famous standard program *Hallo World*!. Instead, we suggest learning mathematical platforms like Wolfram Mathematica, Maple, MATLAB etc. that focus on algorithmization processes providing ready tools for basic mathematical problems rather than peculiarities of programming language. We accept the last one, the MATLAB, as one of the most appropriate for students in aeronavigation. As such, we follow to revolutionary educational approach "*Learn things by imaginable computer experiments*" suggested in recent book [1].

Such an educational approach requires just another means to attract students, and also a totally different collection of exercises and practicing tasks. It is to background in this paper that such a difficult problem as Traveling Salesman Problem (TSP) may serve as one of them. The latter combines all the cognitive content required for mastering algorithmization and programming with the practical direction to aeronavigation area. We discuss in this paper the most direct solution of the TSP in MATLAB along with fundamental subprograms required for it.

Mathematical formulation of the Traveling Salesman Problem (TSP) was initially given in 1800s by W.R.Hamilton. It sounds in the following way: a "salesman" from the city 0 should visit all the other n cities named as 1, 2, . . . , n only once and come back to 0; among $N=n!$ possible routes the shortest is to be found. Despite the simplicity of the formulation and the significant "age" of the problem, it turned to be one of most complicated in the discrete mathematics and optimization theory up to nowadays.

Direct solution of the TSP lies in the "honest" search of all the possible routes, accurate calculation their length and comparing them until all the variants are checked. Existence of a solution is, theoretically, thus evident. With the grows of n, the number of cities, it turns however that the time, required for enumeration of all possibilities, grows drastically so that the solution cannot be achieved during the reasonable time period. As an example: the time $T(100)$ is, say, equal to 1 minute for n=100; the time for n=101 will be $T(101)=101*T(100)$, i.e. about 100 minutes; moreover, the next case for n=102 cities will consume the time $T(102)=102*T(101)$, i.e. about 100^2 minutes, or 167 hours, or about 7 days. That is why this "naive" way was called “brute-force algorithm”, and efforts were paid into invention of more heuristic but realistic algorithms. Several such algorithms were elaborated, that found their recent applications in effective popular automotive GPS navigators [2]. However, the TSP still remains unsolved “in full”. The problem’s state of the art has been completely described in popular resources as [3,4]. It is not surprising that the TSP is topical for aeronavigation as well.

The Traveling Salesman Problem has already been realized in MATLAB. One should simply run in the Command Window

$$>>travel \tag{1}$$

(the symbol >> denotes relation to the Command Window of MATLAB). Graphical User Interface (GUI) that appears is shown in the Figure 1A along with solution for n=50 cities on American map. It is imperfection of this program that enumeration of routes currently in consideration is too fast to follow them and to understand the process. Why do we suggest such TSP problem for engineering programming education just when it has been solved and realized in such and in similar demonstrations? Our answer is: 1. To present to students such a practical task on their major in aeronavigation area; 2. To encourage them to their original research and development, and 3. To allow research of their own by means of programming, especially testing the program efficiency (section IV,F). It is to account as well that the MATLAB-program has other weak points and is oriented to USA rather than to our country Ukraine.

Graphical appearance of our program called *SalesMan.m* has been shown in the Figure 1,B. It uses the map of Ukraine. Issuing *SalesMan* in the MATLAB Command Window like (1) leads to the Graphical User Interface (GUI) shown. The button “*Help*” provides a short explanation window *2a* on the right top. One could choose the number of cities in the narrow List Box window *3* to consider, *n*. For demonstration purpose, it is prescribed for only *n* of 5, 10, 15 and 20. When chosen, the button “*Generate cities*” is to be pressed, and corresponded number of Ukrainian cities becomes labeled as green points, see Fig. 1B for n=20. Pressing then the button “*Optimize distances*” *4b* starts process of possible routes enumeration, and each route under consideration may be observed by user. At the end, the final route with the least length is demonstrated. As told, we “honestly” enumerate all the possible routes what is called the “Brute-force Method”. We find it methodologically correct to research this method first; students will have a comparison base if go on with other methods, more heuristic.

When the final programming product has been highlighted in such a way, we can start explanation how to go to such result. To achieve it, one needs to split the whole problem to several tasks, subtasks and subprogram. We describe most important of them in the next section. There are few relative simple subprograms among them, but there are also some especially important ones that form an educational and intellectual background of the profession of programming.

First, one needs to create Graphical User Interface (GUI) of the program where all its functionality should be foreseen by means of windows for inputting and outputting information and by buttons that start execution of certain tasks. One of latter is a procedure how to choose particular cities. Secondly, a subprogram should be elaborated that enumerates all possible routes between the cities chosen (the brute-force method). Thirdly, all the routes generated are to be "passed by the program" and the length of them calculated. It would be visual to demonstrate on the map any route currently in consideration and control duration of the visualization. Finally, the route with the least length is to be returned as the final problem solution for the city collection chosen.

There is a special program in MATLAB, *guide*, that helps in creation Graphical User Interface. Choosing standard GUI-elements such as Static Text *1*, Edit Text, List Box *3* or Pop-Up Menus, Push Buttons *2* and *4* and Axes *5* etc. from special visual environment, programmers are able to create variety of pleasant GUIs. For our GUI in Fig. 1,B these elements have been displayed under the numbers specified. The program is saved in MATLAB workspace in two files *SalesMan.fig* and *SalesMan.m*. The first one is a binary file keeping all the visual information (GUI element positions, their colors, fonts etc.), but the second is the text with the future program. It contains function signatures for all the GUI-elements yet empty and to be programmed in next sections.

What is to stress here is projection of picture with a map of Ukraine to the GIU axes *5*, Fig. 1B. This is an undocumented MATLAB' feature that will be explained in a separate publication.

The simplest GUI-elements of the GUI-program Fig. 1B are the Static Texts *1* and the Push Button *2*. The first ones are unchangeable and serve mainly for inscription and titling. The Push Button *2*, through corresponding function within the *SalesMan.m*, refers to only ready MATLAB-command *helpdlg*( ) that displays the Help-information labeled as *2a*. To the List Box *3* corresponds another function in the program-file *SalesMan.m* that supplies the integer *n* obtained to one more function of the Push button *4a* "*Generate cities*". The latter starts a simple logic that chose one of totally four prepared collections of cities along with their coordinate pairs $\{x_i,y_i\}$ on the Ukrainian map. The final route will be colored green and its length, the least among others, will be displayed in the Edit Text window *6*.

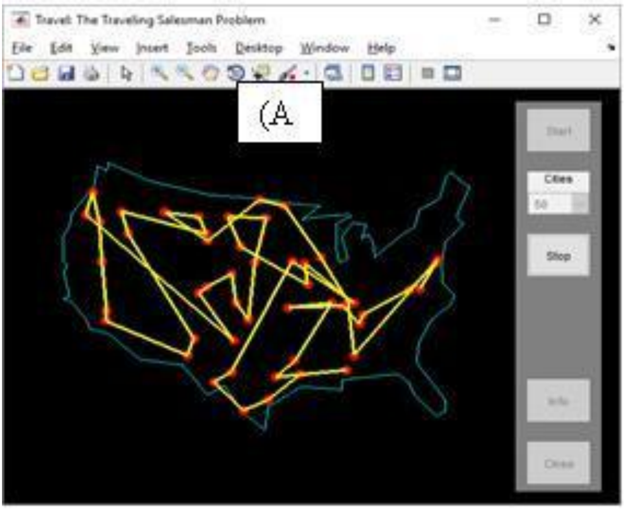

Fig. 1: (A) TSP GUI in MATLAB; (B) GUI of our MATLAB-program with the map of Ukraine

Behind this Button in the file *SalesMan.m* lies the most profound algorithm portion that starts all possible enumerations of city collection chosen and, simultaneously, calculation of their route length. At the same time the route under consideration is ruled thick yellow to visually follow and observe the algorithm action. This consideration of all the roots is called the “Brute Force Algorithm”. It may be partially shortened in time if it breaks out any current route with the length that exceeds the length of previous routes already examined. Different approaches are mentioned in section *F*.

The most important part of the algorithm described is generation of permutations of cities from the collection chosen.

Many of algorithms and subprograms required here may devote special attention. Generation of permutations is particularly difficult to students and is described in more details below. Solution suggested below is based on recursion what is one of key stone algorithms in Computer Science.

Say, we need to get all permutations of numbers 1, 2, . . ., n, what means that function T=*Permutations*(n) depends on n. In the simplest case n=1 the list of permutations T contains only 1. If n=2 the *Permutation*-program returns T as a matrix [1 2]. Similar, *Permutation*(3)=[1 2 3; 1 3 2; 3 1 2] , i.e. new element 3 situates within all previous matrix rows.

As the result, students have a pleasant up-to-date graphical program *SalesMan* that realizes the real logistics problem in aeronavigation area. It is worth to provide its wide investigation, and particularly the time it consumes. They estimate that the *Time* is proportional to $n!$, i.e. it grows drastically huge, see section *II*. It is to motivate them to look for other algorithms able to reduce the *Time* significantly. A number of heuristic approaches were suggested in five last decades [2,3] but the TSP remains far from complete solution.

Conclusion

Despite the Traveling Salesman Problem (TSP) is one of the most difficult in discrete mathematics, its synopsis was shortly suggested to include in educational courses for students in aeronavigation area. MATLAB was considered as one of most appropriate mathematical workbenches for this. The program *SalesMan* was developed and briefly explained as a single GUI-program that manages several other programs and algorithms to realize “brute-force method” in the search of shortest route between given number of cities. Ukrainian map and several collections of Ukrainian cities were used to demonstrate the program. Several programs employed belong to key stone algorithms of the Computer Science.

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Gain-scheduled lateral control system for an UAV

The gain-scheduling successive loop control design for linear parameter-varying system in terms of linear matrix inequalities is considered.

Flight control of modern UAVs confronts the challenge of high-precision tracking with strong robustness for the entire flight envelope. In this case gain scheduling (GS) control becomes very powerful instrument for increasing of flight control system robustness. An effective approach to solve the nonlinear control problem is using gain scheduling with linear parameter-varying (LPV) controller. For example, the parameters of the mathematical model of an aircraft depend on the altitude and speed (Mach number), which determine the dynamic pressure (DP): $\bar{q} = \rho v^2 / 2$, where ρ is density of air, kg/m^3, v is air speed, m/s. The flight control system explored in this paper consists of a Successive Loop Closure (SLC) baseline controller [1] which can be obtained conveniently by solving linear matrix inequalities (LMI) [2] – [4], [7] with reduced computational complexity. In order to obtain numerical results we consider lateral motion control including roll angle stabilization as the inner loop, heading angle stabilization as the intermediate loop, and the reference track stabilization in the horizontal plane as the outer loop. The model of UAV used in this research is Aerosonde which is supported by Aerosim Matlab Toolbox [9].

Let us consider a LPV system in form

$$\begin{cases} \dot{x}(t) = A(\bar{q})x(t) + B(\bar{q})u(t) + B_\nu(\bar{q})\nu(t) \\ y(t) = C(\bar{q})x(t) + D(\bar{q})u(t) \end{cases} \quad (1)$$

where $x = [\beta, p, r, \varphi, \psi, \tilde{y}]^T$ is the state vector with components: sideslip angle β, roll and yaw rates p, r respectively, and roll and yaw angles ϕ, ψ and cross-track error $\tilde{y}$; $u = [\delta_a, \delta_\gamma]^T$ - the control vector with components: the deflection of ailerons and rudder respectively; $y = [p, r, \varphi, \psi, \tilde{y}, V_{\tilde{y}}]^T$ - the observation vector, where $V_{\tilde{y}}$ stands for the side velocity; A, B, C and D are the state matrices that depend on parameter DP; B_v is the matrix external disturbance. The block diagram of the UAV lateral motion control system with SLP is shown in Fig. 1 [10].

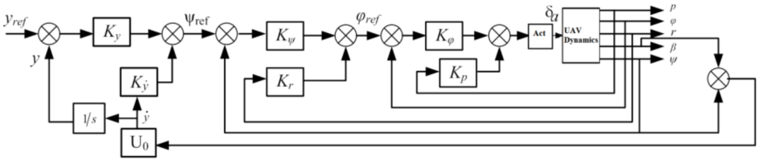

Fig. 1. Block diagram of the UAV lateral motion with successive loop control

It represents 3 successive closed loops with standard PD control laws, so the innermost loop (roll angle control) has control law

$$\delta a(z) = W_{act}(z) \cdot (K_\varphi \varphi + K_p p); \tag{2}$$

The same PD control laws are accepted for the yaw angle control (intermediate loop) with coefficients K_ψ, K_r as well as for the outermost cross-track error y loop with coefficients $K_{\tilde{y}}, K_{V_y}$ .The output of the outer control law serves as the reference (command) signal to the corresponding inner loop. It is known [2, 8] that in order to suppress sideslip angle β for the coordinated turn execution, the standard washout filter with transfer function

$$W_{wf}(s) = K_{wf} \frac{T_{wf} s}{T_{wf} s + 1}$$

is applied as a local feedback from the yaw rate p, r sensor to the deflection of rudder δ_r . For the sake of the further simplification we neglect the dynamics of this local loop, so we will consider only main contour with single input – deflection of the aileron δ_a , as it is shown in the Fig. 1.

The goal of the research is to design a family of local LMI-controllers.

The algorithm of controller design in terms of LMIs was proposed in [3,4] .

The control law is given by

$$u(t) = -Ky(t) = -KCx(t) \tag{3}$$

where *K* is a constant output feedback gain matrix.

The exogenous disturbances ν are restricted by L_2 -norm

$$\|v(t)\|^2 = \int_0^\infty (v^T v) dt < \infty \cdot \tag{4}$$

L_2 -norm assures disturbance attenuation with a predefined level, ν .

K matrix minimizes a performance index:

$$J(K) = \int_0^\infty \|z(t)\|^2 dt = \int_0^\infty (x^T Q x + u^T R u) dt \le \gamma^2 \int_0^\infty v^T v dt, \forall v(t) \ne 0$$

where $Q \ge 0$, $R > 0$ are diagonal matrices, weighting each state and control variables, respectively.

The system L_2 gain is said to be bounded or attenuated by γ if [3], [4], [7]:

$$\frac{\int_0^\infty \|z(t)\|^2 dt}{\int_0^\infty \|v(t)\|^2 dt} = \frac{\int_0^\infty (x^T Qx + u^T Ru)dt}{\int_0^\infty v^T v dt} \le \gamma^2$$

Therefore, it is necessary to find constant output feedback gain matrix K that stabilizes the control plant such that the infinity norm of the transfer function referring exogenous input to performance output $z(t)$ approaches minimum. The minimum L_2-gain (4) is denoted by γ^*. The output feedback gain matrix K could be found by solving the following LMI [3]

$$\begin{bmatrix} PA_i + A_i^T P + Q & P_n B & P_n B_{iv} & 0 \\ B_i^T P & -R & 0 & 0 \\ B_{iv}^T P & 0 & -\gamma^2 I & 0 \\ 0 & 0 & 0 & -R \end{bmatrix} \le 0 \qquad (5)$$

where i =1, ..., N in (5) denotes the set of models associated with scheduled operating conditions within the flight envelope.

The matrices K are: $K_i = R^{-1} B_i^T P_i Ci^T (C_i C_i^T)^{-1}$.

It is desired to find a family of static output-feedback control gain matrices K such that the system is stable and the L_2 gain is bounded by a prescribed value γ.

A gain scheduling control system design takes following steps:

1.Choose the operating points or region in the scheduling space, which is defined by flight envelope of UAV. Obtain a plant model for each operating region by linearizing the plant's model in the several equilibrium operating points.

2. Design a family of local LMI-controllers for the obtained plant models.
3. Implement a scheduling mechanism.
4. Assess the GS closed loop stability and performance.

The block-scheme of a GS-feedback loop is shown on Fig. 2. The vector of adjustable parameters of the autopilot K has the following components:

$$\bar{K}(\bar{q}) = [K_\varphi(\bar{q}), K_p(\bar{q}), K_\psi(\bar{q}), K_r(\bar{q}), K_{\tilde{y}}(\bar{q}), K_{V_{\tilde{y}}}(\bar{q})]^T \qquad (6)$$

The objective of linearization scheduling is that the equilibrium family of the controller (6) matches the equilibrium family of the plant (1), such that: the closed-loop system still can be tuned appropriately with respect to performance and robustness demands; the linearization family of the controller equals the designed family of linear controllers.

It was considered the interpolation of the control signals generated by linear interpolation. The model of the atmospheric conditions is a Dryden filter [8]. The performance and robustness indices are possible to estimate after a family of gain-scheduled static output controllers is obtained using proposed approach. Thus, performance is estimated by H_2-norm of system function with respect to disturbance, whereas the robustness is estimated by H_∞-norm of the complementary sensitivity function [9].

The nonlinear model of the Aerosonde is linearized for the range of operating conditions respected to the range of DP from 200 to 650 kg/(ms^2) with a granularity of 50 kg/(ms^2). The LPV controller model is a finite set of linear controller models obtained for the operating grid of DP values. The set of linear controllers are shown in Table I. Linear interpolation on a set of data points ($K_{\phi i}, q_i$), (K_{pi}, q_i), (K_{ri}, q_i), ($K_{\tilde{y}i}, q_i$), ($K_{V\tilde{y}i}, q_i$) is defined as the concatenation of linear interpolants between each pair of data points. Three flight conditions was chosen to describe controller efficiency.

Table I

Controller characteristics

DP, $\frac{\text{kg}\cdot\text{m}}{\text{s}^2}$	Controller gains $\bar{K}(\bar{q}) = [K_{\tilde{y}}(\bar{q}), K_p(\bar{q}), K_r(\bar{q}), K_\varphi(\bar{q}), K_\psi(\bar{q}), K_{V_{\tilde{y}}}(\bar{q})]^T$
<200	[0.0762 5.5182 2.8793 1.4693 0.1947 1.162];
400	[0.0876 6.727 3.0362 1.2665 0.192 1.1604];
600	[0.1069 8.9126 3.379 1.345 0.3529 1.1508];

Table II reflects standard deviations of the UAV outputs in a stochastic case of parametrically perturbed model with the static output feedback controller in a control loop. As it follows from this table r.m.s. of state variables in the stochastic case are varying in reasonable limits.

Table II

SIMULATION RESULTS

DP, kgm/s^2	Standart deviation					
	σ_β, deg	σ_p, deg/s	σ_r, deg/s	σ_ϕ, deg	σ_ψ, deg	$\sigma_{\delta a}$, deg
200	0.0892	0.1214	0.0206	0.0546	0.1873	0.0681
400	0.0694	0.1678	0.0407	0.1272	0.4528	0.0787
600	0.1108	0.2141	0.027	0.0674	0.1735	0.0936

Performance and robustness indices are shown in Table III. The low variation of the values of H_∞–norms proves the high degree of the system robustness. Basing on the H_2-norm values, it is possible to conclude that the norms vary in small ranges. Their close values give a possibility to state that the efficiency of the closed-loop system is held at the desired level.

Table III

System norms

DP, $\frac{\text{kg}\cdot\text{m}}{\text{s}^2}$	H_2-norm		H_∞-norm
	Deterministic case	Stochastic case	
<200	0.0437	0.1135	0.566
400	0.2458	0.5277	0.6940
600	0.0192	0.0314	0.599

Conclusions

The work presented in this paper was motivated by an UAV with a wide flight envelope. Such vehicles have large parametric variations in the presence of uncertainties. The article presents a procedure of robust GS controller design. The flight control system consists of a SLC baseline controller which can be obtained conveniently by solving LMIs. The method is relatively easy to apply owing to the availabilty of UAV's computational tools.

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Features of inertially stabilized platforms research by means of simulation

The problem of research of inertially stabilized platforms by means of simulation is considered. The approaches to testing ISP operated on ground vehicles by means of simulation are represented.

Important problems of design of inertially stabilized platforms (ISP) can be solved using principles of inertial stabilization. Modern ISPs are operated on aircrafts, marine and unmanned aerial vehicles. Keeping of the stable orientation of information and measuring devices in direction of an observation object becomes a difficult problem if they are mounted on vehicles. Control by orientation of information and measuring instruments lines-of-sight allows to solve this problem.

The necessity to improve ISPs is caused by some factors. It should be noted, that accuracy and other operating performances of information and measuring devices have been significantly increased during last years. These achievements could not be implemented without respective progress in stabilization systems. This causes the necessity to increase precision and dynamic performances of ISPs including improvement of techniques of a designed system research.

In the general case the problem of inertial stabilization represents a task of control by orientation of information and measuring devices of the wide class [1]. A main feature of the inertial stabilization lies in using of inertial sensors of control contours. In accordance with standards developed by the Institute of Electrical and Electronics Engineers in USA and adapted by many countries (Europe, Japan and Canada) the inertial sensor represents a fully autonomous sensor of determination of object's location, spatial orientation and motion parameters except for additional information necessary for its alignment [2].

The issue of research is approach to checking and testing of ISP providing stabilization and tracking of observation equipment operated on ground vehicles in difficult conditions of real functioning. Such ISPs are characterized by significant changes (±50%) of such parameters as inertia moment and rigidity of elastic connection between actuator and moving platform. It is necessary also to take into consideration influence of coordinate disturbances caused by unbalance moment and moment due to angular rate caused by irregularities of road or terrain relief.

The researched system includes the stabilization object, measuring system, actuator and controller. Usage of the robust controller is convenient for such systems as they are subjected to intensive and various parametrical and coordinate disturbances during real operation.

Basic trends of ISP design are represented in [1, 3]. An algorithm of design of robust system of platform angular motion, which is represented in [4], provides synthesis of a system capable to function in difficult conditions of real operation.

The modern approach to synthesis of robust systems consists of two stages [5]. The proper synthesis of the robust system is carried at the first stage. Checking of the synthesized system performances is carried out at the second stage. After results of this checking the repetition of the synthesis procedure is possible after correction of optimization criterion, weighting coefficients and initial conditions. Features of the first design stage are represented in scientific-technical literature in detail. And features checking during the second stage require further research.

For systems of control by angular motion of ISPs the transient quality indices are of great importance such as speed of operation, dynamic error, and angular rigidity by a moment [6]. Dynamic errors of stabilization systems are all errors arising during dynamic processes, for example, influence of changed controls.

In the general case ISP operated on ground vehicles can function in three modes such as tracking, stabilization and combined previous modes. A platform with payload is controlled by the signal $U_c(t)$, which is given from the control console. And vehicle's angular rate $\omega_{\tilde{n}}$ may be considered as disturbance. During ISP check organization it is necessary to take into consideration two features. In the first place, vehicle's motion is translational. Proper stabilization is implemented on the basis of measurements of platform absolute angular rate. In the second place, it is necessary to take into account unbalance moment acting on the actuator.

There are three basic components of ISP errors [6]. The first component is tracking error. It characterizes error of the reference signal and is defined by the expression

$$x_{tr} = \frac{U_c}{[1+W(p)]}, \qquad (1)$$

here $W(p)$ is the transfer function of the open-loop system of platform motion control. The second component characterizes an error caused by action of the external moments. Usually this error is determined relative to an angle of platform position. It can be described by the expression

$$x_m = \frac{W_{m1}(p)M_{um}}{[1+W(p)]p}, \qquad (2)$$

here W_{m_1} is the transfer function by the unbalance moment; M_{um} is the unbalance moment. The third component is stabilization error. It takes into account influence of ground vehicle's angular rate. It is determined relative to the angle of platform position and takes into account a moment of rotation, which is caused by ground vehicle angular rate. The total stabilization error is defined by the expression

$$x_{st} = \frac{\left(1-W_{m_2}(p)W_d(p)Jp\right)\omega_{\acute{\imath}}}{[1+W(p)]p}, \qquad (3)$$

here $W_{m2}(p)$ is the transfer function by the rotation moment caused by the ground vehicle angular rate; $W_d(p)$ is the transfer function of the reduced moment caused by the vehicle angular rate; J is the moment of the stabilized platform inertia.

The tracking error is determined by the given voltage of the control console and estimation of the appropriate angular rate. For simplification the simulation it is convenient to carry out in conditions of ground vehicle immovability. Then the tracking error (1) will be determined by the transient equation $x_{tr} = x_{st}h(t)$.

For estimation of the error by the moment (2) it is convenient to give the step signal corresponding to unbalance moment and to determine the difference of angles defining position of the platform before and after moment application. Simulation is carried out in conditions of the ground vehicle immovability. Such approach allows estimating the system angular rigidity by a moment.

Stabilization error can be estimated by simulation of ground vehicle angular motion changing by the harmonic law, which corresponds to the check route. In this case direction of ground vehicle motion and respectively direction of dry friction forces action are continuously changed. An error of platform position determination in the steady mode will also change by the harmonic law $x(t) = x_{\max} \sin(\omega_k t + \psi)$.

Accuracy of stabilization can be estimated by the maximum amplitude of the error. Value of the amplitude can be determined by the symbol method by means of substitution $p = j\omega_k$ into the expression (3)

$$x_{\max} = \frac{\omega_c - |W_{m_2}(j\omega)W_p(j\omega)Jj\omega|\,\omega_\mathrm{c}}{|1+W(j\omega)|\,j\omega}\,. \tag{4}$$

As the amplitude of an error is sufficiently less than the amplitude of the reference command, the expression (4) can be changed by the approximate expression [7]

$$x_{\max} = \frac{\omega_c - |W_{m_2}(j\omega)W_p(j\omega)Jj\omega|\,\omega_c}{|W(j\omega)|\,j\omega}\,, \tag{5}$$

here $|W(j\omega)|$ is the modulus of the frequency transfer function of the open-loop system, $\omega = \omega_c$. Maximum amplitude value calculated based on the formula (5) is 5 arc min.

Disadvantage of such approach to simulation is dependence on the concrete value of the test signal. To avoid such disadvantage it is possible using the relative amplitude error. For this it is necessary to carry out two test measurements in conditions of influence of angular rates $\omega_{c_1}, \omega_{c_2}$, which, for example, correspond to maximum values of angles 2 and 2.5 deg., and consider the relative error

$$\Delta x_{\max} = \left(\frac{x_{\max_1}}{\varphi_{\max_1}} - \frac{x_{\max_2}}{\varphi_{\max_2}} \right) \cdot 100\%\,.$$

The expression (5) allows forming of requirements to the logarithmic amplitude characteristic of the system. If these requirements will be satisfied, the stabilization error amplitude in the steady mode will not exceed a given value. These requirements can be determined by the condition [7]

$$L(\omega_c) \geq 20\lg A(\omega_c) \geq 20\lg \frac{\omega_c - |W_{m_2}(j\omega)W_p(j\omega)Jj\omega|\,\omega_c}{x_{\max}}\,.$$

Results of simulation are represented in Figs 1, 2.

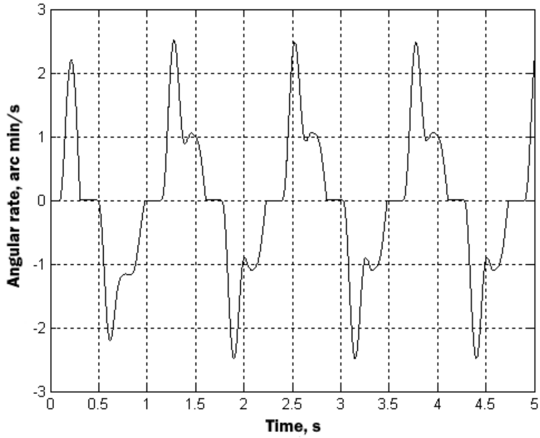

Fig. 1. Angular rate of ISP

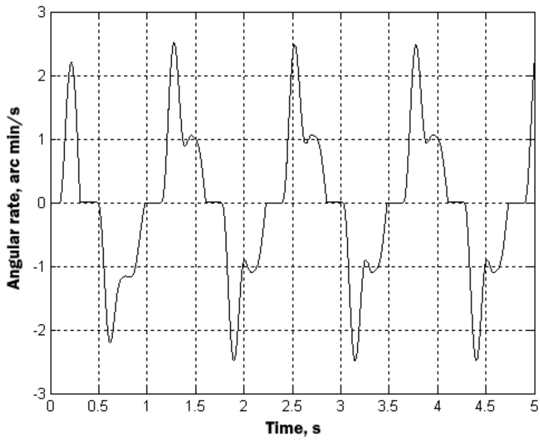

Fig. 2. Angular position of ISP

To provide correspondence of simulation to checks on the test route it is necessary to take into consideration features of test equipment. Therefore it is necessary to study ways of definition of test signals, which must correspond to disturbances of the test route. This is carried out by means of bench assigned for tests of the system of platform angular motion. In the first place, the test signal may be given at the integrator input as a voltage; in the second place – in the integrator circuit after demodulator; in the third place – at the gyro rate sensor in the form of signal proportional to the angular rate. Results of simulation represented in Figs 1, 2, correspond to the first case of test signal determination.

During design of system of platform angular motion control is important to research dependence of accuracy and dynamic parameters on the residue unbalance moment. This dependence can be represented in the following form

$$\Delta M_{ub} = -M_{ub} \cos\varphi_p + k_s A, \qquad (6)$$

here φ_p is angle of turn of platform turn, k_s is transfer coefficient of the spring compensator; A is an angle of spring setting.

Conclusions

The concept of ISP is analyzed. The approach to organization of checks of the synthesized system taking into consideration features of ISPs assigned for operation on the ground vehicles. The way to estimate the dynamic error and angular rigidity of the system of stabilized platform motion control operated on the ground vehicle is proposed. The expression for research influence of the unbalance moment on the system performances is given. The simulation results are represented. Perspectives of the further development of the represented researches lie in spreading of the represented approaches on other types of vehicles.

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Synthesis of the Digital Autopilot for an Aircraft Using l1-Approach

The optimal digital autopilot needed to control of the roll for an aircraft in the presence of an arbitrary unmeasured disturbances is addressed in this paper.

The problem of efficiently controlling the motion of an aircraft in a non-stationary environment capable to ensure its high performance index is important enough from the practical point of view [1]. To solve this problem, the different approaches based on the modern control theory, including adaptive and robust control, neural networks, etc., have been reported by many researches (see, for example, [2, 3]).

One of the efficient methods devised in the modern control theory for rejecting any unmeasured disturbance is based on the l_1-optimization concept [4]. This concept has been utilized in [5] to design the digital lateral autopilot for aircraft capable to cope with a gust.

This paper extends the approach which we have first reported among other authors in [5] to deal with a digital autopilot for the lateral motion control. More certainty, the purpose of the paper is to synthesize a digital autopilot which is able to maintain a given roll orientation of an aircraft with a desired accuracy and to cope with an arbitrary external disturbance (a gust). As in traditional continuous-time (analogue) control systems, the digital control system is designed as the two-circuit closed-loop control system having the inner feedback loop and the external feedback loop. In contrast with [5], the aileron servo dynamics are taken into account to ensure the stability of closed loop.

Let $\dot{\gamma}(t)$ and $\xi(t)$ denote the roll rate angle and the aileron deflection of an aircraft, respectively, at a time t. According to [6, chap. 3] the lateral dynamics equation of an aircraft derived from the linearized lateral equation of the aircraft motion can be described by the continuous-time transfer function

$$W_\xi(s) := \frac{\dot{\Gamma}(s)}{\Xi(s)} = \frac{K_\xi}{T_\xi s + 1}, \tag{1}$$

where $\dot{\Gamma}(s)$ and $\Xi(s)$ represent the Laplace transforms of $\dot{\gamma}(t)$ and $\xi(t)$, respectively. K_ξ and T_ξ are the aerodynamic derivatives (more certainly, T_ξ is the damping derivative in the roll channel and K_ξ is the roll moment).

By definition, the transfer function from $\dot{\gamma}$ to γ that is output is given by

$$W_0(s) = \frac{K_0}{s}, \tag{2}$$

where K_0 may be considered as an integrator gain whose dimension is s^{-1}.

As in [6, chap. 4], it is assumed that continuous-time transfer describing the aileron servo dynamics is

$$W_{\mathrm{S}}(s)=\frac{K_{\mathrm{S}}}{T_{\mathrm{S}}s+1}, \tag{3}$$

where K_{S} and T_{S} are its gain and time constant, respectively.

Suppose that $K_{\xi}, K_0, K_{\mathrm{S}}, T_{\xi}, T_{\mathrm{S}}$ in (1) to (3) are known.

Define by $d(t)$ an external signal (in particular, a gust) disturbing the angular velocity $\dot{\gamma}$. This signal plies the role of an unmeasurable arbitrary disturbance. Without loss of generality, it is assumed that it has to be upper bounded in modulus.

Let $\gamma^0(t)$ denote the desired roll orientation at the time t. It is assumed that $\gamma^0(t)$ is a continuous upper bounded function of t.

Define now the output error $e(t)$ as

$$e(t)=\gamma^0(t)-\gamma(t). \tag{4}$$

The aim of the controller design may be written as the requirement

$$\lim_{t\to\infty}\sup|e(t)|\to\inf_{\{u(t)\}}. \tag{5}$$

The controller satisfying (5) is called optimal.

To implement the controller design concept proposed in this paper, two feedback loops similar to that in [5, 6] are incorporated in the autopilot system, as shown in Fig. 1. But, in contrast with [6], they are designed as the discrete time close-loop control circuits using two separate controllers. To this end, two samplers are incorporated in the feedback loops; see Fig. 1. These samplers are needed in order to convert analogue signals $\dot{\gamma}(t)$ and $\gamma(t)$ in digital form at each *n*th time instant $t=nT_0$ $(n=0,1,2,\ldots)$ to producing the discrete-time signals $\dot{\gamma}(nT_0)$ and $\gamma(nT_0)$, respectively, with the sampling period T_0. On the other hand, the signal $u(nT_0)$ formed by digital controller at the same time instant converts to analogue form $u(t)$ using the so-called zero-order hold (ZOH).

The aim of the inner control loop exploiting the discrete-time PI control is to stabilize the roll rate $\dot{\gamma}(nT_0)$ at a given value, $\dot{\gamma}^0(nT_0)$, which is the output of the external control loop, as shown in Fig. 1.

The feedback control law of this digital controller is

$$u(nT_0)=k_{\mathrm{p}}^{\mathrm{in}}e_{\dot{\gamma}}(nT_0)+k_{\mathrm{i}}^{\mathrm{in}}\sum_{i=0}^{n}e_{\dot{\gamma}}(iT_0),$$

where $e_{\dot{\gamma}}(nT_0)$, is the deflection of the true angular velocity, $\dot{\gamma}(nT_0)$, from a given angular velocity, $\dot{\gamma}^0(nT_0)$, at the time instant $t=nT_0$ given by

$e_{\dot\gamma}(nT_0) = \dot\gamma^0(nT_0) - \dot\gamma(nT_0)$, and $k_{\mathrm{P}}^{\mathrm{in}}$ and $k_{\mathrm{I}}^{\mathrm{in}}$ represent its parameters.

The sampled-data transfer function of the PI controller is determined as follows:

$$C^{\mathrm{in}}(z) := \frac{U(z)}{E_{\dot\gamma}(z)} = k_{\mathrm{P}}^{\mathrm{in}} + \frac{k_{\mathrm{I}}^{\mathrm{in}} z}{z-1},$$

where $U(z) := Z\{u(nT_0)\}$ and $E_{\dot\gamma} := Z\{e_{\dot\gamma}(nT_0)\}$ the Z-transforms of the sequences $\{u(nT_0)\}$ and $e_{\dot\gamma}(nT_0)$, respectively.

The external feedback loop which contains the usual P controller is used to stabilize the roll angle, $\gamma(nT_0)$, around the desired value, $\gamma^0(nT_0)$. Its control law is defined by $\dot\gamma^0(nT_0) = k_{\mathrm{P}}^{\mathrm{ex}} e_\gamma(nT_0)$ together with the error $e(nT_0) = \gamma^0(nT_0) - \gamma(nT_0)$, where $\gamma^0(nT_0)$ and $\gamma(nT_0)$ are a desired and true roll orientation at the time instant $t = nT_0$, respectively. Then the sampled-data transfer function describing the external P controller will be defined as

$$C^{\mathrm{ex}}(z) = k_{\mathrm{P}}^{\mathrm{ex}}.$$

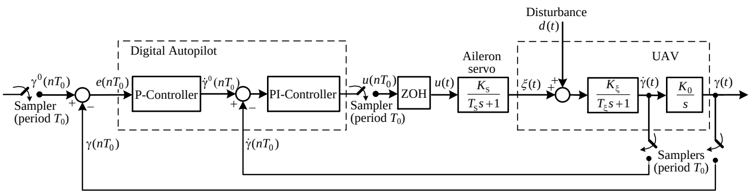

Fig. 1. Structure of digital control system containing the autopilot for the lateral motion control

In order to choose the optimal parameters of both digital controllers, the so-called $\mathbf{l}_1$-optimization approach is utilized.

It can be finally established that

$$\limsup_{n\to\infty} |e_\gamma(nT_0)| \le \|H^{\mathrm{ex}}(k_c)\|_1 \|v^{\mathrm{ex}}\|_\infty + O\big(\|\delta v\|_\infty\big) < \infty,$$

where

$$H^{\mathrm{ex}}(z, k_c) = \frac{1}{1 + C^{\mathrm{in}}(z) W_s W_\xi(z) + C^{\mathrm{in}}(z) C^{\mathrm{ex}}(z) + W_{\mathrm{S}} W_\xi W_0(z)} \tag{6}$$

depends on the vector $k_{\mathrm{C}} = [k_{\mathrm{P}}^{\mathrm{in}}, k_{\mathrm{I}}^{\mathrm{in}}, k_{\mathrm{P}}^{\mathrm{ex}}]^T$ of the controller parameters and $\|v^{\mathrm{ex}}\|_\infty$ is the ∞-norm of the sequence $\{v^{\mathrm{ex}}(nT_0)\}$ defined as

$v^{\text{ex}}(nT_0) = Z\left\{L^{-1}\left\{W_\xi(s)W_0(s)D(s)\right\}_{t=nT_0}\right\}$ (Due to space limitation, details are omitted.)

It turned out that the set Ω^{in} of pairs $\left(k_{\text{P}}^{\text{in}},\, k_{\text{I}}^{\text{in}}\right)$ under which the inner loop will be stable is bounded and the set Ω^{ex} of k_{P}^{ex}s guaranteeing the stability of the external loop for these k_{P}^{in}s and k_{I}^{in}s is also bounded. These facts make it possible to utilize the well-known Weierstrass theorem [7, chap. 1, sect 3]. By virtue of this theorem, there exists the minimum

$$k_{\text{C}}^{*} = \min_{k\in\Omega^{\text{in}}\times\Omega^{\text{ex}}} \| H^{\text{ex}}(k_{\text{C}}) \|_1 \,. \tag{7}$$

Unfortunately, the l_1-norm, $\| H^{\text{ex}}(\text{z},\, k_{\text{C}}) \|_1$ given by (6), is non-differentiable function with respect to the components $k_{\text{P}}^{\text{in}},\, k_{\text{I}}^{\text{in}},\, k_{\text{P}}^{\text{ex}}$ of k_{C}. Therefore, the random search technique is required to find the optimal parameter vector, k_{C}^{*}, defined by (7).

The $\mathbf{l}_1$-optimization algorithm employing the random search is as follows [7, chap. 6, item 4]:

Step #1: Setting $k=0$ choose an arbitrary $\widehat{k}_{\text{C}}^{0} \in \Omega$, where $\Omega = \Omega^{\text{in}} \times \Omega^{\text{ex}}$ is the bounded set.

Step #2: Compute a trial point $\widehat{k}_{\text{C}}^{k+} \in \Omega$, according to the rule

$$\widehat{k}_{\text{C}}^{k+} = \widehat{k}_{\text{C}}^{k} + r^{k},$$

where r^{k} is a realization of a suitably distributed random vector.

Step #3: If $\| H(\widehat{k}_{\text{C}}^{k+}) \|_1 < \| H(\widehat{k}_{\text{C}}^{k}) \|_1$ then $\widehat{k}_{\text{C}}^{k+1} = \widehat{k}_{\text{C}}^{k+}$, else $\widehat{k}_{\text{C}}^{k+1} = \widehat{k}_{\text{C}}^{k}$,

Step #4: Increment *k* by one and go to Step #2.

To evaluate the performance index of the control system that uses the l_1-optimization approach, several simulation experiments were conducted. In these experiments, variable $d(t)$ similar to the wind gust was simulated as Dryden Wind Turbulence Model. The duration of the observations was 500 s. Results of six experiments are presented in Table I.

The first simulation experiment corresponded to the case where the controller parameters were optimized using the method proposed in the work [14]. In this case, we first optimized the two parameters of the inner controller. Next, based on these parameters, we calculated the one optimal parameter of the external controller.

In the fifth experiment, the optimal parameters of both controllers were calculated simultaneously (according to the proposed approach). It turns out that the parameter k_{P}^{in} of the both l_1-optimal controllers are same whereas k_{I}^{in} and k_{P}^{ex} becomes somewhat different. This leads to the different performance indices.

Namely, in the first experiment, the estimate $\max|e(nT_0)|$ were greater than in fifth experiment. This fact shows that the simultaneous l_1-optimization is more efficient. We observe that if k_P^{in} and k_I^{in} become approximately equal but k_P^{ex} increases then $\max|e(nT_0)|$ decreases (see Table 1). Note that if the controller parameters essentially differ from their optimal values (as in sixth experiment), then the performance index of the control system becomes unsatisfactory.

Table I. Performance indices of the control system

Number of experiment	k_P^{in}	k_I^{in}	k_P^{ex}	Maximum $\lvert e(nT_0)\rvert$ for $n \in [0 \;\; 5\cdot 10^4]$
1	4	0.08	3.7	0.0203
2	4	0.1	3.7	0.0173
3	4	0.1	3.5	0.0180
4	4	0.1	3.8	0.0169
5	4	0.1	4.1	0.0160
6	3	0.05	6.8	0.0382

Conclusions

This paper dealt with the l_1-optimization concept applied for synthesizing the lateral autopilot for aircraft. It was established that the two-circuit l_1-optimal PI and P control laws can cope with the wind gust and ensure the desired roll orientation. This makes it possible to achieve the control objective. A distinguishing feature of the control algorithms is that they are sufficiently simple. This is important from the practical point of view.

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Features the diagnosis of mental and emotional state of a person

In the paper, the problem of diagnosis of person's emotional state by technical means in interest of burnout emotional warning is considered.

The life of modern people filled with different events, one way or another involve changes to the mental and emotional state. The manifestations of mental and emotional states can be both positive and negative. The negative consequence considered burnout syndrome. This state is the most dangerous because it can lead to economic losses and irreversible consequences in their professional activities. So, at the European Conference of the World Health Organization, held in 2005, it noted that the cost of solving the problems of mental and emotional state of the working people of the European Union amounts to 3-4% of gross national income [1].

Burnout syndrome faced by people whose work takes place under conditions of constant stress and responsibility for a life another people, namely, military personnel, pilots, astronauts, medical professionals, teachers, social workers [2].

The main reason of burnout considered a psychological, mental super fatigue. This occurs when the requirements (internal and external) for a long time dominated over resources (internal and external) a human equilibrium is disturbed, which inevitably leads to a syndrome of mental and emotional burnout. The connection of the identified changes to the nature of the professional activities involving responsibility for the fate, health and lives of people is set. These changes interpreted as the result of exposure to prolonged occupational stress.

Now allocate about 100 symptoms, one way or another associated with the syndrome of emotional burnout. First of all, it should be noted that the conditions of professional activity can sometimes appear and cause chronic fatigue syndrome, which, incidentally, is often accompanied by syndrome of emotional burnout. In chronic fatigue syndrome are typical complaints of patients: progressive fatigue, decreased performance; poor tolerance of the previously usual loads; muscle weakness; muscle pain; sleep disorders; headache; forgetfulness; irritability; decrease in mental activity and ability to concentrate.

A significant role in the fight against burnout syndrome is given primarily to the patient. To prevent the occurrence of burnout or reduce the degree of severity may, subject to such recommendations [3]:

- identify short-term and long-term goals (if the patient improves long-term motivation, and achieving short-term goals - success raises self-effect);
- create a "time-outs" to maintain mental and physical balance of the daily schedule "work-rest";
- be master the skills and abilities of self-regulation (relaxation, ideomotor acts, the definition of objectives and the positive inner attitude, increasing resistance to stress);

- improve the professional and qualification level, engage in self-improvement, visit the training courses, conferences, etc.;
- get away from unnecessary competition; focus on the activities useful to society;
- improve communication skills, share emotions with others;
- conduct a correct way of life, give up bad habits, to normalize or to improve the physical condition.

Effective preventive measures considered burnout:
- calculate and deliberate distribution of the daily physical and mental load;
- develop the ability to switch from one activity to another;
- refer to conflicts at work as a necessary boost to self-improvement;
- know your abilities and goals, not to strive to be the best, always and everywhere.

Psycho-emotional state - it is the human reaction to the relationship with the environment, expressed in terms of the appearance of his feeling comfortable or uncomfortable state. Independently recognize the state of burnout syndrome is impossible because of the conservatism of retardation and personality assessments. Therefore, scientists of different countries have developed methodology for assessing the mental and emotional state, and developed tools for the independent qualification of this state.

Traditional methods by [3] for studying the emotional state are monitored and a questionnaire survey. Since the emergence of the emotions associated with the change of physiological parameters, natural desire of researchers, diagnosing the presence of a particular emotional state, based on the "objective" indicators.

Methods of self-estimation emotional states, proposed by K. Izard (1976), its standardized emotional states that represented as differentiated table of emotions. According to this procedure, the description of the individual emotional experience translated into individual categories of emotions.

The most sensitive indicators of emotional arousal are tremor, kinematometriya (play preset range of motion), reflexometerization (measuring time simple and complex sensorimotor reaction), the reaction to the moving object and the measurement of time intervals.

When measuring the emotional tension can be used as indicators the temperature of skin on the fingers. The finger temperature dynamics allows us to differentiate emotional load: anxiety and depression when there is a temperature decrease, and positive emotions accompanied by its increase.

The method is based on a detailed study of the anatomy the facial muscles is called Facial Action Coding System (FACS). In the course of the study it was identified 41 motor unit, which is composed of 24 individual reaction pattern of facial muscles and 20 patterns that reflect the work of the muscle groups involved, for example, in biting the lips. The use of this technique showed that the negative emotions (anger, fear, disgust, sadness) activated for about 41% of all facial muscles.

In some situations, the only channel through which can enter information about the emotional state of a person (pilots, astronauts, meteorologists in the far north, and so on), is a voice. In connection with this the objective development (instrumental) methods of diagnosis of these conditions for the various parameters of speech is of great practical importance. There are the following characteristics:

fundamental frequency of speech for each period, the average pitch frequency of speech for any length of utterance, frequency change interval of base tone, irregularity curve of base tone. These indicators allow us to determine the degree of emotional arousal speaker.

Evaluation of psycho-emotional and functional status based on considered methodologies constructed a number of diagnostic tools that recommended for use in a specialized, individual and family survey. The most famous among them "Kirlian bioelectrography", the registrar evaluation of functional and emotional state «ROFES», a fitness bracelet Xiaomi Mi Band, clever hours.

The device "Kirlian bioelectrography" [4] works on the principle of discharge visualization. Material removal information comes from the radiation at their fingertips. The character of radiation fingerprint allows you to set the human condition and to make a preliminary conclusion.

Registrar «ROSFET» [5] using biologically active point MS7 that microcurrent is excited and analyzed reactions to stimulation. Included with the software evaluation instrument except neuroses, irritability, stress levels and surge assesses 17 major organs and systems, which makes useful for routine monitoring of physical condition.

Fitness bracelets [6] and smart watches [7] are able to carry out daily monitoring of physical activity using pedometer and meter of heart rate. Full control of the psycho-emotional state now for them is impossible.

Thus, the registrar of mental and emotional state of a person is a device, which based on learning the body's reaction to the typical actions and its compares with the reference values. Benchmarking is obtained by long time observation of certain categories of persons with well-known psycho-emotional state. The device has a display device that displays the measurement results that can be compared with typical values indicate the current state or the degree of deviation from the norm. Orienting the software on a specific operating software platform its capabilities can be extended with comments and recommendations. The diagram USE-CASE, Fig. 1, can represent the main scenario of interaction between the device and the user of the computer.

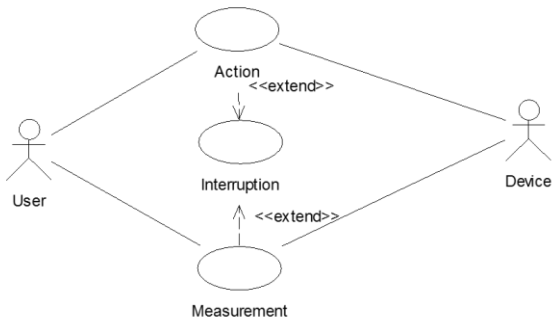

Fig. 1. Main scenario for processing of measurement results

Operation «interruption» needed for restoration or change person state throughout some time.

Conclusions

Controlling mental and emotional state becomes important for various professional groups of people, especially those related to risk (military, pilots, social workers and others). This is due to the invisible appearance this state, with heavy loss of individual and community, as well as the difficulty of self-establishing the state of mental and emotional causes of burnout.

Existing therapeutic approaches based on the patient's part in the process of emerging from this state. In addition to the psychological impact to the patient needed: compliance work and rest, avoiding harmful habits, proper nutrition, clarifying professional and personal goals.

Timely detection of the state of discomfort and constant control of the quality of life is possible when using special diagnostic equipment. Insufficient level of industrial development in this direction stimulates the search for new and effective solutions, the basic directions of creation of technical solutions presented in this paper.

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Robust adaptive stabilization of multivariable static systems with unknown square gain matrices and bounded disturbances having unknown bounds

This work deals with designing the adaptive robust control systems containing linear discrete-time multivariable static plants which have unknown and possibly singular square gain matrices in the presence of arbitrary bounded disturbances whose bounds are unknown. The asymptotical properties of these systems are established.

The problem of stabilizing linear multivariable (interconnected) systems stated several decades ago in the paper [1] remains actual up to now [2]. It is important problem from both theoretical and practical point of view.

Since the seventies, the so-called internal model method becomes popular among other methods dealing with an improvement of the control system by exploiting the different types of plant and disturbances models. A perspective modification of the internal model control principle is the model inverse approach [2]. Unfortunately, this approach is quite unacceptable when the systems to be controlled are square but singular because they become noninvertible. It turned out that the so-called generalized inverse (pseudoinverse) model approach can be exploited to cope with the nonivertibility of singular system [3].

The common feature of the works [1, 3] dealing with the control of multivariable plants is that their parameters are assumed to be known. Usually, the adaptive approach is used to cope with the parametric uncertainty [4, 5]. Namely, the inverse model approach was before utilized in [6] for controlling a multivariable static plant whose gain matrix is unknown but nonsingular.

Different adaptive methods have recently been advanced in literature [7, 8]. However, they do not make it possible to avoid the crucial assumption with respect to the nonsingularity of the gain matrix introduced before in the book [5, item 4.2.3°] and also in the textbook [6, item 5.2.3].

A new method for the adaptive robust control of multivariable static plant whose gain matrix may be singular in the presence of arbitrary bounded disturbances has been presented in [9]. The essential assumption made in [9] is that their bounds are known. This paper is an extension of [9] to deal with the adaptive stabilization of multivariable static plants which haves any square gain matrix assuming the bounds on these disturbances are unknown.

Consider a linear multivariable static plant described by

$$y_n = Bu_n + v_n, \tag{1}$$

where $y_n = [y_n^{(1)}, \ldots, y_n^{(N)}]^{\mathrm{T}}$ is the N-dimensional output vector to be measured at nth time instant, $u_n = [u_n^{(1)}, \ldots, u_n^{(N)}]^{\mathrm{T}}$ is the N-dimensional vector of unmeasurable disturbances.

$$B = \begin{pmatrix} b_{11} & \dots & b_{1N} \\ \dots & \dots & \dots \\ b_{N1} & \dots & b_{NN} \end{pmatrix}$$

is an arbitrary transfer $N \times N$ gain matrix. It is assumed that its elements are all unknown. However, there are some interval estimates

$$\underline{b}_{ik} \le b_{ik} \le \overline{b}_{ik}, \quad i, k = 1, \dots, N \tag{2}$$

with the known upper and lower bounds. This implies that B in (1) may be ill-conditioned or even singular, in general.

Suppose $\{v_n^{(i)}\}$ represents the ith unmeasurable bounded disturbance sequence satisfying

$$| v_n^{(i)} | \le \varepsilon_i < \infty \quad \forall\, i = 1, \dots, N, \tag{3}$$

where ε_i is an upper bound on $v_n^{(i)}$. We assume that ε_i s are unknown and it is essential.

Let

$$y^0 = [y^{0(1)}, \dots, y^{0(N)}]^{\mathrm{T}}$$

denote the desired output vector whose components satisfy $| y^{0(1)} | + \dots + | y^{0(N)} | \ne 0.$

The problem is to design the adaptive controller guaranteeing

$$\limsup_{n \to \infty} (\| y_n \| + \tau \| u_n \|) < \infty, \quad \tau > 0 \tag{4}$$

provided the assumptions (2) and (3).

Basic idea proposed by the authors in [9] is the transaction from the adaptive identification of the true plant having the singular transfer matrix $\tilde{B}$ to the adaptive identification of a fictitious plant with the nonsingular transfer matrix of the form

$$\tilde{B} = B + \delta_0 I, \tag{5}$$

where I denotes the identity matrix and δ_0 is a fixed quantity determined later.

Although $\tilde{B}$ as well as B remain unknown, the requirement

$$\det \tilde{B} \ne 0 \tag{6}$$

can always be satisfied by the suitable choice of δ_0 in (5).

The equation of the fictitious plant is derived by adding the quantity $\delta_0 u_{n-1}$ to the both sides of (1). Then, due to (5) we obtain the equation

$$\tilde{y}_n = \tilde{B} u_{n-1} + v_n, \tag{7}$$

equivalent to the true plant equation for

$$\tilde{y}_n = y_n + \delta_0 u_{n-1}. \tag{8}$$

We observe from (7) that the true and fictitious plants have the same inputs u_n and are subjected to the same unmeasurable disturbance v_n. It is essential that output $\tilde{y}_n$ of the fictitious plant, by virtue of (8), can always be measured.

Following to [9], define

$$\beta_{\min}^{(i)} := \underline{b}_{ii} - \sum_{k=1,\,k\neq i}^{N} \max\{|\,\underline{b}_{ik}\,|, |\,\bar{b}_{ik}\,|\},$$
$$\beta_{\max}^{(i)} := \bar{b}_{ii} + \sum_{k=1,\,k\neq i}^{N} \max\{|\,\underline{b}_{ik}\,|, |\,\bar{b}_{ik}\,|\}. \tag{9}$$

Then, δ_0 required to ensure $\det \tilde{B} \neq 0$ is chosen to satisfy the conditions

$$\delta_0 > -\beta_{\min} \text{ for } |\,\beta_{\min}\,| < |\,\beta_{\max}\,|, \quad \delta_0 < -\beta_{\max} \text{ for } |\,\beta_{\min}\,| > |\,\beta_{\max}\,|, \tag{10}$$

where

$$\beta_{\min} := \min\{\beta_{\min}^{(1)}, \ldots, \beta_{\min}^{(N)}\}, \quad \beta_{\max} := \max\{\beta_{\max}^{(1)}, \ldots, \beta_{\max}^{(N)}\}. \tag{11}$$

As in [8, item 4.2], the adaptive control law is designed in the form

$$u_{n+1} = u_n + \tilde{B}_n^{-1}\tilde{e}_n, \tag{12}$$

where instead of the current estimate B_n, another $\tilde{B}_n$ is exploited, where the output error

$$e_n = y^0 - y_n$$

is replaced by

$$\tilde{e}_n = y^0 - \tilde{y}_n. \tag{13}$$

with $\tilde{y}_n$ given by the expression (8).

The adaptive identification algorithm used to determine the estimates $\tilde{B}_n$ may be taken as the iterative procedure

$$\tilde{b}_n^{(i)} = \tilde{b}_{n-1}^{(i)} - \gamma_n^{(i)} \frac{f(\tilde{e}_n^{*(i)}, \varepsilon_{n-1}^{(i)})}{1 + \|\nabla u_n\|^2} \nabla u_n \operatorname{sign} \tilde{e}_n^{*(i)}, \quad i = 1, \ldots, N, \tag{14}$$

proposed in [8, item 4.2]. In this algorithm, the notation $\tilde{b}_n^{(i)} := [\tilde{b}_{i1}(n), \ldots, \tilde{b}_{iN}(n)]^{\mathrm{T}}$ is introduced.

$$f(e, \bar{\varepsilon}) = \begin{cases} 0, & \text{if } |e| \leq \bar{\varepsilon}, \\ |\,e\,| - \bar{\varepsilon} & \text{otherwise} \end{cases} \tag{15}$$

represents the dead-zone function depending on the identification error

$$\tilde{e}_n^{*(i)} = \nabla\tilde{y}_n^{(i)} - \tilde{b}_{n-1}^{(i)\mathrm{T}} \nabla u_n \tag{16}$$

with $\nabla u_n := u_n - u_{n-1}$, $\nabla\tilde{y}_n^{(i)} := \tilde{y}_n^{(i)} - \tilde{y}_{n-1}^{(i)}$ and also on the current estimate $\varepsilon_{n-1}^{(i)}$ found at the (n–1)th time instant. The coefficients $\gamma_n^{(i)}$ are chosen as

$$0 < \gamma' \leq \gamma_n^{(i)} \leq \gamma'' < 2 \tag{17}$$

to satisfy (6).

Similar to [8, item 4.2], the algorithm for estimating $\varepsilon_n^{(i)}$ is designed in the form of the following iterative procedure:

$$\varepsilon_n^{(i)} = \varepsilon_{n-1}^{(i)} + \gamma_n^{(i)} \frac{f(\tilde{e}_n^{*(i)}, \varepsilon_{n-1}^{(i)})}{1 + \|\nabla u_n\|^2}, \quad i = 1, \ldots, N \tag{18}$$

with

$$\varepsilon_0^{(i)} = 0 \quad \forall i = 1, \ldots, N. \tag{19}$$

The asymptotical behavior of the adaptive control system is established in the following theorem (the main result).

Theorem. Determine δ_0 using the formulas (9)–(11) and choose an arbitrary initial $\tilde{B}_0$ according to the expression (5) with $B_0 = \{b_{ik}(0)\}$ whose elements satisfy

$$\underline{b}_{ik} \le b_{ik}(0) \le \overline{b}_{ik}.$$

Subject to the assumptions given in the inequalities (2), (3) with known $\underline{b}_{ik}$s, $\overline{b}_{ik}$s and ε_is the adaptive control algorithm described in the equations (12) to (19) when applied to the plant (1) yields:

i) the matrix sequence $\{\tilde{B}_n\} := \tilde{B}_1, \tilde{B}_2, \ldots,$ induced by the identification procedure converges, i.e.,

$$\lim_{n\to\infty} \tilde{B}_n = \tilde{B}_\infty;$$

ii) there exists a limit

$$\lim_{n\to\infty} \varepsilon_n^{(i)} = \varepsilon_\infty^{(i)}, \quad i = 1, \ldots, N;$$

iii) the requirement (4) is satisfied.

The proof follows the lines of the books [6, 8]. (Due to space limitation, details are omitted.)

It can be observed that the sequences $\varepsilon_n^{(i)}$ is non-decreasing.

Note that there is no guarantee that the ultimate performance index is the same as in the nonadaptive control system containing the generalized inverse model.

Conclusion

It was established, that there is the possibility to design the adaptive robust controller stabilizing the linear multivariable plant whose gain matrix is singular in the presence of the bounded disturbances with unknown bounds.

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Features information UAV control system

The paper discusses the features of the information channel UAV is considered a way to encrypt data, using direct and inverse dynamic systems. With encryption program - the decryption carried out a series of experiments to transform the data, which showed some features of algorithms based on the above-mentioned systems.

Today, there are a number of technical issues hindering the UAV development. The overarching task is to ensure information transmission between an aerial vehicle also called, for brevity's sake, the 'Board' and a ground control station (GCS) that we further designate using the term the 'Ground' to the volume required, at the given rate and without noise. This task can be solved by increasing the capacity and noise resistance of the information transmission channels.

Topical issues of classified information in communication channels with ground control UAV investigated in many recent papers, for example [1], [2]. However, analysis of recent research and publications shows that these issues are not completely addressed in the literature.

The most important information kinds exchanged by the Board and the Ground include the command-line, telemetric and video information.

ON-board video cameras are needed to give the panorama in sight of UAV to detect various objects afield and determine their coordinates, to explore areas of forest and peat-bog fires, major man-induced disasters, to perform environmental monitoring, etc. Particular tactical tasks carried out using the aircraft-borne video cameras are confidential and protected from unauthorized disclosure. The use of stream ciphers offers a simple solution for cryptographic information security in broadband video transmission system.

The problem of vulnerability of the channels used to transmit information between UAV and the ground control station more often being a tablet computer or a laptop, can be solved by using one of the following methods:

– the use of autonomous UAV;

– the use of satellite repeaters;

– closure of communication lines by using cryptographic means.

In most applications, the last of the above mentioned methods turns to be the most appropriate and cost-effective one.

In evaluating the requirements applicable to channel protection system using cryptographic means, the following aspects can be distinguished: speed-of-response, encryption reliability, weight and overall dimensions of the on-board system part. These factors are in conflict with each other, especially with increasing channel carrying capacity and low weight of UAV.

Several factors determine the choice of the encryption algorithm, such as organizational (including certification issues) and technical ones, of which an important moment is feasibility on the available component basis.

The aim of this paper is to develop of software and modeling cypher algorithm that ensures high-speed streamed cryptographic conversion of signals transmitted from the UAV board.

In recent years, a new direction in cryptology is being developed, which is associated with the use of dynamical systems with chaotic behavior [3]. One of the basic approaches in this direction is based on the use of inverse control systems for developing cryptographic algorithms [4].

Dynamical systems with chaotic behavior are being widely used now and are used in various fields, in particular for ensuring cryptographic protection of information. Such systems can serve as the basis for pseudorandom sequence generators that are further used to encrypt plaintext data. On the other hand, every dynamical system of the input-output structure can be directly used for conversion of information. On the basis of such systems an encoder is developed. The log-in is a digitized message, while the log-out is an encrypted signal directed to the telecommunications network. A necessary condition for unique decrypting is availability of the feedback system.

The cheapest of the UAV does not provide cryptographic protection of the communication channel. That is, the same commands coming from the ground to the board and from board to the ground correspond to the same signals. This allows an attacker to take control of the UAV.

Any information processed by different discrete calculators can eventually be represented by a sequence of bits (0 or 1). This representation, in fact, is used in its conversion using a variety of dynamical chaotic systems. However, in computing systems to represent different types of data they use larger units that is to say 88 bytes (bit), and machine words from 16 to 64, usually depending on the machine digit capacity. Most commonly byte representation of information is used. Thus, the code tables in computing systems for representing textual information indicate correspondence between 256 bytes and characters of different scripts.

In many cases, the use of the byte information representation also simplifies algorithms of its processing by computing systems. Therefore, we will further consider the byte to be a unit of digital information, and the information processed in computer environment, will be represented as a sequence of different bytes.

The method of data encryption will be the method of direct information conversion by a dynamical chaotic system using forward and backward systems.

The encryption algorithm used in this work is based on the use of discrete analogue of the Chua dynamical chaotic system [4].

The final Chua machine is described by the system of equations:

Direct system

$$\dot{x}_1 = A_1(A_2(x_2 - x_1) - (x_1 + 1))$$
$$\dot{x}_2 = A_3(A_2(x_1 - x_2) - x_3 + Av_{in})$$
$$\dot{x}_3 = A_4(x_2 - A_5 x_3)$$

Inverse system

$$\dot{x}_1 = A_1(A_2(x_2' - x_1') - (x_1' + 1)$$
$$V_{out} = \frac{1}{A}(\frac{1}{A_3}\dot{x}_2 - A_2(x_1' - x_2') + x_3'$$
$$\dot{x}_3' = A_4(x_2' - A_5 x_3')$$

Here v_{in} and v_{out} – inputs direct and inverse systems respectively. A set of input and output symbols, components $x_i(t)$, $i = 1, 2, 3$ are understood as the elements of the Galois field $GF(q)$ or the ring $Z(q)$, and operations of addition or multiplication are relative operations in this field or ring. This allows the use of inexpensive signal processing controller is not great AC.

For digital information conversion, the fields and rings of characteristic 2 are usually used, that is to say $q = 2n$, $n \in N$. Given the nature of information representation in the computer memory, the program uses the fields $GF(2^{8k})$ or the rings $Z(2^{8k})$, $k = 1, 2, 3, 4$. This is due to the fact that the information file is stored in the computer memory as a sequence of bytes. There are several types of the Galois field representation. The program uses two of them: integer representation, and vector representation. Implicitly, polynomial representation is also applied in developing calculation algorithms in the fields.

The key of the decryption system are system coefficients and initial state for the machine. Sampled differential equations with step 1, we get:

Direct system:

$$\begin{cases} x_1(t+1) = x_1(t) + A_1\left[A_2(x_2(t) - x_1(t)) - (x_1(t) + 1)\right], \\ x_2(t+1) = x_2(t) + A_3\left[A_2\left[x_1(t) - x_2(t)\right] - x_3(t) + Av_{in}(t)\right], \\ x_3(t+1) = x_3(t) + A_4\left[x_2(t) - A_5 x_3(t)\right]. \end{cases}$$

Here output of system $v_{out}(t) = x_2(t)$.

Inverse system:

$$\begin{cases} x_1(t+1) = x_1(t) + A_1\left[A_2(x_2(t) - x_1(t)) - (x_1(t) + 1)\right], \\ v_{out}(t+1) = \dfrac{1}{A}\left(\dfrac{x_2(t+1) - x_2(t)}{A_3} - A_2\left[x_1(t) - x_2(t)\right] + x_3(t)\right), \\ x_3(t+1) = x_3(t) + A_4\left[x_2(t) - A_5 x_3(t)\right]. \end{cases}$$

Re-calculation of coefficients of the reverse machine occurs during system setup for file decryption. As a result of encoder output will be a sequence, which should have the properties of a pseudo-random one. To study the pseudo-random sequence of numbers, there are two groups of tests.

Graphic tests. Statistical properties of sequences are displayed as curves, the form of which is used to make conclusions about the properties of the sequence under test.

Evaluation tests. Statistical properties of sequences are defined by numerical characteristics.

Based on evaluation criteria, conclusions about the proximity degree for characteristics of the sequence under test and a true random sequence are made.

Figs 1-4 show the results of the encryption and continuous periodic signals using Chua machine in the final ring $Z(2^8)$ of the following conditions $A_1=9$, $A_2=99$, $A_3=113$, $x_{10}=116$, $x_{20}=47$, $x_{30}=38$.

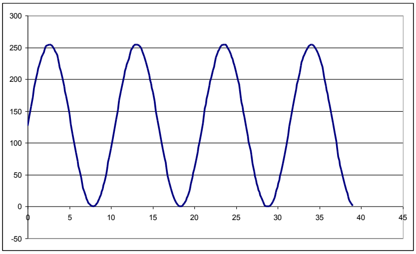

Fig. 1. The periodic signal

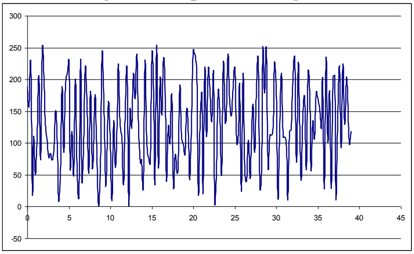

Fig. 2. Transformed periodic signal via Chua system

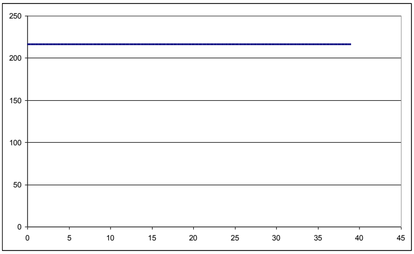

Fig. 3. The permanent signal

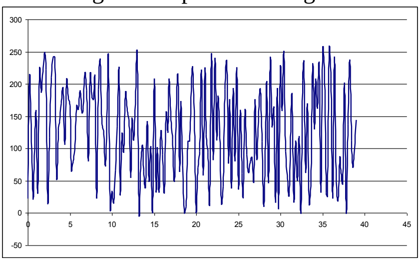

Fig. 4. The converted DC signal by Chua system

To estimate the pseudo random sequence of numbers generated using the Chua system, a package of statistical NIST tests was applied.

For encryption, the Chua system was used in finite rings (2^p) and fields $GF\ (2^p)\ 8 \leq p \leq 128$.

Test 1. Analysis of algorithms using graphical visualization. For this test 10 various incoming sequences of 320 000 length were used. Each sequence was ciphered by each algorithm 20 times with different, randomly chosen parameters. As a result of the tests performed, the following conclusions were made:

– When the ring output increases, the ‘blurring’ improves.

– When non-linearity is added in the first equation of the Lorentz system, the picture ‘improves’ slightly.

– In the fields $GF\ (2^8)$, $GF\ (2^{16})$, the modified Chua system has a uniform blurred image.

Test 2. Using the package of NIST statistical tests to assess the quality of pseudo-random sequence generators. In this test, a sequence of units of length 1,000,000 is encrypted 125 times. Each parameter moves in increments of $2^p/5$, and all possible combinations are considered. Thus, we obtained 125 sequences. A battery of NIST tests in applied to them.

The NIST tests show that encryption by the Chua system in the ring $Z\ (2^8)$ produces an unsatisfactory result. With the increasing ring output the result improves while the test time reduces. When adding a predicate to the system a slight improvement of the result is observed. Performing all operations in the fields $GF\ (2^p)$ significantly improves the results.

Conclusions

The researches carried out and their evaluation allow us suggest that we obtained new results that extend the theoretical basis of the modern cryptology and seem to be efficient for developing efficient cryptographic algorithms. At the same time, there is a number of open issues related to the impact of dynamic parameters on the stability of cryptographic algorithms to attacks, resistance to information distortion, and appearance of invariant varieties.

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Entropy analysis for interacting macrosystems

Entropy is able to unambiguously reflect the probability of the macrostate of the system only in such cases, when the basic postulate of statistical mechanics is valid - postulate of equal a priori probability of the microstates. It is shown, that for the majority of non-physical macrosystems it is invalid, and the role of the entropy should be played by more general characteristic, which was obtained in this work and named as entropy divergence. In accordance with the principle of continuity it contains Boltzmann entropy as a component.

The variation principle of entropy maximum allows us to find the most probable system configuration, and this is precisely its *macrostate,* which can be reconstituted by the maximum number of distinct *microstates*. Having appeared in the depths of statistical physics, this principle soon became applicable in other fields of economic, humanitarian, and natural sciences.

However, not everybody considers such borrowing valid. Many physicists are very distrustful to the idea of using the entropy maximum principle for such objects kind analysis. Although to ignore the examples of successful application of this principle for the analysis of non-physical systems is quite difficult. "Non-physicists" treat it as an especially popular since Janes formalism appearance [1], which allows calculating a conditional entropy maximum as an integral criterion of the most probable configuration of the macrosystem.

The objections of physicists, who have been growing on Boltzmann and Gibbs ideas, are sufficiently substantiated. Statistical mechanics considers in general a priori uniform probability systems, where each single element has the same initial probability of all phase space cells settlement that in turn determines the equal probability of all possible microstates of the system realization. In addition, such a limitation as a condition of a priori equal probability of microstates is *the main postulate of statistical physics* [2-5].

An asymmetry phenomenon of a priori conditions and hence of the inequality of a priori microstates probabilities are just not considered by many authors as usual. When studying the complex objects (for example, in economics, in case of deriving the law of social incomes distribution [6, 7] there is used, mainly traditional entropy schemes, without changes, borrowed from statistical mechanics. Equally, such comment can be attributed to other existing entropy systems modeling attempts: transport [8], ecological [9], social [10].

The aim to use the entropy principle reasonably for macrosystems of different nature requires a generalization of traditional statistical entropy form. Such "corrected" function should take into account not only a uniform (as Boltzmann entropy), but also an arbitrary distribution character of a priori probabilities, stemming from the mutual influence of macrosystems.

Following the purpose stated, let us abandon the basic postulate of the statistical physics and assume that for the cells of the individual state space there are typical not equal, but random settlement probabilities. Let $P:\{p_1, p_2, ...p_M\}$ (under $\sum_{i=1}^{M} p_i = 1$) is a variety of a priori probabilities of settlement among M cells of one of N elements (first in line).

Let us consider the space of individual states, having two $(M = 2)$ cells with a priori probabilities of their settlement $P:\{p_1, p_2\}$. Let these cells be committed to be settled randomly by three $(N = 3)$ identical agents. Cartesian product $P \times P \times P$ allows to define all eight $(M^N = 2^3)$ possible probable combinations probability values, i.e. eight values *of microstates probability.*

In this example, many statistical weights $W:\{1;3;3;1\}$ are equal to the variety of binomial (because $M = 2$) third degree coefficients (because $N = 3$).

Analogously, we can also consider the general case when N elements are distributed among M cells. Let one of possible macrostates of such system be implemented with distribution in cells, respectively $n_1, n_2, ...n_M$ (provided $\sum_{i=1}^{M} n_i = N$). The number of combinations of such distribution option implementation, i.e. the statistical weight of relevant macrostate, is equal to the value of the polynomial (more precisely, "M-nomial") index of N-th degree, which can be calculated using D. Bernoulli formula:

$$W(n_1, n_2, ...n_M) = \frac{N!}{n_1! n_2! ... n_M!}. \tag{1}$$

This macrostate probability is equal respectively to:

$$Q(n_1, n_2, ...n_M; p_1, p_2, ...p_M) = \frac{N!}{n_1! n_2! ... n_M!} \cdot p_1^{n_1} p_2^{n_2} ... p_M^{n_M}, \tag{2}$$

where $P:\{p_1, p_2, ...p_M\}$ is a variety of a priori probabilities.

In the particular case, when a priori probabilities are equal, that is $p_i = \text{const} = \frac{1}{M}$, the expression (2) takes the form:

$$Q(n_1, n_2, ...n_M) = \frac{N!}{n_1! n_2! ... n_M!} \cdot \frac{1}{M^N}. \tag{3}$$

Although Boltzmann entropy is considered a probability function of the system macrostate, it is written through the statistical weight W, which is often named as *thermodynamic probability*. However, W is not normalized in the classic sense and is not a probability. Normalized value is *the probability of the macrostate* Q. To be sure, it is enough to sum (2) and (3) expressions by the total number of macrostates:

$$\sum_{n_1,n_2,...n_M} Q(n_1,n_2,...n_M;p_1,p_2,...p_M) = \sum_{n_1,n_2,...n_M} \frac{N!}{n_1!n_2!...n_M!} \cdot p_1^{n_1} p_2^{n_2} ... p_M^{n_M} = (p_1 + p_2 + ... + p_M)^N = 1$$

(4)

$$\sum_{n_1,n_2,...n_M} Q(n_1,n_2,...n_M) = \sum_{n_1,n_2,...n_M} \frac{N!}{n_1!n_2!...n_M!} \cdot \frac{1}{Ì^{N}} = \left(\underbrace{\frac{1}{M} + \frac{1}{M} + ... + \frac{1}{M}}_{M} \right)^N = 1 . \quad (5)$$

Renunciation of the postulate of equal a priori probability leads to that instead of the expression (3) for macrostate Q probability, it is needed to write "complicated" by a priori probabilities $p_1, p_2, ...p_M$ expression (2). In this case, the statistical weight $W = \frac{N!}{n_1!n_2!...n_M!}$ already "has no right" to determine independently the probability of the macrostate, as it was earlier, when $p_1, p_2, ...p_M$ were equal. Therefore, it is not enough even classical Boltzmann entropy $S = \ln W$, to characterize independently the probability of such a system macrostate, where the postulate of equal a priori probability "does not work" already.

As the required function instead of the entropy $\ln W$, we use a positive value $-\ln Q$, because it does directly contain the probability of the macrostate (expression (2)). Given that $0 \le Q \le 1$, as well, because of the monotony of the logarithm, probability Q corresponds to the minimum of the function:

$$-\ln Q(n_1,n_2,...n_M;p_1,p_2,...p_M) = -\ln\left(\frac{N!}{n_1!n_2!...n_M!} \cdot p_1^{n_1} p_2^{n_2} ... p_M^{n_M} \right). \quad (6)$$

Moreover, given (3), we can see its relation to Boltzmann entropy $S = \ln W$:

$$-\ln Q(n_1,n_2,...n_M;p_1,p_2,...p_M) = -\sum_{i=1}^{M} n_i \ln p_i - S . \quad (7)$$

Including the designation

$D_d(n_1,n_2,...n_M;p_1,p_2,...p_M) = \frac{-\ln Q(n_1,n_2,...n_M;p_1,p_2,...p_M)}{N}$, and writing it in a short form, taking into account (7), we have:

$$D_d = \frac{-\ln Q}{N} = -\sum_{i=1}^{M} \frac{n_i}{N} \ln p_i - \frac{S}{N} . \quad (8)$$

The designation D_d is of the word "divergence" (because the expression (8) may be deduced to the form, matching *Kullback-Leibler divergence* [11]). Subscript d is of the word "different", indicating *different* values of a priori probability. D_d value may be conveniently named ***an entropy divergence,*** having in mind its continuity with the entropy.

Let us show that the expression (8) can really be presented in the form of Kullback divergence. To this end, for (9) we apply the formula of Stirling $\ln m! \approx m \cdot (\ln m - 1)$.

Then: $D_d = -\sum_{i=1}^{M} \frac{n_i}{N} \ln p_i - \ln N + \sum_{i=1}^{M} \frac{n_i}{N} \ln n_i$. Bracing the positive value, we have:

$$D_d = \sum_{i=1}^{M} \frac{n_i}{N} \ln \frac{n_i / N}{p_i} . \tag{9}$$

This expression constitutes ***the entropy divergence*** as the statistical distance between two distributions - current and its maximum achievable - equilibrium distribution.

Findings obtained may provide another research direction development - *Theory of adaptive statistical interaction of complex systems*. The adaptation should be considered as a characteristic of the system in connection with formation of its distribution with a minimum value of the entropy divergence D_d. This process takes into account a priori probabilities, arising because of the effecting of other distributions on the system. Below are shown just a brief essays related to this topic.

A variety of a priori probabilities influencing the distribution within the system, can be considered as perceived by it input signal, and the generated distribution, as its output signal.

Interaction can process, for example, as it is shown in the figure (Fig. 2). Distribution $\mathcal{N}_A : \left(\frac{n_{A1}}{N_A}, \frac{n_{A2}}{N_A}, ..., \frac{n_{AM}}{N_A} \right)$, which can be considered as the output signal of "A system", by entering the "C system", thus generates its variety of a priori probabilities $P_C : (p_{C1}, p_{C2}, ..., p_{CM}) = F(\mathcal{N}_A)$. Here, the indexes of p_{Ci}, n_{Ai} and N_A are indicating the affiliation to the respective systems. The "C system" in turn generates the distribution $\mathcal{N}_C : \left(\frac{n_{C1}}{N_C}, \frac{n_{C2}}{N_C}, ..., \frac{n_{CM}}{N_C} \right)$, which is the input signal for "D system", and so on. It is logical to assume, that the sets of real macrosystems are arranged into long chains and even entire networks, including feedbacks (Fig. 1). As a feedback, there may be an "auto-influence" of its own distribution of the system, but generated in the previous step of the development. It can be interpreted as a system memory, or its gained experience.

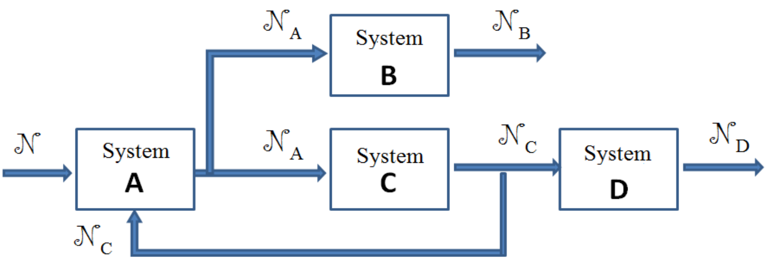

Fig. 1. Statistical interaction of the macrosystems.

Thus, the introduction of a priori probability provides us to track the adaptive interaction of two or more macrosystems, considering them as a single large metasystem. In this case, the properties of the metasystem can be analyzed in the same way, as it is made in the automatic control theory. There are analyzed the characteristics of tracking systems, consisting of interacting dynamic parts. Obviously, by analogy one can expect the appearance of oscillatory effects and resonance phenomena and stability loss phenomena.

On the other hand, a certain combination of interacting macrosystems' properties is expected to lead to an unexpected effect of entropy reduction. Indeed, the distribution entropy of "A system" may be reduced if it would be circled individually or in conjunction with "C system" (Fig. 1) a positive feedback (with indicators of the degree $\eta_{A} > 0$, $\eta_{C} > 0$) and found the combined distribution.

Feedback allows us to consider the effect of its own distribution of the system in the previous step of its formation. Previously it was said, that it can be considered as a system memory record or its acquired experience (learning) record.

Then we may notice, that in the emerging macrosystem, circled positive feedback, in one of the cells (modal) there can be promoted a process of accelerated growth of the probability up to a value of 1. Nevertheless, such a self-organization should mean the emergence of *a stable structure.*

There is some irony in that. After all, if in the stage of early representations the entropy extremum condition has led to the conclusion on the heat death of the Universe, the more general requirement of entropy divergence extremum within the interacting systems gives the ability to see the mechanism of the spontaneous order.

Conclusions

Formal borrowing of the entropy approaches from the thermodynamics and statistical physics to analyze non-physical macrosystems (economic, social) is not always valid and may cause errors. It is important to remember that in the physical sciences, such an assumption is valid, as a condition of a priori equal probability of the microstates, and it has the status of the *basic postulate of statistical physics.*

However, this ideal characteristic, which is due to the phase cells settlement conditions symmetry, is not always the case in the above-mentioned non-physical macrosystems due to their fundamental inability to be isolated. Typically, each of them with certain necessity is included into the scheme of a causal interaction with many other macrosystems, mutually distorting the conditions of their formation. For example, an economic system cannot exist outside social or political system, and demographic system cannot be isolated from economic or environmental system.

When the postulate of equal a priori probabilities becomes invalid, Boltzmann entropy $S = \ln W$ (and other derivatives of its form) cannot longer play the role of a function, characterizing the probability of the macrostate of the system. Such a task can be handled by only more general characteristic, which is called here the entropy divergence D_d. In accordance with the principle of continuity it contains the entropy as a component. In relation to the properties of the entropy divergence a number of theorems are proved.

It is shown that the criterion of the equilibrium state of the system in the general case is a conditional minimum of the entropy divergence $\left(D_d\right)_{min}$. In addition, such a widely used criteria as the conditional maximum of the entropy S_{max}, corresponds to it in the particular case of equal a priori probabilities.

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Stabilization and pointing system for wheel-track vehicle based on AHRS

This paper shows a possibility of creation stabilization and pointing system for wheel-track vehicle based on AHRS. It is illustrated by the biaxial system of indirect stabilization.

Development and creation of stabilization and pointing systems for equipment, placed on vehicles is an actual task of industry. Among the large number of such equipment is actively used and developed radars, optoelectronic modules, navigation systems, unmanned aerial vehicles (UAV) and others. One of the main steps in design and creation of stabilization and pointing systems is calculating and choosing gyroscopic device, which provides the information about the object position, linear and angular displacement, velocity and acceleration.

Thanks to intensive development of microelectronics and microprocessor technology, to date there is a wide choice of gyroscopic devices, which are used for creation of the stabilization and pointing systems. One of the most promising areas is the use of measuring devices, based on technologies of microelectromechanical systems. In particular, use of devices such AHRS (Attitude and Heading Reference Systems), which includes three accelerometers, three magnetometers and three gyroscopic sensor that provides full information of the object [1, 2].

AHRS designed for determination of the object rotation at any given time relative to his some start position. Fig. 1 shows the functional diagram biaxial indirect stabilization system based on AHRS. Accelerometer forms vector acceleration of gravity V_A, and magnetometers forms vector magnetic induction V_M. Knowing these two vectors it is easy to determine the position of the object in space.

However, when object is moving in its coordinate system along a complex trajectory, it exposed to some external disturbances: the force of gravity, centrifugal force and the Coriolis force. These disturbances are measured with a certain limited accuracy and speed, and the additional magnetic field can be distorted by several factors, such as radiation of electrical equipment, iron structures and more.

Therefore, as a result of the measurement will be formed: the object acceleration vector V_A that is correlated with vector of gravity of Earth at rest; magnetic induction vector V_M that is correlated with the magnetic induction vector of Earth and the angular velocity vector V_G.

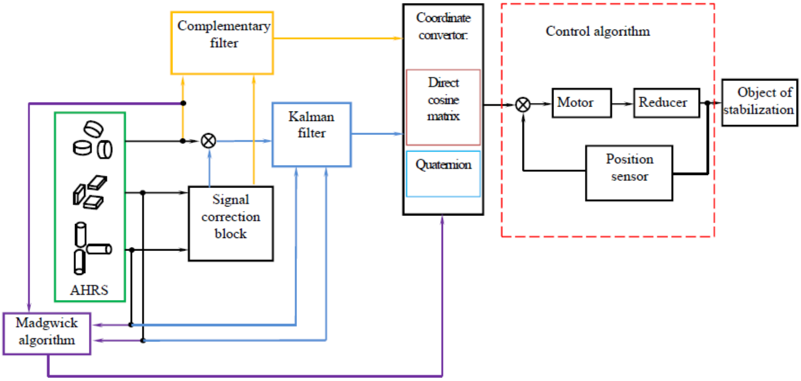

Fig. 1 Biaxial indirect stabilization system based on AHRS

The main objective of AHRS is a correction of the measured errors of object angular velocity, using data from the accelerometer and magnetometer. There are many algorithms nowadays destined to solve these problems. The most common used are the algorithms based on Kalman filter (KF) [1] and its modifications (adaptive KF, extended KF) [2, 3]. Other algorithms use a complementary filter and Madgwick algorithm [4, 5].

There is a class of objects, which for some reason (such as mass-dimensional characteristics) implementation of stabilization and pointing systems is possible as biaxial system with indirect method of stabilization. The indirect method of stabilization for any equipment (optical-electronic module, radar, gun tube) on a wheel-track vehicle is to hold some equipment axis in a given direction (relative to the Earth or to the chosen benchmark). This is done by entering the roll and pitches angles into the stabilization system and object rotating around relative axes. The essence of indirect method of stabilization is to convert angular coordinates, that characterize a given position of the equipment axis, for example, in earth coordinate system, to the appropriate angular coordinates (stabilization parameters), referred to the related coordinate system. After that the actuating units move the equipment through an angle, proportional to these parameters.

Solving the task of converting the angular coordinates is as follows: roll and pitch angles of a moving object, derived from AHRS, sending to the coordinate converter. Also there sending the angular coordinates of direction for a landmark, for example, in earth coordinate system. The coordinate converter transfers them to the angular coordinates in related coordinate system and the actuating unit works off these coordinates. Due to this movement the equipment axis will maintain its direction at a given reference point regardless of roll and pitch angles of a moving object.

Denote as $O\xi\eta\zeta$ – fixed coordinate system that is parallel to the axes of the earth, and $OXYZ$– the coordinate system rigidly connected with the object (Fig. 2).

The problem of coordinate conversion is to mapping base of fixed coordinate system to the mobile base system [5]. In general, the transition can be represented as:

$$[X, Y, Z] = A[\xi, \eta, \zeta],$$

(1)

where A is the transition matrix:

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \quad (2)$$

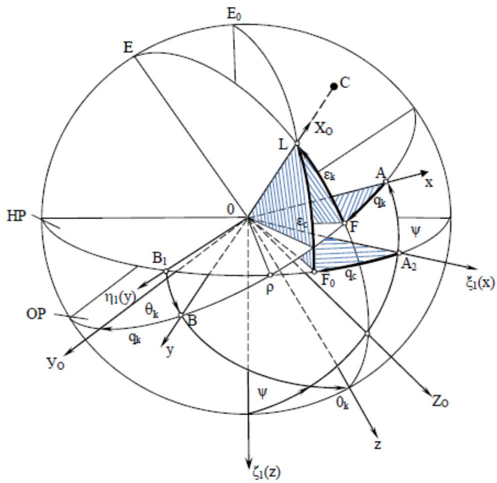

Fig. 2 Object and Earth coordinate systems

Matrix A can be found through the matrix of direction cosines by three consecutive rotations of the original system on the angles yaw A_Y , pitch A_P and roll A_R :

$$A = A_R A_P A_Y \quad (3)$$

Another method of coordinate conversion based on the end turns of rigid body and quaternion conception. Denote the vector directed to the landmark in space (Fig. 2). The projection of this vector on the bases G and B are quaternions R_G and R_B accordingly:

$$R_G = R_{G\xi} i + R_{G\eta} k + R_{G\zeta} j$$
$$R_B = R_{B\xi} i + R_{B\eta} k + R_{B\zeta} j$$

(4)

Then the transition from fixed coordinate system to system, coupled with the object can be written as:

$$R_B = \tilde{\Lambda} \circ R_G \circ \Lambda \,, \qquad (5)$$

where $\Lambda = q_0 + q_1 i + q_2 k + q_3 j$ rotation quaternion and $\tilde{\Lambda} = q_0 - q_1 i - q_2 k - q_3 j$ quaternion, conjugate to Λ, and expressions q_0, q_1, q_2, q_3 are Rodrigues-Hamilton`s parameters.

The result:

$$\begin{aligned}
R_{B\xi} &= \left(1 - 2\left(q_2^2 + q_3^2\right)\right) R_{G\xi} + 2\left(q_0 q_3 + q_1 q_2\right) R_{G\eta} + 2\left(q_1 q_3 - q_0 q_2\right) R_{G\zeta} \\
R_{B\eta} &= 2\left(q_1 q_2 - q_0 q_3\right) R_{G\xi} + \left(1 - 2\left(q_1^2 + q_3^2\right)\right) R_{G\eta} + 2\left(q_0 q_1 + q_2 q_3\right) R_{G\zeta} \\
R_{B\zeta} &= 2\left(q_0 q_2 + q_1 q_3\right) R_{G\xi} + 2\left(q_2 q_3 - q_0 q_1\right) R_{G\eta} + \left(1 - 2\left(q_1^2 + q_2^2\right)\right) R_{G\zeta}
\end{aligned} \qquad (6)$$

If expression (6) written as:

$$[\xi, \eta, \zeta]_B = A[\xi, \eta, \zeta]_G \,, \qquad (7)$$

it will match the expression (1), and the direction cosines matrix A is expressed by Rodrigues-Hamilton`s parameters.

Define the parameters for biaxial indirect stabilization system (Fig. 2). The transition from base G to base B is through two consecutive turns to roll θ_k and pitch ψ angles, which correspond to $\Theta = \cos\frac{\theta_k}{2} + j\sin\frac{\theta_k}{2}$ and $\Psi = \cos\frac{\psi}{2} + k\sin\frac{\psi}{2}$ quaternions, resulting quaternion is $K = \Psi \circ \Theta$. Obtain expressions for the parameters Rodrigues-Hamilton's quaternion K:

$$\begin{aligned}
q_0 &= \cos\frac{\psi}{2}\cos\frac{\theta_k}{2}, \quad q_1 = -\sin\frac{\psi}{2}\sin\frac{\theta_k}{2}, \\
q_2 &= \cos\frac{\psi}{2}\sin\frac{\theta_k}{2}, \quad q_3 = \sin\frac{\psi}{2}\cos\frac{\theta_k}{2}
\end{aligned} \qquad (8)$$

The projection of vector R on the bases G and B accordingly to expression (4) and fig. 2:

$$\begin{aligned}
R_{G\xi} &= -\sin\varepsilon_c, \quad R_{G\eta} = \cos q_c \cos\varepsilon_c, \quad R_{G\zeta} = \sin q_c \cos\varepsilon_c \\
R_{B\xi} &= -\sin\varepsilon_k, \quad R_{B\eta} = \cos q_k \cos\varepsilon_k, \quad R_{B\zeta} = \sin q_k \cos\varepsilon_k
\end{aligned} \qquad (9)$$

According to (5) coordinate conversion will look like $R_B = \tilde{K} \circ R_G \circ K$, as a result we get the expression (6). Substituting in (6) mentioned projection vector R (9), we have:

$$\sin\varepsilon_k = \left(1-2\left(q_2^2+q_3^2\right)\right)\sin\varepsilon_c - 2\left(q_0q_3+q_1q_2\right)\cos q_c\cos\varepsilon_c + \\ + 2\left(q_1q_3-q_0q_2\right)\sin q_c\cos\varepsilon_c \quad (10)$$

$$tgq_k = -2\left(q_0q_2+q_1q_3\right)\sin\varepsilon_c + 2\left(q_2q_3-q_0q_1\right)\cos q_c\cos\varepsilon_c + \left(1-2\left(q_1^2+q_2^2\right)\right)\sin q_c\cos\varepsilon_c / \\ / 2\left(q_1q_2-q_0q_3\right)\sin\varepsilon_c + \left(1-2\left(q_1^2+q_3^2\right)\right)\cos q_c\cos\varepsilon_c + 2\left(q_0q_1+q_2q_3\right)\sin q_c\cos\varepsilon_c \quad (11)$$

Expressions (10), (11) are the system stabilization angles. Thus obtained coordinate transformation algorithm based on the theory of finite rigid body rotations and use quaternions with Rodrigues-Hamilton`s parameters.

The main advantage of using quaternions in coordinate conversion is that the Rodrigues-Hamilton`s parameters does not degenerate under any provisions of rigid body and solving the problem of conversion is reduced to solving a system of four linear equations.

Conclusions

Introduced the approach for creation systems to stabilize and restore wheel-track vehicle based on the use of the measuring module AHRS. Obtained the algorithm for determining the angles of stabilization and show the benefits of using quaternions for coordinate converter for biaxial system of indirect stabilization.

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Damper for vibratory gyroscope that is used in rigid conditions with mechanical impact

This paper analyzes the relationship between damper transmission factor dependence on acceleration and its geometrical parameters. The results of computer simulations are presented. They allow us to determine the characteristics of the damper, required for suppression of external acceleration, acting on the gyroscope.

Vibratory gyroscope is mounted on the platform using a damper of the certain damping factor.
The equation of motion for such a system is the following [1]:

$$M(\ddot{x}_d + \ddot{x}_v) = -k_d x_d - c_d \dot{x}_d; \ \rightarrow M\ddot{x}_d + c_d \dot{x}_d + k_d x_d = -M\ddot{x}_v \qquad (1)$$

where $M = m_d + m_p$, $M\ddot{x}_v = F$ is the force of shock, acting on the gyroscope via damper. Thus the equation of acceleration of current impact is:

$$\ddot{x}_d + \frac{c_d}{M}\dot{x}_d + \frac{k_d}{M}x_d = -\frac{F}{M} = -A(t) \qquad (2)$$

$c_d -$ damping factor, $k_d -$ damper rigidity.
The force of shock is acting on the gyroscope in the form of half-sinusoid impulse with the amplitude A_0 and width T. Analytical expression for the force of shock:

$$A = \begin{cases} A_0 sin\frac{\pi}{T}t & для\ t \le T \\ 0 & для\ \ t > T \end{cases} \qquad (3)$$

The curve of spectrum for the shock impulse function $A(t)$, while $T=2$ msec and $A_0=100g$, is described by the following expression[2]:

$$A(f) = A_0 \frac{\sin(\pi(f-f_s)T)}{2\pi(f-f_s)}; \ \ f_s = \frac{1}{2T}. \qquad (4)$$

The solution of equation (2) gives the following dependence of oscillation amplitude on device frequency [3, 4]:

$$x_d(f) = \frac{MA(f)}{k_d\sqrt{\left(1-\left(\frac{f}{f_0}\right)^2\right)^2 + \left(2\zeta\frac{f}{f_0}\right)^2}} = \frac{MA_0\frac{\sin(\pi(f-f_S)T)}{2\pi(f-f_S)}}{k_d\sqrt{\left(1-\left(\frac{f}{f_0}\right)^2\right)^2 + \left(2\zeta\frac{f}{f_0}\right)^2}} \qquad (5)$$

$f_0 = \frac{1}{2\pi}\sqrt{\frac{k_d}{M}}$ – natural frequency of the damper, $\zeta = \frac{c_d}{2\sqrt{k_d M}} = \frac{1}{2Q}$ – the damping rate, Q – quality factor of the damper.

The solution of equation (5) in time domain is the following:

$$x_d(t) = A_1 e^{\lambda_1 t} + A_2 e^{\lambda_2 t} + B_1 sin\frac{\pi}{T}t + B_2 cos\frac{\pi}{T}t \quad для\ 0 < t \le T \qquad (6)$$

where

$$A_1 = \frac{B_2\lambda_2 - \frac{\pi}{T}B_1}{\lambda_1 - \lambda_2}; \quad A_2 = \frac{\frac{\pi}{T}B_1 - B_2\lambda_1}{\lambda_1 - \lambda_2};$$

$$\lambda_1 = \frac{-c_d - \sqrt{c_d^2 - 4Mk_d}}{2M}; \ \lambda_2 = \frac{-c_d + \sqrt{c_d^2 - 4Mk_d}}{2M};$$

$$B_1 = \frac{M\left(\frac{\pi}{T}\right)^2 - k_d}{c_d^2\left(\frac{\pi}{T}\right)^2 - \left[k_d - M\left(\frac{\pi}{T}\right)^2\right]^2}A_0; \ \ B_2 = \frac{c_d\left(\frac{\pi}{T}\right)}{c_d^2\left(\frac{\pi}{T}\right)^2 - \left[k_d - M\left(\frac{\pi}{T}\right)^2\right]^2}A_0;$$

$$\ddot{x}_d = A_1\lambda_1^2 e^{\lambda_1 t} + A_2\lambda_2^2 e^{\lambda_2 t} - B_1\left(\frac{\pi}{T}\right)^2 sin\frac{\pi}{T}t - B_2\left(\frac{\pi}{T}\right)^2 cos\frac{\pi}{T}t \qquad (7)$$

Damper transmission factor dependence on acceleration:

$$TR_a = \frac{\max(\ddot{x}_d)}{A_0}; \qquad (8)$$

Calculations are performed for the cylindrical shape rubber damper with an outer diameter b, altitude h, and hole of the diameter a along its axis.
Axial k_{ax} and transverse k_s rigidities of the damper are defined by the following expressions [4]:

$$k_{ax} = \frac{E_d A_{cr}}{h}; \ k_s = \frac{A_{cr}G}{h} = \frac{G\pi}{4h}(b^2 - a^2);$$
$$E_d = (4 + 7.5R^{1.79})G; \quad R = \frac{A_{cr}}{A_s} = \frac{b-a}{4h}; A_{cr} = \frac{\pi}{4}(b^2 - a^2), \quad (9)$$

where G – the shear modulus, A_{cr} – the cross-sectional area of the damper, A_s – the lateral surface area of the damper.
Axial and transverse damping factors:

$$c_{ax} = \eta\sqrt{k_{ax}M}; \ \ c_s = \eta\sqrt{k_s M}; \qquad (10)$$

where η – loss factor.

Thus, for axial shock k_d=k_{ax} and c_d=c_{ax}, and for the transverse (lateral) shock k_d=k_s and c_d=c_s.

The acceleration of device movement is acting during axial shock with the amplitude A_0=100g and width 2 msec, along the axis of cylindrical shape damper. The damper is made of silicon rubber with the following parameters: b=20 mm, a=3 mm, h=40 mm, η=0.5, G=2×10^6 Pa, M=(0.4+0.6)=1 kg (0.4 – weight of device, 0.6 – weight of platform), and presented in the figure 1.

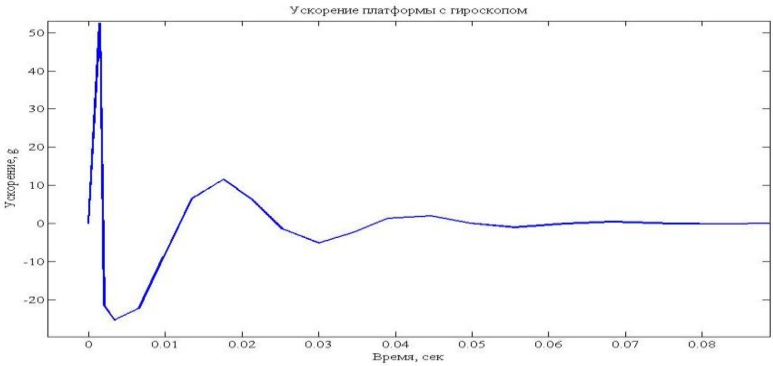

Fig.1. Typical dependence between the acceleration of damping platform with gyro and diameter of damper upon axial shock

The design of the damper during mounting on an object is presented in figure 2.

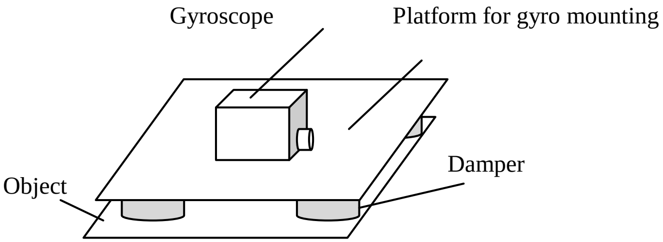

Fig. 2. Gyroscope mounting on the object

Gyroscope is mounted on the object with the help of viscous elastic elements (dampers). Stiffness and damping factor of viscous elastic elements are summing, when they are connected in parallel [5]. Thus, the design presented in the figure 2 will have the following dependences:

$$K_{ax}=4k_{ax};\ C_{ax}=4c_{ax}\ ;\quad K_s=4k_s;\ C_s=4c_s; \tag{11}$$

- Tables 1 and 2 show the calculation of transmission the damper acceleration for silicon rubber coefficients with parameters η=0.5, G=2×10^6 Pa, M=(0.4+0.6)=1kg, for axial and transverse shock with duration 2 msec depending on the size of damper.

Table 1.

Height, h MM / Diameter d, mm	10	20	30	40	50
	TR_{ax} coefficient of transmission the axial shock acceleration				
10	0.67	0.42	0.34	0.43	0.49
20	0.83	0.75	0.68	0.66	0.59
30	0.50	0.83	0.80	0.75	0.70
40	0.24	0.68	0.82	0.83	0.81
50	0.16	0.45	0.70	0.81	0.84

Table 2.

Height, h MM / Diameter d, mm	10	20	30	40	50
	TR_{as} coefficient of transmission the transverse shock acceleration				
10	0.46	0.58	0.61	0.63	0.66
20	0.64	0.42	0.35	0.41	0.66
30	0.73	0.67	0.54	0.44	0.71
40	0.82	0.71	0.68	0.65	0.74
50	0.83	0.73	0.72	0.68	0.73

It follows from the results shown in the tables that the minimal coefficient of acceleration transmission for axial shock is equal to 0.16 (damper size h=10 mm, D=50mm), and for the transverse shock minimal coefficient of acceleration transmission is equal 0.35 (damper size h=30 mm, D=20 mm).

Conclusion

The results show that for protection against transverse shock the damper must be used with size h=30 mm, D=20 mm, because the influence of external acceleration is 2.86 times suppressed, and for protection against axial shock the damper must be used with size h=10 mm, D=50 mm because the influence of external acceleration is 6.25 times suppressed.

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Polarimetric method for forming aircraft landing glideslope

The papers deals with existing methods for forming glideslope and have proposed method for forming glideslope by using polarized light. This method potentially can increase the accuracy and sensitivity of measurement aircraft deviation from glideslope. The scheme of forming aircraft landing glide, which realizes the offered method is offered.

Landing approach and landing of aircraft are one of the most critical phases of flight. Safety and effectiveness of airplane`s landing approach and landing depends on several factors: accuracy of holding the glideslope line, the aircraft`s attitude, weather conditions and others. Ones of the most important parameters are to accuracy of holding the glideslope line and to determine the aircraft`s attitude relative to the horizon. Accurate and continuous measuring deviation of aircraft from glideslope and determination aircraft`s attitude relative to the plane of boarding allows landing in remote locations for planting, to land on a complex algorithm and avoids collision of the aircraft with the ground of separate structures: the wing during landing with roll, nose or tail during landing with pitch.

Aircraft landing glideslope represents a crossing line of two planes: the vertical plane of a landing course which passing through runway axis and the glideslope plane, which inclined to horizon. There are following landing system, depending on the method for forming of course and glideslope planes: simplified landing system, radar landing system, instrument landing system, visual landing system, laser instrument landing systems of direct vision, laser instrument landing systems on the dispersion effect, combined landing system.

In simplified landing system landing course is set by position of land locator beacons and landing glideslope is set by height of fly over characteristic point, which marking by marker beacon. Work of simplified landing system consists in marking the fly moment of aircraft over marker points. In this case pilot should control the altitude of fly.

Radar landing system are designed for precise determine location of aircraft by used ground radar. Ground crew report defined aircraft position to onboard crew for eliminates possible deviations from the glide path. In this system landing course and landing glideslope is set by attitude of ground landing radar electromagnetic field in course and glideslope channels. Mean-square error determination of coordinate by measuring of distance is not more than 20 meters, and azimuth - not more than 0,03 °.

In instrument landing system conditional planes of the landing course and glideslope are set by means of electromagnetic fields of course and glideslope radio beacons which signal are accepted by the onboard equipment.Error of course deviation is ± 10.5 m., and error of glideslope deviation is ± 1.5m.

Visual landing system provide the representation of landing course and glideslope by means of visual reference points.

Laser instrument landing systems on the dispersion effect is designed to generation the estimated trajectory approach by use linear guidance in the form of light rays, which are rigidly connected to the runway. Piloting of an aircraft with use of this system is come to keeping the visual picture of beams in the form of "correct" letter «T». Accuracy of holding course and glide path is evaluated visually by pilots and accuracy of set the course and glide path makes ± 0,5 m.

Laser instrument landing systems of direct vision is designed for three-colored laser radiation. Deviations from the glide path and the course are controlled by pilots by relative position course and glide path laser radiators, which placed on the right and left of the runway. Piloting of an aircraft with use of this system is come to keeping the aircraft in zone, when only green lights are visible. Accuracy of holding course and glide path is evaluated visually by pilots and accuracy of set the course and glide path makes ± 1,5 m.

Combined landing system represents a combination of few landing systems.

Thus, radio-landing system used for landing aircraft in automatic mode. Accuracy of measuring deviation from course is ±10 m and deviation from glide path is ±1,5 m. Laser visual landing systems are not used for landing in automatic mode, because they require the presence of a pilot on aircraft board. Accuracy of measuring deviation from course and glide path is ±0,5 – 1,5 m. Those why existing devices provide continuous and insufficiently accurate measurements deviation of aircraft from landing trajectory. Therefore, in [4] was proposed to develop a polarimetric measurement method for measuring deviation of aircraft from glideslope during landing. This method potentially allows increase the accuracy and sensitivity of measurement.

Optical measurement methods are widely used in various fields of science and technology. Measuring polarization of light - one of the most sensitive methods of optical measurements. It allows to measure the azimuth plane polarization with accuracy 0,0005° [3]. Polarization measurement methods have very high sensitivity. Polarization measurement is a measurement to determine the parameters that characterize the polarization properties of radiation: the degree of polarization, azimuth, ellipticity and others. Currently, have begun to develop polarimetric method for determine the direction of polarized beam. This developing allow to determine the rotation angle of a moving object relative to a fixed point of reference. One method is determine the angle of incidence of polarized radiation. In addition, the polarized radiation can be emitted from a moving object or irradiate the moving object. In this case, in perceiving part of the measurement system used planar isotropic dielectric plate.

Researches resulted in [1] and [2] demonstrate that at falling of linearly polarized light on isotropic dielectric planar plate with weakly absorbing material the reflected and refracted beams will also be linearly polarized and rotations of the polarization plane are depend from the angle of incidence. This conclusion based on Fresnel formulas. The values azimuth plane of polarization to the reflected and refracted beam that has passed through the two faces of the plate, can be determined by the following equations:

$$\varphi_r = \operatorname{arctg}\left(-\frac{\cos(i-r)}{\cos(i+r)}\operatorname{tg}\varphi_e\right),$$
$$\varphi_d = \operatorname{arctg}\left(\left(\cos(i-r)\right)^2 \operatorname{tg}\varphi_e\right). \qquad (1)$$

That why, while passing polarized radiation through the dielectric isotropic plate is happens rotation of the polarization plane. The value of the polarization plane rotation angle depends on the angle of incidence and polarization plane azimuth of the incident beam. Polarimetric method for measuring deviation aircraft from landing trajectory is work as follows. Through measuring the azimuth of polarization plane for refraction beam is determine the incidence angle of beam. The use of modulator in block of radiation allows simultaneous measurement of incidence angle and azimuth of polarization plane for incident beam. The incidence angle depends on angle of deviation at course and angle of deviation at glideslope. Scheme decomposition incidence angle in angle of deviation at course and angle of deviation at glideslope shown in Fig. 1. The dependence incidence angle from angle of deviation at course and angle of deviation at glideslope has the following form: $i = \operatorname{arctg}\sqrt{\operatorname{tg}^2\theta + \operatorname{tg}^2\varphi}$, where i is the incidence angle; θ is the angle of deviation at glideslope; φ angle of deviation at course.

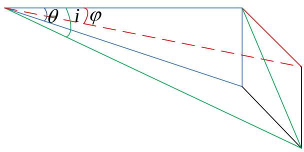

Fig. 1. Scheme decomposition incidence angle in pitch and yaw angles

To measure the incidence angle of the beam in the horizontal and vertical planes is necessary to use two measurement channels. These incidence angles are correspond deviation aircraft from the plane of course and plane of glideslope respectively. Block diagram of the optical measurement channel shown in Fig. 2.

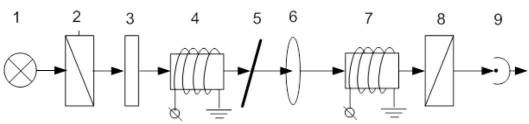

Fig. 2. Block diagram of the optical channel

1 – radiation source; 2 – polarizer; 3 – optical filter; 4 – modulator; 5 – dielectric plate; 6 – focusing lens; 7 – Faraday cells; 8 – analyzer; 9 – photodetector.

The proposed method for measuring deviation of airplane from landing trajectory requires forming glideslope line by using polarized light. Scheme of forming landing glide path by using polarized radiation shown in Fig. 3.

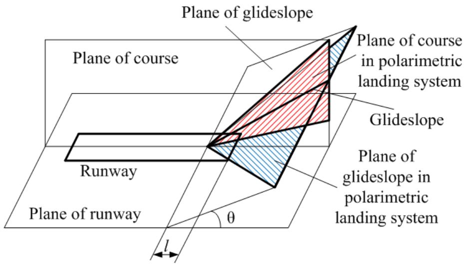

Fig. 3. Scheme of forming landing glide path by using polarized radiation

Forming glideslope line by using polarized light occurs as follows. Plane of the course is formed by scattering of polarized radiation in the vertical plane. However the scattering angle of radiation in the horizontal plane should be minimal. Plane of the glideslope is formed by turning plane of the course (scattering polarized radiation in the vertical plane) in the horizontal plane with simultaneous turning of radiation polarization plane. Thus, plane of the course will be characterized by "zero" azimuth plane of polarization and the plane of glide path will be characterized by "zero" angle of incidence. At the intersection of these planes will form a line of glideslope, which will be characterized by "zero" incidence angle and "zero" azimuth plane of polarization of the incident beam.

Conclusions.

The paper offers the existing methods for forming glideslope and has proposed method for forming glideslope by using polarized light. This method potentially can increase the accuracy and sensitivity of measurement aircraft deviation from glideslope. The scheme of forming aircraft landing glide is offered.

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Environmental monitoring airspace and the environment in the process of registration UAV for processing and correction control center

Theoretical aspects of problems of air assessment of the environment by means of expert procedures are the hot topic of study. Evaluation airspace environment through registration UAV current parameters of the gas mixture.

The need to determine the purpose of the study will formalize the problem correctly solved UAV registration system for the assessment of pollution airspace key factors are measured and determine the effective-ness of its operations and conditions which limit its possibilities. Let $x \in \Omega$ – alternatively in the job evaluation criteria *m* pollution airspace. The recommendations concerning the requirements for reliability assessments and monitoring pollution state registration UAV airspace:

1. Unbiasedness. Evaluation should not contain bias that exaggerates or understates setting for all election PR. This means that the expectation of assessment should reflect the true value of the parameter. If the actual value of the parameter specified as α, and its assessment as $\hat{\alpha}$, the requirement unbiasedness written in the form:

$$M(\hat{\alpha}) = \alpha \qquad (1)$$

2. Persuasiveness. Rating $\hat{\alpha}$ should be close to the value α with increasing sample size. This means that the probability that the difference $|\hat{\alpha} - \alpha|$ is less than some arbitrary number $\varepsilon > 0$, tends to unity at that $n \to \infty$, so

$$\lim_{n \to \infty} P\{|\hat{\alpha} - \alpha| < \varepsilon\} = 1 \qquad (2)$$

3. Efficiency. Of all convincing and unbiased assessments should give preference to that which is closest to the parameter measured, ie in which large deviations using different elections would be met as possible. Mathematically, this means requiring a minimum variance estimation:

$$D(\hat{\alpha}) = \min \qquad (3)$$

The actual data is usually incomplete or insufficiently accurate due to errors of software and hardware monitoring and registration of UAVs. This is also another several reasons:

- Organizational difficulties of collecting and processing information;
- The complexity of research;
- Lack of sensitivity and precision control and recording equipment UAV that is erroneous failure;
- Not always highly qualified artists.

Was found [1] that in many cases these reasons are not present a credible PR characteristics. Sometimes it is difficult to monitor using UAVs as individual sections of airspace surrounding environments-schA due to inability to timely detection of hidden errors (such as in-flight UAV). Thus, these reasons determine the need for widespread use in complex aircraft, space systems and unmanned air condition monitoring, such as the airport environment.

It is known that the equation of isothermal process was derived from experiments British physicist R.Boylem (1662) and regardless French physicist E. Mariotte (1676). So the equation is called the law of Boyle on (Figure 1).

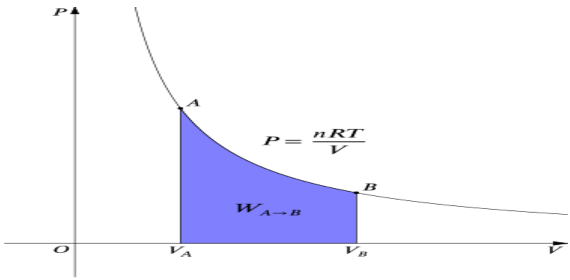

Fig.1. General view of the isotherms for the calculation is as follows

Studied that isobaric process called quasi-independence process that occurs at constant pressure p = const. Reeve-equation isobaric process for some constant amount of matter has the form ν

$$\frac{V}{T} = const \quad або \quad V = V_0 \alpha T \tag{4}$$

where

V_0 – volume of gas at $0°C$.

$\alpha = (1/273{,}15)\ K^{-1}$ – temperature coefficient of thermal expansion of gases.

$$P_h = P_0 e^{-\frac{\mu g h}{RT}}, \tag{5}$$

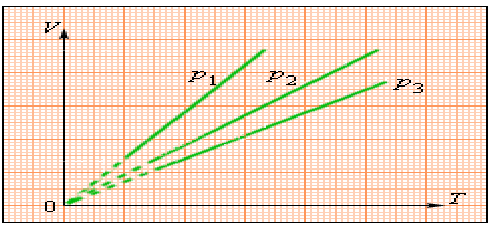

Fig.2. Isobaric processes at different values of pressure p portrayed a group of straight lines, called isobars.

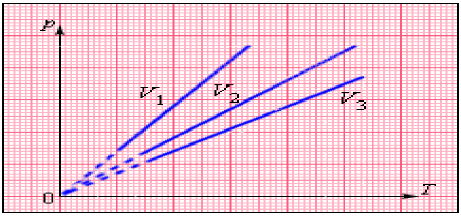

Fig.3. Groups isochore plane*(p, T)*. $V_3 > V_2 > V_1$

The first reason collects molecules on the surface of the second scatters in space.

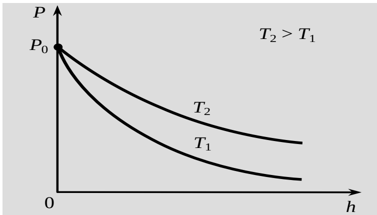

Figure 4. The correlation between gas concentration and temperature at different altitudes UAV flight.

Conclusion

Established that the experiment even distribution of pressure throughout the volume of the studied flask with a gas-ment in his platform model is equal to the energy content of globules that form this volume, which is possible only when the orderly movement of each oscillator. We disagree with the statement that the research process air contamination status and human exposure occurring in the gas mixture in the PR model only has a negative value. From the simulation results revealed that in addition to the negative impact of the processes taking place in the gas mixture PR phenomenon occupies an important place in its positive effect on other processes, allowing to implement resource saving technology.

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Analysis of the model of human relations in the aviation emergency causes stress

The work is devoted to the scientific analysis of psychological stress mechanisms. It describes the changes in relationships between people, and especially of emotions, perception, memory and thinking in aviation emergency situations that cause stress; considered psychologist causes "stress diseases"; It suggests some methods to prevent unwholesome-pleasing effects of stress.

Special attention is paid to the changes in performance of the human operator with the adverse effects of stress and hardly human. It proposed a descriptive model of the dynamics of changes of communication between the members of a small group (of the crew) of the aircraft (PS). The problem of active interaction and mutual interdependence of crew members under stress. Studied the genetic analysis of the prerequisites of individual differences in stress in different people. The results of the experiments that the emergency situations occurring in living and in experimental conditions simulated CA simulator centers may have on a person not only the adverse influence. It is proposed to study the emotional stress and its algorithms offer individual treatment, supplementing and clarifying the known methods.

It is known [1] that is now relatively well studied first stress the development stage of the pilots GA is stage mobilization of adaptive reserves ("alarm"), during which basically ends with the formation of a new "functional system" of the body, adequate to new extreme requirements influencing factors aggressive environment. The second and third stages of development in human stress, t. E. The stage of sustainable consumption adaptive reserves and stage of exhaustion, devoted a few studies carried out either in natural conditions, making it difficult to obtain reliable and comparable data, or in animal experiments [2]. Throughout the growing complexity of the stress and the relative integrity of the nervous regulation of the animal or human body. It is assumed that the reactions involved in stress neurohormones found in ganglia.

The variety of manifestations of prolonged stress, and difficulty organizing experiments with multi day, many months, and so on. N. Human being in extreme conditions, for example, members of the crew of the SS engaged in hours of flights over the ocean for several years, are the main reasons for his lack of knowledge. The concept stress due to its focus on a holistic understanding of the body's adaptive reactions attracted the attention of specialists in the development of human life conditions in the extreme conditions of aviation accidents.

It is proposed to study the technique, when a single phenomenon of stress is crushed when his study of experts in different fields, allowing it to not only be more thoroughly identify, and classify and organize. This fragmentation contributes to a more in-depth study of individual physiological, psychological, medical and biological, moral and sociological manifestations of stress, the laws of their development structures and functional mechanisms underlying these manifestations.

From the comparative analysis of the results shows that a paradoxical situation may occur when a certain level of tension stress when the performance indicators more complex activity may rise higher than the indices increased less complex activities [3]. With an increase in stress intensity proposed to distinguish between two of its level at which there will be a performance of equality is more or less complex activities. If the stress exceeds the strength of the first "surge levels," the more difficult the task will run better simple. Excess second "surge levels' leads to a progressive decrease in the quality of more complex activities, while less complicated can still continue to improve. Prognostic significance of identification (determination) of the levels of stress of tension is obvious, and it is beginning experimenters sometimes leads to confusion on the ground that there is quality improvement activities (when solving simple problems, they underestimate) in people with a sharp deterioration in health during stress (Fig. 1).

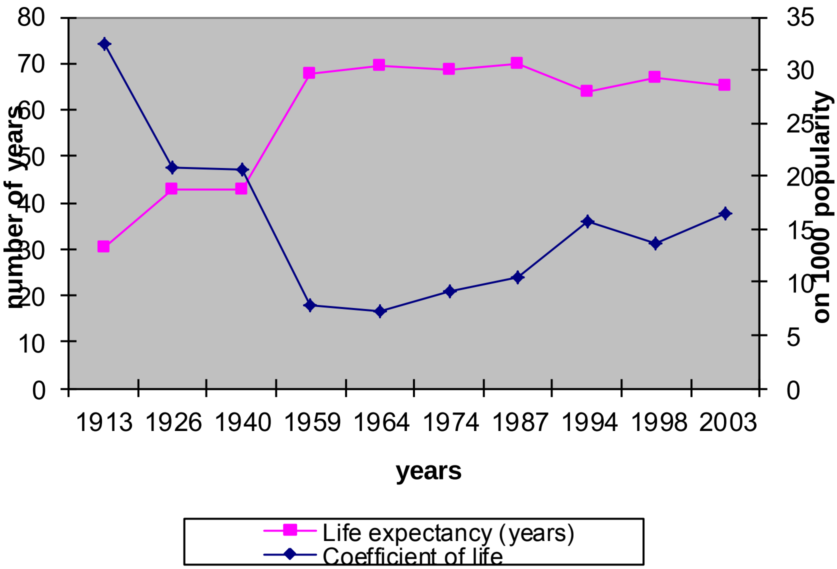

Fig.1. Life expectancy and mortality rate (per 1 thousand. Pers.).

Such phenomenon should be considered as a manifestation of a greater stability under extreme conditions of mental functions, the underlying relatively simple operations in comparison with less stable physiological functions. At the same time, the deterioration of activity in stress should be considered not only as a result of involuntary loss of information, but also as a result of weakening of volitional activity, decreased susceptibility to external motives of activity as a result of care "in itself," that is. Ie. A stress internalization of the individual. Prolonged stress can occur restructuring importance of motives: impelled her activity may slow down, brake - encourage, ie there is the phenomenon of "inverting" motives. You might dislike the attributes or activity to itself. Finally, the deterioration of human activity may be a result of his attempts to actively resist external impulses to stressful activity, or activity in stressful conditions.

Scientific results obtained on the basis of applications of the theory and scientific methodological apparatus research process is the realization of evaluation mechanism within each of these classes [3], because you can define a large number of indicators, which vary depending on the purpose and objectives of the study.

Conclusion

The paper presents methods for the elimination of chronic stress state, and to passengers on an airplane flight CA with the possibility of the situation related to an incident or accident with this emotional and stressful loads.

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Empirical evaluation of dependability of avionics components under conditions of after-sales service

The accuracy of the quantile method with empirical analysis of dependability (MTTF) for the single failures of avionics components was investigated. Complex technique of estimation of the accuracy of the quantile method by using probability-physical model and simulation modeling of failure occurrence process via Mathcad is suggested.

Introduction. Modern aircraft, which is definitely high technology production, has a long lifetime. Where costs necessary for the maintenance of predetermined characteristics of dependability, availability and security of aircraft during operation, can greatly exceed the cost of its purchasing. This is why in the world market a precondition for the making a supply contract for aicraft is meeting the requirements of international standards of integrated logistics support, which is a complex of processes and procedures designed to reduce the costs during the aircraft operational phase and to provide the identification and analysis of the parameters **supportability of operation** of supplied products. Integrated logistics support is means of controlling of the life cycle cost (Life cycle cost – **LCC**) and the main criterion for the decision to purchase aircraft, including the cost of purchasing and maintenance [6].

The effectiveness of after-sales maintenance is characterized by **an integral index of supportability – functionality**

S **=** ϕ (MTMA, MTBMA, RML, LOR, RST, MTTF, MTBF, MTTR, MTBR, ROA), arguments of which at the stage of operation of aircraft are the characteristics of maintenance and dependability measures. Integral index of supportability ***S*** eventually determines the life cycle cost: **LCC** = φ(*S*). Definitions and content of functionality arguments *S* are represented by a table 1.

Table 1.

The contents of the parameters – functionality arguments S, which determine index of operation supportability

Maintenance characteristics		**Dependability measures**	
MTMA	Mean Time Maintenance Actions	**MTTF**	Mean Time To Failure
MTBMA	Mean Time Between Maintenance Actions	**MTBF**	Mean Time Between Failures
RML	Required Maintenance Level	**MTTR**	Mean Time To Repair
LOR	Level of Repair	**MTBR**	Mean Time Between Failures
RST	Required Standby Time	**ROA**	Required Operational Availability

One of the components of integrated logistics support is information support as a part of infrastructure of maintenance and repair system which is a set of interconnected operations of collecting, processing and using the information to control the technical condition and processes of maintenance and repair system based on the modern automated information technologies. There is no doubt that the data about dependability of aircraft components – as the design and engineering, as well as empirical, which are obtained during operation, – should require high credibility, the achievement of which is possible only with small errors of parameter estimates of table. 1 [6].

At the same time, the calculations of dependability by the methods of industry standards and the estimates of integrated levels of failsafe of critical systems and technological processes, techniques based on exponential (*EXP*) distribution of possible failure situations are used [1]. *EXP*-model satisfactorily described the distribution of failures of elemental base during middle of 19th century and at the same time it was introduced to all industry standards for calculations of dependability. However, for highly reliable and functionally complex element base *EXP*-model of failures has serious problems with the adequacy of predictive and empirical estimates of dependability of elements and systems: methodological error estimates of dependability measures, obtained on the basis of an exponential failure model, reach hundreds and thousands of percent, which significantly reduces the efficiency of integrated logistics support [1, 7]. At the same time, the existing legal and technical basis [4, 5] offers new and modern technology of research of dependability of technical systems, which uses a probabilistic and physical approach.

In this context (information operation support $\Rightarrow$ accuracy of dependability estimates $\Rightarrow$ the authenticity of information) to obtain empirical dependability estimates of maintained aircraft components, it is recommended to use quantile method [1, 6].

The report proposes a method of estimating the accuracy of the quantile method based on simulation modeling of the appearance of single failures, which confirms the high validity of the obtained empirical estimates of MTTF.

2. Complex approach to the estimation of the accuracy of dependability measures for quantile method. The accuracy of prediction by MTTF the method of quantile can be estimated on the basis of complexation of statistical experiment (SE) and analytical calculations (AC) by dependencies (4.2) and (4.3), represented by the diagram in Fig. 1.

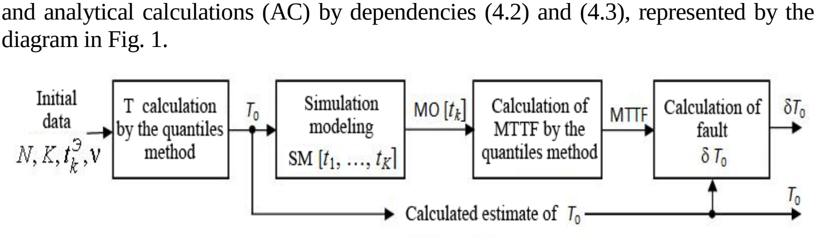

Fig. 1. Diagram of complexation the SE and AC to estimate the error δT_0

Four procedures are implemented in the proposed technique:

Procedure 1. Actually the solution of problem of forecasting by the given input data in accordance with the algorithm given in Listing 1 and the results obtained – assessment T_0. we will implement the procedure with the example of calculation MTTF satellite navigation equipment.

Task. Let a part of the onboard equipment of airline's aircraft is operated by N = 50 similar sets of equipment for receiving and processing of satellite data, providing in-flight navigation tasks solution. Within 3,000 flight hours after the start of their operation the loss of flight functions (functionality) was recorded by built-in means of control and confirmed by ground inspections for three sets, while their times to failure were $t_1^Э = 2010$, $t_2^Э = 2580$ *and* $t_3^Э = 3000$ flight hours (K = 3). For subsequent forecasting of dependability for the entire period of operation (before reaching the limit state) it is necessary to find an estimate of mean time to failure of maintained sets of satellite navigation equipment by using the quantile method.

Listing 1. Calculation of MTTF by quantile method with single failures

$N := 50 \quad \nu := 0.80 \quad K := 3 \quad t_1 := 2010 \quad t_2 := 2580 \quad t_3 := 3000$ fl.hours $k := 2$

1. Calculations of quantiles of DN-distribution

Given Approximate value $X := 0.1$ Operational failure probability $Q := k \div N$

$$\mathrm{cnorm}\left(\frac{X-1}{\nu\cdot\sqrt{X}}\right) + \exp\left(\frac{2}{\nu^2}\right)\cdot\mathrm{cnorm}\left(-\frac{X+1}{\nu\cdot\sqrt{X}}\right) - \frac{k}{N} = 0 \qquad Q = 0.04$$

Mean times to first failure $x_1 \ldots x_K$ are obtained as result of Find(X) solution of equation at consecutive changes in iditial data of index k from 1 to K

$\mathrm{Find}(X) = 0.23376$ Values $X\left(\frac{k}{N}, \nu\right)$: $x_1 := 0.19612 \quad x_2 := 0.23376 \quad x_3 := 0.26314$

2. Estimate MTTF of operating blocks

$$To := \frac{1}{K}\cdot\sum_{k=1}^{K}\frac{t_k}{x_k} = 1.0896\times 10^4 \text{ flight hours}$$

Procedure 2. Simulation modeling of failures on basis of *DN*-model of dependability [2] with the aim of statistical reproduction of modeling expected values mean time to failure $t_1, \ldots, t_K$ of first $K = 3$ in conjunction with N = 50 similar sets (listing. 2). The simulation program highlights the occurrence of the first K failures in conjunction with N maintained similar sets with parameters T_0 and ν.

Listing 2. Simulation model and statistical estimation of MTTF

```
MO := | for i ∈ 1..W
      |   for j ∈ 1..N
      |     y ← rnd(1)
      |     for m ∈ 1..M
      |       F_m ← cnorm((X_m − 1)/(ν·√X_m)) + exp(2/ν^2)·cnorm(−(X_m + 1)/(ν·√X_m))
      |       break if F_m > y
      |     dn_j ← (X_{m−1} + (y − F_{m−1})/(F_m − F_{m−1} + 10^(−100))·ΔX)·μ
      |   Y ← sort(dn)
      |   for k ∈ 1..K
      |     T_{k,i} ← Y_k
      | for k ∈ 1..K
      |   for i ∈ 1..W
      |     T_i ← T_{k,i}
      |   MO_k ← mean(T)
      | return MO
```

Predicted reliability parameters

$\mu := 1.0896 \cdot 10^{4}$ fl. hours, $\nu := 0.80$

Number of operating components of onboard equipmentof same type $N = 50$

Expected value (EV) of mean time to failure of first K failed sets of processing satellite data hardware

$$MO = \begin{pmatrix} 2.019 \times 10^{3} \\ 2.474 \times 10^{3} \\ 2.811 \times 10^{3} \end{pmatrix}$$

Procedure 3. Calculation of MTTF by quantile method by results of modeling, ie by modeling operating time $t_1^M = 2019$, $t_2^M = 2474$ *и* $t_3^M = 2811$ flight hours in accordance with the analytical dependences on list. 1. Results are presented in list. 3.

Listing 3. Calculation of MTTF by quantile method by results of modeling.

Probability of k-th failure is determined by DN-model of dependability, where X is the value of mean time, which corresponds operational failure probability k / N, for $k := 1..K$

$k := 2$ Given Reference $X := 0.3$

$$\mathrm{cnorm}\left(\frac{X-1}{\nu\cdot\sqrt{X}}\right) + \exp\left(\frac{2}{\nu^2}\right)\cdot\mathrm{cnorm}\left(-\frac{X+1}{\nu\cdot\sqrt{X}}\right) - \frac{k}{N} = 0$$

$\mathrm{Find}(X) = 0.233761$

Mean times to first failure $x_1 := 0.196125$ $x_2 := 0.233761$ $x_3 := 0.263144$

Static mean operating times to failure of operating components ($K = 3$)

$t_1 := MO_1 = 2.019 \times 10^{3}$ $t_2 := MO_2 = 2.474 \times 10^{3}$ $t_3 := MO_3 = 2.811 \times 10^{3}$ л. часов

Static estimate of mean time to failure by the quantiles method for individual failures ($K = 3$)

$$MTTF := \frac{1}{K}\cdot\sum_{k=1}^{K}\frac{t_k}{x_k} = 1.052 \times 10^{4}$$ flight hours with failure $$\delta\mu := \frac{\mu - MTTF}{\mu} = 3.451\%$$

Procedure 4. Calculation of methodical error of the quantile method

$$\delta T_0 = \frac{T_0 - \text{MTTF}}{T_0} \cdot 100\ \% = 3{,}5\ \%. \qquad (3)$$

3. Conclusion.

1) Estimates for the accuracy of the method of quantiles obtained on the basis of a complex methodology that combines analytical computations and simulation modeling, carried out by the Mathcad system, which got the status of the international standard of mathematical analysis for all areas of science and technology [3, 7].

2) At the stage of operation of aircraft the quantiles method with use of Probabilistic-physical model of failures is an effective tool for obtaining the adequate estimates of dependability of maintained avionics components.

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Psychological features of future creative thinking of air traffic managers

This article describes the psychological features of mental imagery of future managers of air traffic. Indicated the basic tools for the development of this type of mental activity of specialists of the aviation industry. Established that educational guidance, carried out by teachers during the training sessions, is a necessary condition updating cognitive set future managers of air traffic, which leads to the development of imaginative thinking.

The current stage of development of society characterized by rapid burst of innovative technologies in the aviation industry, the effectiveness of which depends on the availability of professionals with significant intellectual and creative potential. That is why the main focus of the educational process aviation schools today is the formation of the creative person that is able to solve complex problems in unusual conditions, flexibly and independently use the acquired knowledge in different life and professional situations.

According to this research, priority of modern aviation education is the study of cognitive development managers of air traffic, because it is the active form of objective reflection of reality, providing new knowledge and skills, reveals the essence of things and phenomena. One of the essential types of thinking as the highest form of knowledge of the objective world stands shaped his vision that promotes cognitive human capabilities in the handling images of varying degrees of generality, signaling and audio messaging.

As the thought process creative thinking has a three-part structure: concept image - the effect of their complex interactions. The most important feature of imaginative thinking is the character of the thought process, its efficiency, speed of updating knowledge systems needed to resolve unplanned situations probabilistic approach in solving many problems and selection of optimal solutions, which makes the process of solving industrial problems particularly challenging.

The development of figurative thinking improves intellectual skills of the person and coaches its creativity, that positively affects the professional skills of future managers. According to the research, the problem of imaginative thinking was to examine the features of the development experts in the industry.

The main characteristics of the modern manager include: understanding figurative work situations and integrated approach to their review, means ownership of intellectual, analytical, design, design skills, several activities simultaneously. The speed of transition from one activity to another plan - from the abstract to the verbal-visual-effective, and vice versa, stands as a criterion of development of creative thinking.

So, imaginative thinking is quite specific type of human cognitive activity, the purpose of which is the ability of the individual to relate information perceived with understanding its contents. It was a "process modeling of attitudes to the subject of reality that made a correlation between prevailing in the minds of the basic elements of thinking and sensory data coming from outside" [1; 39]. Thus, the specificity is determined imaginative thinking and imaginative nature of the information, content information of the individual self-expression and active in the process of cognitive activity.

Thus, creative thinking influenced by certain laws and regulation of the flow of human intelligence operations: first, it is not only the sensory-specific reflection of reality, as a function of operating the abstract logical categories; second, the display features of its perception through a system of ideas and concepts. Thus, understanding information and imaginative nature of the subject and understanding of the logical structure shaped sound creates a true understanding of the concept.

Considering specified, it becomes clear that one of the main factors of successful professional manager is the presence of a high level of creative thinking, which simultaneously serves as an integral unit and professionally important qualities of future specialist.

Creative thinking is a generalized and indirect form of human mental reflection of reality, establishing connections and relationships between the object known.

As creative thinking is an important factor for professional development manager as a specialist. The development of the mental-shaped features underlying productive activity training specialist, manifested in its various future activities:

♦ imaginative understanding of working situations and integrated approach to their review,

♦ possession of different ways of intellectual activity,

♦ manifestation analytical, design, design skills,

♦ speed of transition from one activity to another plan - from the abstract to the verbal-visual-effective, and vice versa.

Because mental cognitive activity of students-managers are in an active stage of development, emotional sphere is still very sensitive, appealing teacher in the classroom while mastering certain subjects purely educational material will not give meaningful results. In our opinion, the best effect by setting the students to perform an action, the formation of such images means that by themselves are like invisible, but at the same time, promote the absorption of fundamental knowledge. That is why we believe that an effective means of imaginative thinking are the educational guidelines, systematic application of which causes the formation of internal student readiness to create, understand and display of figurative material that facilitates updating the system settings of imaginative thinking in general. So effective tool flow imaginative mental activity of students-managers act actualized teaching guidelines setting.

Considering the impact of pedagogical guidelines for the development of figurative thinking of future managers, we agree with the research that distinguished in Ukrainian language the term "set" and "guidance." Thus, studying the formation of philosophical systems V.M. Tsvirkun [2] notes that the verb "set" in the

Ukrainian language means the finishing of a specific action. And that, besides the term "set" in our language we use the term "guideline". The difference between "guidance" and "set" is that "guidelines" is characterized by the direction action instruction on something that is constantly in the spotlight, and "set" refers to something stable, almost permanent, an action completed, fixed result and this result is “settles" as structural element of consciousness, with so steadily that consciousness without straining it engages in each case their active influence on life, and therefore any activity.

According to this, the guidance is a direction vector of student’s action during the training activities and set - willing to act according to the determined by guidance direction. We believe that it is actualized setting instructions teaching conducting training sessions ensure harmonious development of creative thinking that will facilitate the formation of professional skills of future managers and positively affect the figurative cognitive activity of students.

In justifying the choice of optimizing the development of figurative thinking of students of aviation industry, it should be noted that the full implementation of its formation and characteristics requires activation and interaction of the main areas of mental activity (sensory-sensory, cognitive and activity) student. Because identity manifestation of selective perception, characterized by disregard awareness incomprehensible to him of reality generated by superficial attitude towards the comprehension of teaching material. This, in turn, contributes to passivity or banality minds. That is, students who are not prepared to accept and understand the material will never attain its expressive content in general.

Therefore, without the prior students’ readiness for learning activities information submitted teacher may make future managers emotions, thoughts and aspirations that do not meet the comprehension of its content. In this case will form an indifferent attitude to accept the material. Thus, students take passive pleasure, emotional impression pass formally without affecting their personality without causing their thoughts. That is, without the willingness to student perception of the material influences guiding teacher, no matter how good they are, will not give the desired effect because they can fall on the "not prepared ground".

So, any student activities, including the mental, is based on a prior readiness for it. Accordingly L.S. Vygotsky observed that before you want to call some of the child to be interested in it, caring about to discover that she is ready for this activity that she had strained all the forces necessary for this, and the child will act by herself, the teacher can only control and direct this activity.

Therefore, with the help of the educational guidance teacher will be able not only to check the readiness for activities, but also call and manage it. This, in turn, acts as a basis predictions of actions of the student, his mental programming-like activity in the process of communicating with the educational material. That is, the rational influence educational guidance teacher in the classroom, students, psychologists updated responses, which depend on the content of emotions and feelings, images and associations, thoughts and beliefs.

They contribute to a deeper penetration into the emotional content of the material, reinforce the impression of the perceived information. Their influence has positive impact on student mental readiness for perception of information and work on its image, they encourage him to active-shaped the mental activity.

Thus, pedagogical instruction on the lessons will promote the development of the distinction (analysis, synthesis, separation chief, generalization, specification, ordering) audio stream of information, understanding of images that is the content of the process of creative thinking.

Implementation of these abilities of students in the educational impact of the guidelines largely determines its true motivation of cognitive activity, orientation, effectiveness and efficiency. That is, use in educational studies teacher attitudes favorable impact on the development not only of cognitive processes and is the key to holistic development of personality of future managers. This, in turn, significantly expanding its range of action and affects the generation of new relations between the perception of educational material, cognitive and imaginative activities and personal and motivational personality formation.

Educational guidance is an integral entity, which regulates and directs the psychological and physical efforts of the person to make his mental-like activity. It is an integral formation of varying degrees of mental awareness that performs system-function and appears to hold the integrity of psychological cognitive system images, which includes cognitive activity, the identity of the student in the unity of that part of the objective world, which has its value, meaning and value.

The mentioned above characteristics of pedagogical guidelines suggest that it is: first, one of the most important determinants of objective learning of the student; secondly, its formation based on external perception and internal training material development of mental processes; thirdly, educational guidance, as determined by age characteristics of the person, is a necessary component of the formation of creative thinking of students-managers and the basis for further development of their professional activities.

Given the indicated, pedagogical guidance performs the important function of management actions and thoughts during the formation of the internal position of the student. It acts as a bridge for the transition of "external" layers (structure perception of educational material) in the "internal" (image building) and vice versa. That is, during the class, using teacher instruction, help students organize and understand their images, establish the sequence of their creation and erase display facilities.

Consequently, the use of educational guidance by teacher during classes has a positive effect on students' understanding of information and imaginative cognition training material and ensure the implementation of educational, training and developmental functions of the individual.

Thus, we can conclude that creative thinking plays an important role in the careers manager of airspace, giving him a better opportunity to learn, reflect and navigate in in certain situation. Through creative thinking future specialist has the ability to solve complex professional tasks, draw conclusions from the experience of practice.

In addition, it should be noted the fact that the actualization of this type of mental activity carried out by the impact of educational guidance teachers in the training of future managers. Prospects for further research we see in the study areas of psycho- pedagogical support of formation of figurative thinking at various stages of personal growth professional.

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The Human Factor as an Informative Parameter of Integrated System of Biometric Control and Handle of Complex Technical System

Investigation of psycho-physiological aspect of human factor in work of difficult technical system is described. The motives of human behavior in a conflict situation, the causes of human error and the requirements for the provision of information flow are considered. The conclusion is that in order to improve safety there should be some minimum biometric parameters registered on-line to determine the stream of psycho-physiological human condition.

During operation of complex machines and systems human and machine are united in one complex technical system. In the course of its operation in the subsystem "Human-Machine-Environment" comes human and the other device subsystems. The subsystem "Human-Machine-Environment" is restored and maintained. Therefore, it has structural, informational and functional redundancy. Reliability subsystem may be higher than the reliability of other subsystems of complex technical systems. The efficiency and reliability of the subsystem "Human-Machine-Environment" largely depend on the psycho-physiological characteristics of human and of the fitness machines to interact with the person. That is, we need a biometric control of physiological and psychological possibilities of human. security issues is particularly important in high stress mode, when the failure of one of the elements of such a system can lead to catastrophic consequences.

Ergonomic properties of the person are a set of anthropometric, physiological and psychological properties. The impact of human factors on the level of safety when operating complex technical systems are considered in detail in work [1]. One of the subsystems of the integrated monitoring and control system is a system of biometric control complex technical service personnel system.

As stated in [2], it is necessary to bear in mind the dual role of human from the standpoint of safety on the one hand, people - this is a very perfect system, it can be difficult to assess the situation and make decisions that are not able to accept any control vehicle; On the other hand, the person himself is subject "failure" if its nervous system and the physical state are impermissible overload.

Special problems is the collective system - a complex machine - environment. In it, besides the already mentioned factors, the leading role played by social relationships, hierarchy of individual performers, the organizational structure of the units, ideology and human relations, quality handle and reliability.

Thus, the aim of this work is to study the importance of the psycho-physiological aspects of the human factor in complex technical systems.

One of the main features of human psycho-physiological is a high degree of professional risk. This is due to the emergence of conflicting motives of behavior in conflict situations. The following human motives [3]:

- Scornful attitude to risk;

- Lack of discipline;
- The habit of danger;
- Revaluation of its features.

Model of human-machine system shown in figure.

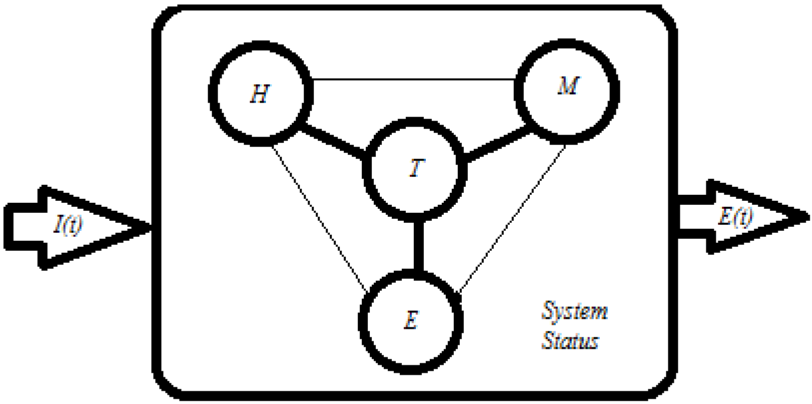

Figure. Model of human-machine system: *H* - human; *M* - the machine; *E* - working environment that are associated with each other and the outside (for the whole system) environment with the help of technology (T); *I(t)* - The input of information and material disturbance (control commands to the machinery, etc.); *U(t)* - Reports on the operation of complex technical systems in real time, and. etc.

It should be noted that the person in contrast to automation, do not behave rationally. Moreover, it provides an intuitive search for solutions that meet the statistical criteria, or produces the substitution to be the decision of the association process with some previously been the situation for which it has deposited in the memory of a decision on the previous experience. This solution, however, is possible only on the basis of an appropriate mental model of the system behavior.

In addition to the above capabilities, a person as part of the subsystem "Human-Machine-Environment" shows significant shortcomings:

- Memory limitations;
- The absence or presence of a mental model with errors;
- Limited reliability;
- The lack of constancy of disability, especially after prolonged use;
- Prejudice and fixity;
- Lack of mental arithmetic;
- Limited bandwidth for manual response.

According to [1], there are three types of human behavior:

- Based on knowledge;
- Based on the rules;

- Based on availability.

The automation level (AL) of human-machine system [1]:

$$AL = \frac{F_{aut}}{F_{aut+h}},$$

where F_{aut} - the functions that can be made automatic; F_{aut+h} - the functions which can be performed either human or automatic.

Then the highest possible level of automation, where the maximum possible number of automated functions:

$$AL_{max} = \frac{F_{aut+h} - F_h}{F_{aut+h}}.$$

When designing technical systems the concept of "human failure" is the transformation of the fact that the human with his inborn and acquired abilities and weaknesses insufficiently taken into account. Therefore urgent task so design the system "Human-Machine-Environment" that it most "considered" with the person. Thus, there are two possibilities for optimization: first - by humans in relation to the car, and the second - on the machine side with respect to the person. Generally speaking, the more accurate term "human failure" to replace the concept of "service error".

The basic service errors reasons include [1]:

- Situational factors (inconvenient layout, the workplace, the environment, information control);

- Physical, emotional, social and organizational factors (fatigue, illness, stress, negative production environment, poor staff training);

- A misperception of risk.

When taking into account the human factor is necessary to pay special attention to the processing and compression supplied by the controlling subsystems and the central information and control complex information. It is necessary for an adequate and timely flow of information coming assimilation and adopt on that basis the right decisions. To achieve this effect, the seal data must comply with certain requirements, which can be summarized as follows:

1. The definitions. The person should receive specific information, according to which it is necessary to take very specific and unambiguous action. The incoming information should not give cause for hesitation or be in some way ambiguous.

2. The reversibility. If necessary, the information must be able to be deployed for a more detailed analysis of the causes that have created it.

3. The representativeness. The incoming information must be in a form that can not be disregarded. For example, the system light and sound alarms, placed directly in the workplace.

Evaluation of reliability and safety of complex technical system is convenient to carry out without taking into account the following general points:

- The human operator activity is potentially dangerous, since it is related to the conduct of technological processes, and the latter - with power (generation, storage, conversion of mechanical, electrical, chemical and other energy).

- Accidents are preceded by a chain of preconditions that lead to loss of process control, undesirable emissions used in it energy or hazardous substances and their effects on people, equipment and the environment.

- Causal links incident chains are erroneous and unauthorized personnel actions, malfunctions and failures of equipment, as well noncalculated impact on them from outside.

By the human operator in this context, in addition to the requirements arising from the direct production goals must be presented the following set of requirements:

1) the infallibility,

2) availability,

3) regeneration,

4) timely,

5) the accuracy of perception and response to incoming information.

In accordance with this, additional measures for professional selection of persons serving a complex technical system.

The factors that contribute to errors in the work of the operator, and leading to an increase in the danger of doing the work, should include [1]:

- Lack of information on accidents;

- Lack of time to make decisions;

- An inadequate response to stress (stress impact is compounded by the fear caused by increased responsibility, self-doubt, lack of knowledge and experience).

Obviously, some of these errors, the causes of which are not related to the individual personal qualities, can be ruled out as a result of training and special training.

Conclusions

So, it can be argued that:

- A complete and unambiguous forecast of the level of security in the conduct of work on the human factor is not possible because of the specific psycho-physiological characteristics of the person;

- As the monitored parameters the number of employees, their age and skills can be used on the factors that need to be assessed on a scale;

- The main way of improving the safety level on the human factor, is to conduct teaching-training sessions with the staff and regular monitoring of its psycho-physiological characteristics.

In general, the subsystem "Attendants" is largely specific. However, despite this, its operation can be viewed from the position of system integrators, as well as the functioning of all the other subsystems. Most of the operation of this subsystem is similar to the operation of the subsystem "Technological equipment". Indeed, the subsystem "Attendants" renders by setting the mode of operation of the process equipment direct impact on the marginal rock massif, changing its state.

Obviously, going beyond some limits of parameters of subsystem "Attendants", entails a similar change in the behavior of individual employees. On the other hand, their wrong actions may result in malfunction of the entire complex technical system.

Then, to estimate the probability of reliable operation "Attendants" subsystem can offer the following set of informative parameters, which is a quasi-permanent (it is updated by the change to change):

- Number of workers;
- Their qualifications;
- Age;
- The ratio of working to their optimum (desired) amount;
- Other operating parameters that can affect the safety of operations.

Furthermore, there should be some minimum biometric parameters are continuously detected (in on-line mode). To those may include: body temperature of a human operator, respiratory rate and heart rate, may check the acoustic and infrared radiation from the surface of the worker's body. To date, these measurements are not made because of the complexity of their implementation in a production environment, as well as the high cost of the equipment used.

However, it is clear that such information could be one of the key elements on the way to solving the problem of increasing the level of safety.

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The evolution of the concept of safety and accident prevention

Reviewed and analyzed requirements concepts ICAO to ensure flight safety. It is shown that their introduction into practice has led to the reduction of flight accidents and catastrophes. Examines the ICAO requirements for flight safety in the near future.

The practical result of the international recognition of the utopian concept of absolute security, on the Specialized meeting of ICAO in the early 80-ies formally adopted the concept of residual risk that has been documented in the ICAO Manual on the prevention of accidents (1984 year) without any explanation about the magnitude of this risk [1]. A study of the concept of residual risk in the aviation industry was the results of the analysis of the dynamics of accidents.

Traditionally operations based on laws and regulations, most of which are your requirements, directly or indirectly, are aimed at maintaining or improving safety flight (SF). This «traditional» approach to SF, often referred to as normative [1], and in 2006 year – «retroactive» to ensure SF has been and remains an integral element of all types of aircraft. Regulatory support of SF, as shown by many years of practice, makes it quite effectively to prevent the repetition of past accident (PA), the causes of which are well established. A particularly high efficiency in the country or industry in the face of massive exploitation of limited number of types of the park series of aircraft). Measures to ensure SF carried out generally in accordance with the requirements of normative documents, has been quite successful and effective, we are not only a requirement, but a natural necessity at any level of development of the aviation industry.

According to ICAO on scheduled airlines the number of fatalities per 100 million passenger-kilometers, beginning in 1960, fell steadily more than doubled every 5 years: from 0,75 (1965 year) to 0,08 (1975 year). However, in the period 1975-1986 year (two to five years) the indicator remained at the level of 0,08 – 0,09 percent, which was the basis for assumptions about reaching the limit of efficiency of regulatory support SF (fig.1.1) [1]. Thus, as shows the analysis of the causes of AP, incidents continued to take place even in cases when meet the requirements of all applicable regulatory documents.

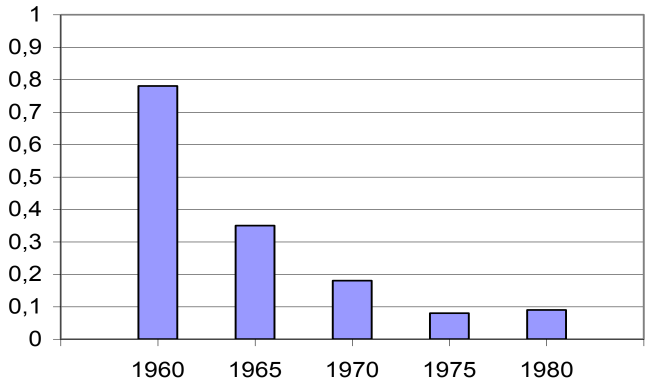

Figure 1.1 – Fatalities/100 million passenger-kilometres on scheduled airlines

Stabilization of the achieved level of SF (if not excluded AP) in the last years of the last Millennium is confirmed by the statistics of Boeing Corporation: one accident with casualties on 1000000 flights. Moreover, the main causes of AP (civil aviation) remained the same as during the preceding 8-10 years [2].

These figures give reason to accept the assumption that the described traditional method of controlling the level of SF has exhausted its practical potential has reached its maximum level of efficiency and requires, if not replace, the serious qualitative changes.

ICAO Specialized meetings came to the conclusion that the prevention of AP should take measures, to complement regulatory procedures to ensure the SF. The mentioned activities are different from the traditional regulatory framework for the SF that it is connected with active search, the so-called - according to ICAO, emergency factors. Naturally, these factors must be addressed, and to avoid their occurrence. Note: the factor is meant any condition, event or circumstance which may lead to accident.

As a result of this conclusion of the divisional meeting of ICAO in 1984, prepared the Manual of accident prevention (MAP), in which the conclusion is made about necessity of additional measures «deviant character» and as a task for the future is recognized to develop improved methods and programmes to prevent AP. Concluded that the subsequent development of the aircraft associated with the emergence of new emergency factors. Formulated the requirements for the combined efforts of all sectors of the aviation industry, including management, pilots and technical staff, developers, manufacturers and government agencies. The necessity of, at both the state and corporate levels, programmes for the prevention of AP, supplementing traditional regulatory activities [1].

Probabilistic-statistical analysis of aviation events and subsequent factor analysis confirmed that at a relatively low disposable sample such rare events, which include AP, with a limited set of combinations of potentially adverse factors (AF) flight (a set of combinations is limited by the criterion of almost incredible events, i.e. with a probability less than 10-9), provided the ordinary (the event only one of the possible combinations of AF) and the absence of aftereffects, characterized by [3]:

1. The number of possible (potential) combinations of adverse factors contributing to the development of AP, significantly more than the number of events AP (the number of combinations of NF, caused AP) for a limited period of observation, what is the life cycle of the aircraft type. A significant portion of the possible combinations of AF, does not have time to form up in view of the low probability of occurrence.

2. Almost an incredible event ($P \leq 10^{-9}$) is a manifestation of one of the possible combinations of AF in its entirety forms the already unlikely ($10^{-9} \leq P \leq 10^{-6}$) or quite likely ($P \geq 10^{-6}$) event when the number of combinations of AF in excess of 103.

It is obvious that the absolute elimination of the influence of even one of any combination of AF identified during the investigation of another AP, prevent the repetition of such AP, and reduces the cumulative probability up to a small extent. At the same time, the elimination of certain potential AF (and its links) that form in two or more combinations with other AF the largest component in the total probability of AP, gives a reduction in the likelihood of AP is not less than an order of magnitude [14].

A consequence of the transition from the concept of absolute security to the concept of acceptability of residual risks was the introduction of concepts [4, 5, 6]:

– a given level of SF – on an international scale;

acceptable level of SF – scale state;

– set the level of SF – scale agencies, airlines;

– the current level of SF – at some point or for some period of evaluation of SF.

A given level of SF forms the ICAO in form of requirements to the member States of the Commonwealth [7].

In accordance with the requirements of the Standards and Recommended practices (SARPS) of ICAO, each member state of the ICAO is obliged to have a national Program of safety in order to achieve an acceptable level of safety, and every operator must have a System of safety management (SSM) – to achieve an acceptable level of safety in its areas of activity (fig.1.2).

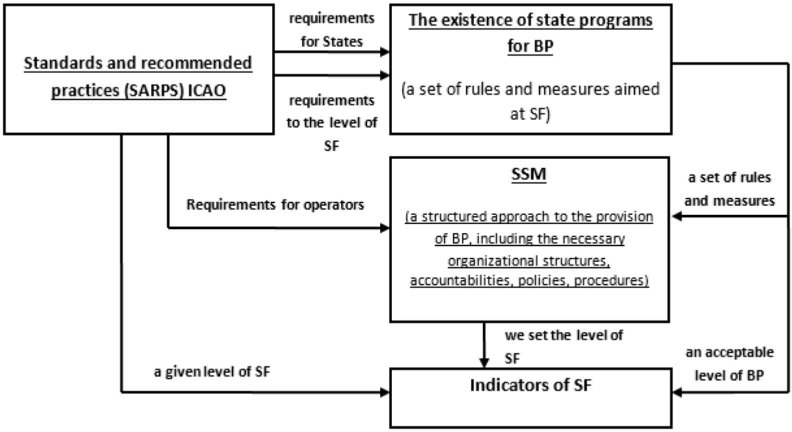

Figure 1.2 – the ICAO Requirements and state authority for safety flight

An acceptable level of SF reflects the goals of authority's oversight of the operator (aircraft/ airport) or service provider regarding SF. From the point of view of the relationship between competent authorities for supervision and operators/service providers, it represents minimally acceptable to the authority for supervision purpose, which must be provided by the operators/service providers when performing basic production functions. An acceptable level is the basis on which the authority for supervision specifies the operators requirements to the level of SF and can assess their compliance with the current level of SF in real time. The indicators of the level of SF should be simple and linked to key elements of safety Programme of a state or of SSM of the operator/service provider.

We set the level of SF reflects the corporate objectives of the operator in the field of safety management is adopted annually in accordance with the acceptable level and with a specified rate of increase of SF in the framework of the SSM relative to the previously achieved level.

The current level of SF should not only meet the acceptable level, but to reflect the pace of decrease in frequency (statistical probability) aviation events fixed degrees of severity, beginning with the incidents.

ICAO, as an example, an acceptable level of SF in the state, notes that it establishes a Supervisory authority, should be achieved within the framework of the State program for SF and is expressed in relative terms (as of 2006 year):

a) 0.5 fatal accident per 100,000 hours of flight time for operators (airlines) with a decrease of this index by 40% over 5 years;

b) 50 aircraft incidents per 100,000 hours of flight time with a decrease of this ratio on average by 25% over the past 3 years [1].

In accordance with the aims of ICAO in the field of maintenance SF for 2008-2011 year, contained in the Global plan of safety [7] international civil aviation are required to achieve results:

1. The reduction in the number of AP and fatalities worldwide irrespective of the volume of air traffic.

2. A significant reduction in the frequency of AP, especially in those regions where these remain high.

3. By the end of 2011 no single ICAO region shall not have the frequency level of the AP (Based on a rolling average over five years) more than twice the worldwide rate.

At the same time, what will be the level of SF in ICAO 2011 - no data.

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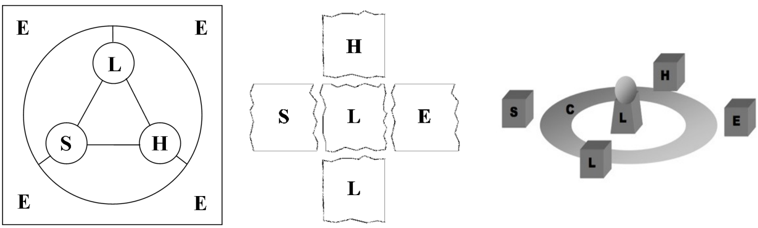
The Development of Ideas about Human Factor

According to the human factors model SHELL supplemented by a component of "organizational culture", the article suggested the additional model for the analysis of areas of possible incompatibilities in the structure of human factors in view of the "operating philosophy" genesis and manifestations.

Currently, the main feature of the development of aircraft equipment became automatization. Currently, the main feature of the development of aircraft equipment became automatization. As has been noted by many authors, it raises to man the new opportunities and new challenges. Obviously, finding the best ways of further development of aviation technology will contribute to look at innovation from the standpoint of the human factor.

The human factor distinguished by complexity its structure and linkages of elements, making it difficult to estimate and correct the effects of the ongoing evolution of technology and equipment from the viewpoint of human role and capacities. In the general view a human factor commonly understood as a whole set of effects of contact of a human with information, tools, tasks and rules of activities, as well as physical and social environment that have an impact on performance.

The evolution of human factors concepts reflected the desire for exhaustive coverage of its important aspects. Thus, the development of the concept E.Edwards (Fig. 1a) was proposed F.Hawkins improved model (Fig. 1b), which included two elements are «Liveware». Element L, located in the external circuit models Hawkins reflects factors such as teamwork, communication, leadership, social norms, while the central element L defined by a set of human individuality aspects such as knowledge, attitudes, cultural characteristics, manifestations of stress, etc. [2].



a b c

Fig. 1. Variants of vision of the human factor model: a) the SHEL model (E. Edwards, 1972); b) the SHELL model (F.H. Hawkins, 1987); c) the variant of presentation of the SCHELL human factor model [7]

The use of composite materials is due to high strength and stiffness and low weight compared to metallic materials. However, a significant disadvantage of polymer composites is the possibility of hidden internal destructive micro shock due to various influences, which can cause accidents in the operation of the aircraft.

An interesting question is whether there may be additional interconnections between elements of the SHELL model, such as S-H, and whether they also require especial consideration from the standpoint of the human factor as important in essence? The argument in favor of a positive answer to this question is that the equipment and rules are created by people - carriers of certain ideas about a wide range of human characteristics and ways to optimize the human factor. In fact, the spread of certain ideas about the human factor may be considered as socio-cultural phenomenon. A man is the carrier of the inner world of the individual, aspirations, feelings and spirituality. This is very evident in the sphere of professional activity. While physiological and psycho-physiological factors are determine operational capabilities and limitations of the human operator, then the psychological and socio-cultural factors allow us to judge that people are introduced into the work situation at the expense of the generated in ontogenesis peculiarities as values, attitudes of behavior, style of relationships with others and lifestyle, communication skills, knowledge and professional experience. Attention to cultural (socio-cultural) aspects of the human factor observed for a long time [3, 4, etc.], including in the context of improvement of crew resource management programs [5]. Socio-cultural aspect found expression in a model of the human factor SCHELL (Fig. 1-B), where component C is defined as "organizational and national cultures that influence the interaction" [6, 7, 8].

We analyzed complex and contradictory processes manifestations of socio-cultural factor in the post-soviet space in the context of regulation joint activity in the composition of the flight crew and practices of crew training by programs for learning effective interaction [10, 11]. It has been shown there are phenomena that can directly threaten flight safety in a collision of different professional worldviews, traditions and individual differences of professional experience.

Thus, the analysis of crew's training programs prevalent on the post-soviet space testified that some of them directly contradict the modern concept of CRM, but consistent with the inherited corporate culture and individual professional worldviews [10]. Under these conditions at some stage of society transformation the whole layer of problems occurred against the backdrop of transfer into post-soviet space of air transport industry some norms and rules of interaction between members of flight crews that were established in accordance with the representations that differed from prevailing in the entrenched culture.

The model of the human factor can be understood as the *risk map* which helps to see hazardous areas of inconsistencies. We see that it is evolving in the direction of increasing the number of its components. They will lead to a further increase in model complexity, but certain phenomena associated with the human factor, obviously require additional constructs.

Output may be to the basic concept supplemented other agreed models aimed at disclosing some aspects that were not direct representation in the main concept. Next steps are directed to this goal.

In spheres where sophisticated equipment is operated, an important component of the human factor is the specific entity that we call *operational* *philosophy*. Under this concept we understand the basic ideas and requirements for the content and organization of the process of people activity as a part of socio-technical systems, as well as ways to ensure reliability of human component and the whole system. One of the functions of operating philosophy is to ensure the unity of design solutions machine component and specified operational rules. But the fundamental role of operational philosophy is a conceptual agreement between all the components of the human factor.

The content of operating philosophy is usually determined by aircraft manufacturer, herewith it should be based on operational experience. Inconsistency of prescribed operational philosophy and socio-cultural features of the organization of the operator can be a very real danger (Fig. 2).

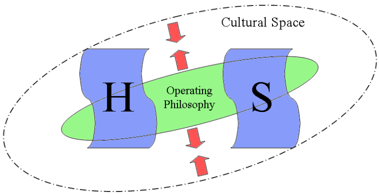


Fig. 2. Field of operational philosophy manifestations

Operation philosophy has non-contradictorily fit into the corporate culture and space of individual worldviews (Fig. 3).

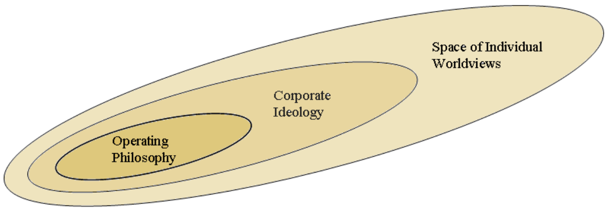


Fig. 3. Acceptable interrelations spaces of operational and regulatory philosophy, corporate ideology and individual weltanschauung

In our view, the operating philosophy is based on an understanding of the opportunities and vulnerabilities of human and, accordingly, on a notion situations and risks that can be overcome through human potential, as well as on perceptions of the risks and difficulties that may arise due to limitations of a man (Fig. 4). It is important that this should apply to both individual and team activity.

In addition to the problem of integrity of professional culture of world aviation, there is also a problem of consistency outlooks on the human factor among the developers of aviation equipment and among operators (Fig. 5). Distortion of philosophy of operation as a result of many factors at the stage of realization of design intent may exacerbate this problem.

Professional outlook is defined by the essence of performed activities, which are different for the developers of aircraft equipment and for pilots. Automation is part and parcel of modern aviation thus its developers are indirectly present next to pilots in a cockpit. They have become virtual crew members, in particular way [9].

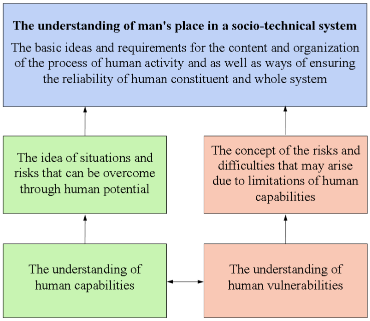


Fig. 4. Genesis of operating philosophy

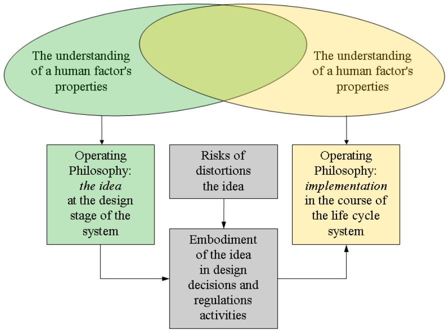


Fig. 5. Coherence worldviews developers and operators as an aspect of the human factor

Based on the above, we see possible entered in consideration of the human factor aspects such as "requirements for a human" and "operating philosophy", correlating them with the possibilities of human and socio-cultural features of team and organization (Fig. 6) [12].

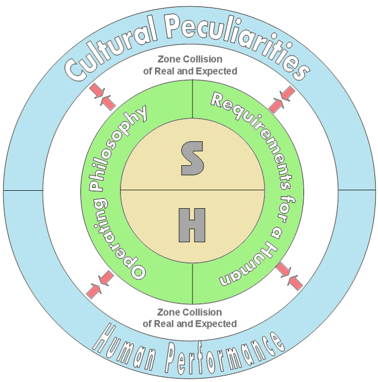


Fig. 6. Areas of dangerous incompatibilities manifestation (Petrenko, 2015)

This model corresponds with concept SCHELL and directs attention to the "zone collision of real and expected". Thus four key areas for analysis (shown in red) can identify, namely (in addition to accordance between human capabilities and requirements for human):

– accordance between requirements for human and cultural peculiarities of social space;

– accordance between operation philosophy and human capabilities;

– accordance between operation philosophy and cultural peculiarities of social space.

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Intellectual automated control of human state monitoring systems

The process of human state monitoring can be presented as control system, which include object of control (human), control subsystem, including involving human operator (doctor) and feedback; allows exploring the control process of complex system by the known methods.

Problem statement. Problems of intelligent automatic control system are important in many cases:

- Hospital patients for a period of rehabilitation often need round the clock monitoring of the operation of relevant internal organs (kidneys, lungs, brain, spleen, heart, intestines, etc. ;

- During the treatment of human the great importance is the patient's psycho-emotional state, since the diagnosis and correction of emotional state has a positive effect on treatment outcome.

With the development and improvement of technology in modern intellectual automated control system (IACS) can solve the problem effectively monitor the human condition. This publication was first offered to consider human (H) as a control object (CO), human condition monitoring and diagnosis is help and compared to patient's normal state of according to the analysis of phase portraits.

The purpose of the publication is to:

- Development of the algorithms of human psycho-emotional diagnosing and monitoring;
- Development of modeling, analysis and synthesis IACS algorithm;
- IACS modeling, analysis and synthesis of IACS "Control device (CD) – H" by the algorithms.

Main part. Research of H activity in the complex system of technical ergatic system with the help of system approach, give opportunity to calculate the physiological properties of human activity in real time [1; 2]. The system for monitoring the current emotional state of Human-Operator (H-O) (pilot) and diagnostics strains emotional experience as transitions to dangerous types of H-O (reasonable or emotional) in extreme situations and determining the functional stability of L-O for the prediction of the flight situation were developed by authors [3].This system (IACS) is proposed to monitor the human condition in medicine, training of athletes, treatment of people and automatic monitoring of individuals who are in dangerous environments, etc. The essence of control system in terms of prints of handling conditions is establishing and description of the relationships and interdependencies between the essential factors, parameters and characteristics of control device (CD) and CO (H).

Algorithm of human's emotional diagnosing and monitoring

1. Definition of phase portrait of human H_n - diagnosis of normal condition by characteristics of performance, movement, communication, etc. [3].
2. Introduction into circuit IACS of human parameters and real-time monitoring of human condition H_n.
3. Analysis of system IACS "CD- human H_n" (current condition)
   a) Determination of system IACS "CD - human H_n" stability;
   b) Determination of area of system IACS "CD - human H_n" stability;
   c) In case of violation of system IACS "CD - human H_n" stability, system correction is required;
   d) Determination of characteristics of links for human condition correction.
4. Synthesis of new corrected system IACS "CD - human H_{n+1} ".
5. Analysis of new system IACS "CD- human H_{n+1}" (current human condition).

For testing single system approach to the researching of polyergatic systems it is advisable all diversity of management systems to reduce to several typical systems, in which main elements are distinguished, and it's functioning should be estimated during investigation of any system.

Using dynamic modeling method for solving the problems of complex technical ergatic systems maintenance can lead to exactly the same models. The approach lies in construction of the system of equations, which describing CO, H-O equations of automatic control system (ACS), analysis of control system (CS) for the stability, synthesis of new reliable system. [3; 4].

Modelling, analysis and synthesis of IACS "CD-H" by algorisms

IACS "CD –H" – could be displayed by following functional diagram (Fig. 1), which reflects activity DHO in case of H condition monitoring, i.e. during changes of blood pressure H - $\Psi ф$.

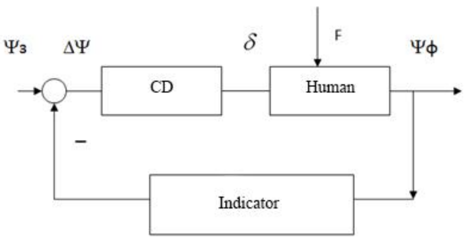

Fig 1. Functional diagram of IACS "Control device (CD) – H"

During identification with the help of indicators of deviation $\Delta\Psi$ ($\Delta\Psi = \Psi ф$ - $\Psi з$) actual blood pressure $\Psi ф$ from defined pressure $\Psi з$ of H, CD (or H-O (Doctor)) relevant information is analyzing and controlling action is defined δ until deviation $\Delta\Psi$ disappears. Was obtained of system IACS "CD - human Hn" stability for using criteria: Mikhailov, Nyquist, Hurwitz and area of stability for all coefficients andconstants.

Determination of IACS "CD - H" by the Mikhailov criterion. To find the hodograph by Mikhailov criterion it is necessary to put into a characteristic equation *jw* instead of *p*, received vector *M(jw)* as the sum of the actual *P(w)* and imaginary part:

$$M(p) = (T_2 p + 1)(T_3 p + 1) + K_1 K_2 K_3 K_{ind} K_{CD} (T_1 p + 1)$$

$$M(jw) = (T_2 jw + 1)(T_3 jw + 1) + K_1 K_2 K_3 K_{ind} K_{CD} (T_1 jw + 1) = P(w) + jQ(w)$$

$$P(w) = 1 + K_1 K_2 K_3 K_{ind} K_{CD} - T_2 T_3 w^2$$

$$Q(w) = (T_2 + T_3 + K_1 K_2 K_3 K_{ind} K_{CD} T_1) w$$

Where real part is *P(w)* and imaginary part is *Q(w).*

According to the characteristics of value *P(w)* and *Q(w)* Mikhailov's hodograph is built. Calculation of real and imaginary part of vector *M(jw)* during changing frequency parameter w from 0 to ∞ is possible to proceed with the help of MS Excel. If hodograph covers 2 quadrants (*n=2*) in the positive direction (counterclockwise), system is stable. (Fig. 2).

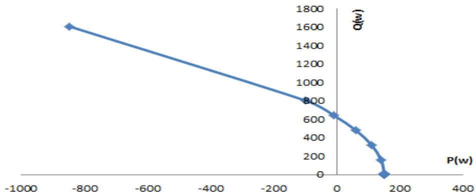

Fig. 2 Mikhailov's hodograph, $T_3 = 1$

Values of time coefficients and constants are shown in Table 1. Changing some coefficients, i.e. coefficient $T_3 = 1$ we are changing to $T_3 = 0{,}1$ (Fig.2), on Fig. 3 we have $T_1 = T_2$, and on Fig.4 we have Kind = 100, Kcd = 100. Therefore, while increasing control coefficients, areas of stability are increasing.

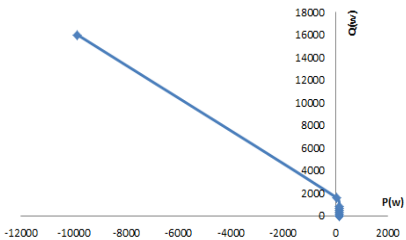

Fig. 3 Mikhailov's hodograph, $T_1 = T_2 = 1$

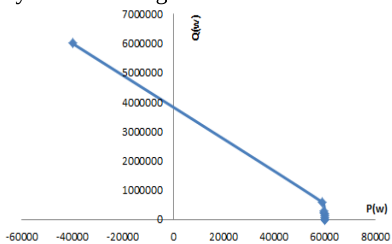

Fig. 4 Mikhailov's hodograph, $K_{ind} = K_{cd} = 100$

Table 1

Coefficients /constants	Values of time coefficients and constants			
	$T_3 = 1$	$T_3 = 0{,}1$	$T_1 = T_2$	Kind= 100, Kcd=100
k1	1	1	1	1
k2	2	2	2	2
k3	3	3	3	3
T1	1	1	1	1
T2	10	10	1	10
T3	1	0,1	1	1
Kind	5	5	5	100
Kcd	5	5	5	100

Determination of IACS "CD - H" by the Nyquist criterion for using algorithm of determination of ergatic system stability [10].

Stability of the system is determined by the Nyquist criterion under appropriate deformation of emotional experience. For example, was obtained aviation system (AS) stability using the Nyquist criterion with consideration of the dispersions by operative model in emotional state. Indication of diagnostics results of current emotional state pilot in flight using dynamic panel display of digital data encoding [9; 10].

There is Nyquist's hodograph without delay for IACS on Fig.5.

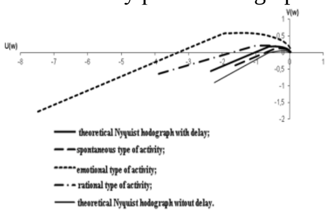

Fig. 5 Nyquist hodograph to diagnose emotional state of H in AS

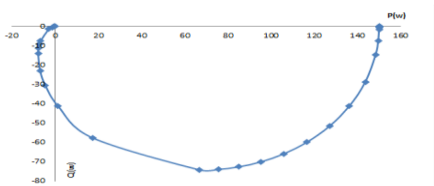

Fig. 5 Nyquist hodograph for monitor the H condition in IACS

Synthesis of IACS on the basis of monitoring and diagnostics of H is made by building transition process. Indicators of quality of IACS and reliability H were defined: over-control, oscillations, time of adjusting, etc. Correction of IACS was help: characteristic of desired system was obtained. Synthesis and adjustment of the system is planned through a variety of methods to improve human wellbeing and regulation of the human condition.

Conclusion

The intelligent automated control system of monitoring and diagnosis of the human condition that is being treated has been proposed. System IACS has been built with the help of dynamic modelling principles, the algorithm of human psycho-emotional diagnosing and monitoring through IACS system has been provided. IACS subsystems have been formalized in the form of transmission functions and algorithm of modeling, analysis and synthesis by methods of IACS automatic control theory has been developed. An example of IACS modelling by analysis of the influence of the time constants and coefficients on the stability and reliability of the system, including and humans has been represented. Therefore, as a CO it is proposed to consider the human, for whom applying diagnosis and monitoring of H condition in comparison to its normal state by the analysis of phase portraits, we can develop methods for adjusting and improving the human condition.

In case of presentation IACS as socio-technical systems it is possible to diagnose, monitor and control of the human condition during the performance of professional activities; the system of monitoring the emotional condition of operator caused by environmental influences (occurrence of a non-standard in-flight situation, accident, psycho-emotional stress) with the definition of relevant stability has been offered. Research can be applied to airlines seeking to achieve high quality of monitoring by LOSA program ("Line operations Safety Audit"), while simulator training for operators [3; 5; 9]. It is planned to define system of indicators of physiological and psychological human comfort from the position of theory of self-organization of complex systems [6], and to investigate practical usage in the fields of medicine [5; 6], psychology [7], aviation [9; 10] and design [6 - 8].

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Analysis of DME/DME positioning facility for Ukrainian airspace

The questions of DME/DME positioning have been discussed. Availability and accuracy of positioning by DME/DME approach were estimated for Ukrainian airspace. In the article, the analysis of current state of NAVAIDS service in comparison with previous one was indicated.

Introduction.

During the last years Ukrainian Navigation Aids (NAVAIDS) infrastructure has been changing rapidly. Several domestic problems were the reason of this changes. In summer of 2016 four DME ground radiobeacons have been suspended for un-predicted time period in eastern and southern regions of Ukraine. Also, new ground based equipment of NAVAIDS were installed for civil aviation service support.

Detection of aircraft location in the airspace is one of the key problems in aviation. Accuracy and availability of coordinate's detection is valuable part of flight safety. Many different approaches have been using to improve positioning losses on board of aircraft.

The main reason of this investigation has been highlighted by aviation safety, because NAVAIDS positioning algorithm is the main of alternative navigation facilities of aircraft [1-3]. Alternative to global navigation satellite system (GNSS) positioning systems play the key roll in case of some problems with receiving navigation signals from satellites. It can be the result of bad satellite geometry, some processes in ionosphere [4] or radio interference with military equipment.

Flight management system (FMS) uses other positioning methods to determine the coordinates in case of malfunction airborne equipment of GNSS or inability to determine the coordinates. In this case we can use other positioning techniques like inertial navigation or positioning by signals from radio beacons. Inertial Navigation System may be used for limited time in consequence of the additive error [5]. Positioning algorithms of FMS are alternative source of position information. It is based on the usage of information from navigation beacons such as NDB, DME, VOR, DVOR etc. [1-3].

Analysis of changes in NAVIDS

Unfortunately, ground based part of DME in eastern and southern areas of Ukrainian airspace has been out of service [6]. It includes the following DME radio beacons [1]:

- DON, Donetsk, 48.0718002319336 N, 37.7359008789062 E;
- SMF, Simferopol, 45.051399230957 N, 33.9793014526367 E;
- KER, Kerch, 45.3708992004395 N, 36.405101776123 E;
- MRP, Mariupol, 47.0750999450684 N, 37.4518013000488 E.

Besides, into the central part of Ukraine eight [6] updated and new DME radio beacons have been installed in last three years. All of new NAVAIDS are providing their services for civil aviation. New DMEs include [6]:

- BAH, Bakhmach, 51.0354 N, 32.5312 E (2016);
- IKI, Kyiv/Zhyliany, 50.23599 N, 30.26265 E (2013);
- IKV, Kyiv/Zhyliany, 50.24040 N, 30.27444 E (2013);
- KSN, Koshany, 50.56455 N, 30.58401 E (2014);
- KVH, Kirovohrad, 48.32405 N, 32.17309 E (2014);
- SLV, Soloviivka, 50.11125 N, 29.34125E (2013);
- STB, Stebliv, 49.24187 N, 31.04364 E (2014);
- YHT, Yahotyn, 50.15544 N, 31.47403 E (2014).

New DME radio beacons fill out the most PBN requirements [7] for air navigation services in Ukrainian airspace and improve navigation facility.

Current NAVAID network in Ukraine consists of twenty DME radio beacons[6] (table. 1.).

Table 1.

Ground equipment of DME in Ukrainian NAVAIDS network

No.	Identi-fication	Name	Latitude	Longitude	Collocated VOR, Identifi-cation	Chan-nel
1	BAH	Bakhmach	51.0354N	32.5312E		114X
2	BRP	Boryspil	50.17085N	30.54035E	BRP	106X
3	DNP	Dnipropetrovs'k	48.21354N	35.0611E	DNP	72X
4	IVF	Ivano-Frankivs'k	48.5303N	24.4129E	IVF	89X
5	IHA	Kharkiv	49.55441N	36.18102E		54X
6	IHR	Kharkiv	49.55367N	36.16395E		48X
7	IKI	Kyiv/zhyliany	50.23599N	30.26265E		54X
8	IKV	Kyiv/zhyliany	50.24040N	30.27444E		20X
9	KHR	Kharkiv	49.55441N	36.17256E	KHR	112X
10	KSN	Koshany	50.56455N	30.58401E		23X
11	KVH	Kirovohrad	48.32405N	32.17309E	KVH	96X
12	KVR	Kryvyi rih	48.03036N	33.12437E		107X
13	LIV	L'viv	49.4843N	23.5705E	LIV	102X
14	ILO	L'viv	49.4854N	23.5653E		32X
15	ILV	L'viv	49.4805N	23.5806E		40X
16	ODS	Odesa	46.2549N	30.4015E	ODS	86Y
17	SLV	Soloviivka	50.11125N	29.34125E	SLV	80X
18	STB	Stebliv	49.24187N	31.04364E		77X
19	VIN	Vinnytsia	49.1424N	28.3715E		86X
20	YHT	Yahotyn	50.15544N	31.47403E		117X

Analyses of DME Availability.

Availability of DME equipment in Ukrainian airspace will be estimated for a net of nodes with a cell in 1 km. For each point of airspace the distance to the DME ground stations is calculated and compared it with the maximum range of beacons. Radio beacon operational range depends on the class as follows [8]:

- Terminal (T). For the true heights from 305m up to 3658m maximum slant range is 46km;
- Low altitude (L). For the true heights from 305m up to 5486m maximum slant range is 74km;
- High Altitude (H).
  a. For the true heights from 305m up to 4420m maximum slant range is 74 km;
  b. For the true heights from 4420m up to 18288m maximum slant range is 185 km;
  c. For the true heights from 5486m up to 13716m maximum slant range is 241 km.

The horizontal range of the DME activity depends on the aircraft altitude and slant range to the ground radiobeacon location. However, relief also should be consider in DME radio signals availability.

In assessment of positioning availability the grid with nodes will be used. Each of nodes of the grid is equidistant from the surface of global ellipsoid (WGS 84) into distance of investigation height. Quantity of nodes determines the accuracy of assessment. Within the cell an availability is considered as a constant. Availability assessment is performed in the global Cartesian coordinate system ECEF (earth-centered earth-fixed) with the next transformation to geocentric coordinate system LLA (Latitude Longitude Altitude).

The results of accessibility estimation to the altitude of 8000 m is shown in Fig. 1. Areas contour indicate the amount of radio navigation stations available in the airspace.

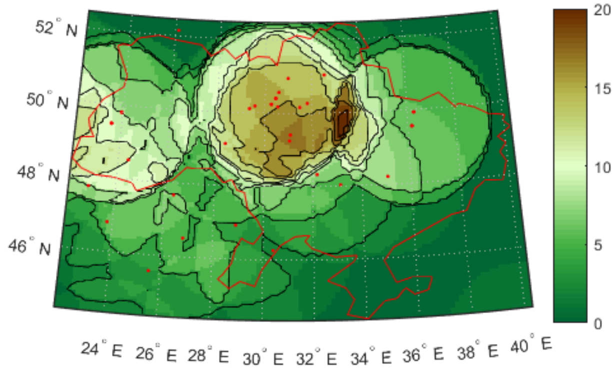

Fig. 1. Amount of available DME station

Analyses of DME/DME positioning accuracy.

Accuracy of DME/DME positioning is analyzing by Dilution of precision (DOP) coefficients. There are three main of them for DME/DME positioning:

– HDOP (Horizontal DOP) – accuracy rate of change in the horizontal plane,

– VDOP (Vertical DOP) – accuracy rate of change in the vertical plane,

– PDOP (Position DOP) – total accuracy rate coefficient.

Multi DME methodology [1-2] is used for DOP coefficients estimation. Results of these analyses are represented on fig. 2.

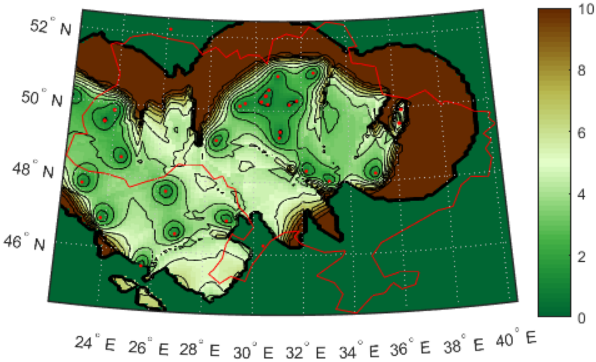

Fig. 2. HDOP

NAVAIDS infrastructure of Ukraine has been changing rapidly for the last three years. Many new equipment has been installed as a result fig.1 and fig. 2 indicates availability of DME/DME positioning with quite good positioning accuracy.

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Timing problem of multi DME/DME approach

The main problem of multi DME/DME positioning approach has been discussed. Timing problem related to avionics structure of civil aircraft that is result of possibility of operation with one pair of DMEs at one time. Recurrent investigation was proposed to solve the timing problem.

Introduction.

Detection of aircraft location is one of the most important tasks in air navigation. Each navigation task is grounded on positioning method. Successful movement depends on accuracy of coordinate detection of the vehicle. In air navigation sphere availability and accuracy of positioning provides flight safety. Nowadays Global Navigation Satellite System (GNSS) provides more accurate global position data than other techniques. GNSS is represented by GPS, GLONASS and GALILEO. Each airspace user has to use GNSS equipment for positioning purposes as the main source of coordinate location. But, sometimes in some regions an accuracy of positioning may be not enough to guarantee the required level of flight safety. It is a result of influence of different factors like pure satellite geometry, process inside of ionosphere, interference etc [1]. There are some specific techniques to solve this problem on board of each modern aircraft.

Nowadays many manufactures of GNSS receivers integrate inertial principle inside of equipment to improve positioning accuracy and increase availability of coordinate data. There are several different approaches to use inertial principle into different levels of data computation inside of receivers. Besides, positive effect of such kind of integration is limited in operation time. Inertial navigation can be useful only in limited time period according to additional nature of errors.

In case of high errors of inertial navigation and absence of data from GNSS, positioning by NAVAIDS is used [2-4]. Many modern flight management systems (FMS) have preinstalled algorithms of location detection by distance and angle data from Automatic directional finder (ADF), on-board part of Distance measurement equipment (DME) or receivers of VOR [2-4]. Usually, it includes the following geometrical principles: DME/DME, DME/VOR, VOR/VOR, NDB/NDB, etc.

In classical scheme of avionics structure (fig. 1) FMS will find radio beacons according to flight planed trajectory and send this data to Radio management equipment that will tune radio navigational equipment of aircraft. Result of measurements will come back to FMS directly from DME, VOR, ADF [5]. Two blocks of each equipment should to be installed on-board of aircraft according to the main avionics requirements. Each equipment of NAVAIDS can operate only with one ground equipment at time. Therefore, at least two distance to DMEs, two angles to VOR and NDB can be proceed at one moment of time.

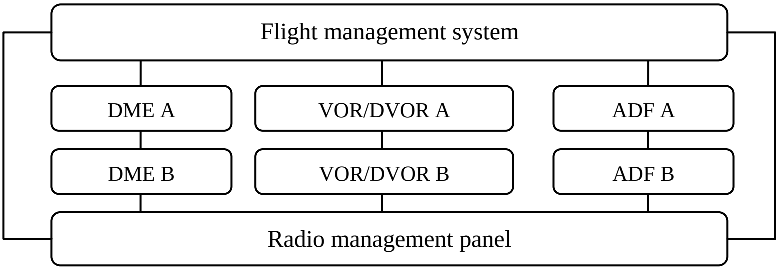

Fig.1. Interchange of NAVAIDS data inside of on-board equipment

Timing in DME/DME positioning

According to data limitation only one pair of DMEs can be used to aircraft location detection. In [3] the main limitation for pairs of DME choosing has been discussed. The direction crossing angle in 30-150˚ is strongly required for RNAV.

Many investigations indicate increasing accuracy of positioning in the result of using multi DME approach. In this case the possibility to get data on board of aircraft from all available DME in operational range is regarded. But multi DME approach can not be realized in hardware, because it will be the result of increasing sizes and prices for equipment. In other hand, there are some mathematical approaches to use multi DME approach. The main problem in multi DME approach is timing. Let’s discus a situation with four DMEs (fig.2) and aircraft that flies in their operational range.

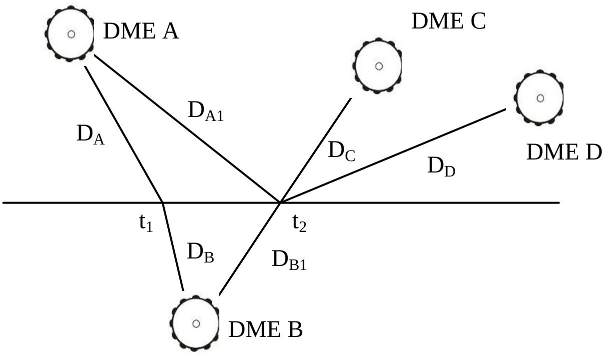

Fig. 2. DME pairs operation

FMS operates with ground stations A and B at time t1, because at one time FMS can get information only from two DMEs. As a result distances DA and DB can be measured. Later at time t2 FMS tune DME equipment for operation with the next pair of DMEs which is represented by C and D ground stations. After distance measurement DC and DD will appear. Also, at time t2 data from previous DME pair are not active, because aircraft has changed the location. Therefore, distances

$D_A \neq D_{A1}$ and $D_B \neq D_{B1}$ and as a result can not be used in multi DME approach together with a second pair CD.

Many algorithms loose difference between D_A and D_{A1} and consider a result in total errors.

In other hand timing problem of multi DME can be solved by using classical approach to predict distances D_{A1} and D_{B1} by previous measurements.

If we can use that aircraft acceleration is absent, we can estimate aircraft location by two previous measurements. But, at first we should use data from the first DME pair to calculate radial speed:

$$V_D=(D_i-D_{i-1})/T,$$

where

i – iteration number,

T – time of observation.

After second observation we can use radial speed to extrapolate DME data for the next period of time:

$$Di=D_{i-1}+V_D T.$$

Extrapolated distance for DME A and DME B can be used together with distances to DME C and DME D in multi DME approach.

Conclusion

Multi DME/DME approach in positioning is more accurate than positioning by pairs of DMEs. Represented approach can be easily used in typical avionics structure to use multi DME algorithms inside of FMS.

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Determination of geographical coordinates of the spacecraft at limited number of visible navigation satellites

The way of determination of geographical coordinates of the spacecraft using on the onboard navigation receivers, an antenna array and the gyroplatform with three gyroscopes is presented. Results of mathematical modeling are given.

Space technologies are being implemented in almost all spheres of human activity: military application, this remote sensing of Earth, communication, navigation, supervision and many other things. By 2012 in orbits around Earth are functioned the really 994 space crafts. The majority of them are acted in the low-orbital area and on geostationary orbit (47% in low orbits, 42% in a geostationary orbit, the others on middle, high-elliptic and ultrahigh). Together with expansion of development of near-earth space also its technologic pollution amplifies. Sources of a technologic pollution of near-earth space are very various. The space debris is formed at start, orbital injection and during operation of the spacecraft. The most powerful source of formation of space debris is destruction of space crafts. The official catalog of the monitoring system of a space of the USA for October 3, 2012 contains 16 530 catalogued space objects, of which 3537 are the payload, 12 993 are launch vehicles airframes and fragments of them.

Struggle with space debris became global problem [1]. One of the major problems at the solution of this problem is the development of navigation and ballistic support service spacecraft – cleaner of spacecraft.

Tendency of the last time there is the transition to autonomous (onboard of spacecraft) navigation systems. The autonomous navigation system allows to increase the accuracy and efficiency in comparison with a land segment of management and to reduce costs of spacecraft flights. Since longer passive parts of the orbital motion, autonomous navigation of service spacecraft is based on using all the time developing satellite radio navigation systems.

When spacecraft flights at high, especially high elliptic orbits, satellite radio navigation systems use is associated with a number of features. One of them is the fact that for the service spacecraft with geosynchronous and high elliptical orbits, the most probable number of visible navigation satellites does not exceed four. In the last decade, intensive searches of way to support navigation in an uncertain field of radio navigation are conducted.

The analysis of development of technologies of use of GNSS signals shows that onboard equipment in the spacecraft several navigation antennas and, in particular, the antenna arrays are often used.

The installation of antenna array on the rigid, focused in own coordinate system, the determination of geographical coordinates of spacecraft and the measurement of a phase difference of navigation signals on 4 elements of antenna arrays has allowed to solve a problem of calculation of orientation angles of spacecraft in geocentric coordinate system [2].

In this paper, we solve the inverse problem: the determination of the geographical coordinates of spacecraft to measure the phase difference of the navigation signals in the 4 elements of the antenna arrays and the orientation angles of spacecraft in the local coordinate system, measured using the gyro platform installed on board with 3 gyroscopes. A mathematical model is developed and carried out a study of accuracy characteristics.

Mathematical model

We will use designations:

e_x, e_y, e_z – Euler angles between the own coordinate system (CS) and geocentric moving coordinate system (GMCS);

α, β, γ – Euler angles between the own and the local coordinate systems. The relationship between these angles is represented by expressions:

$$\alpha = e_x - (\frac{\pi}{2}) \div B, \; \beta = e_y, \; \gamma = e_z - (\frac{\pi}{2}) - L,$$

where B – geographic longitude, L – geographic latitude.

As shown in [2] relationship between Euler angles (e_x, e_y, e_z) and the phase difference is determined by the expression:

$$d_{m,j} = l_m \left(\bar{\mathbf{r}}_j^{GMCS}\right)^{\mathrm{T}} \mathbf{U}x\left(e_x\right)\mathbf{U}y\left(e_y\right)\mathbf{U}z\left(e_z\right)\bar{\mathbf{l}}_m^{CS},$$

where l_m – the length of the line between antennas array element;

$\bar{\mathbf{r}}_j^{GMCS}$ – direction vector of direction line between the j-th satellite and receiver of geocentric moving coordinate system;

$\mathbf{U}x(\;), \mathbf{U}y(\;), \mathbf{U}z(\;)$ – rotation matrix of coordinate system

$\bar{\mathbf{l}}_m^{CS}$ – direction vector *m*-lines of antennas array in GMCS;

m – number of line between the elements of antennas array;

j – number of the satellite from which the signal is received.

Iterative algorithm for determination of vector $\psi = (\alpha, \beta, \gamma)^T$ the orientation angles are obtained according to the maximum likelihood method:

$$\hat{\psi}_k = \hat{\psi}_{k-1} + \left(\mathrm{H}_{k-1}^T(\hat{\psi}_{k-1})\mathrm{H}_{k-1}(\hat{\psi}_{k-1})\right)^{-1}\mathrm{H}_{k-1}^T(\hat{\psi}_{k-1})\mathrm{D}_n^{-1}\left(\mathrm{y}_d - \mathrm{h}(\hat{\psi}_{k-1})\right),$$

where

$$\mathrm{H}_{k-1}(\hat{\psi}_{k-1}) = \frac{\partial \mathrm{h}(\hat{\psi}_{k-1})}{\partial \psi};$$

$$h(\psi)=\begin{vmatrix} l_1(\overline{r_1}^{GMCS})^T \mathrm{Ux}\left(\alpha+\frac{\pi}{2}-B\right)\mathrm{Uy}(\beta)\mathrm{Uz}(\gamma+\frac{\pi}{2}+L)\overline{\mathrm{I}_1}^{CS} \\ \vdots \\ l_M(\overline{r_J}^{GMCS})^T \mathrm{Ux}\left(\alpha+\frac{\pi}{2}-B\right)\mathrm{Uy}(\beta)\mathrm{Uz}(\gamma+\frac{\pi}{2}+L)\overline{\mathrm{I}_M}^{CS} \end{vmatrix}.$$

For solution of this problem it is necessary to accept $\Psi=(B,L)^T$ and the transform matrix $H(\Psi)$.

The complex of programs in MatCad packet are developed for implementation of the model, that allows to research statistical dependence of mathematical expectation mS, a mean square deviation sS, a spherical error of determination B and L from the random (normal) navigation error detection (with parameters $m_k=0$ and σ_k), and also from errors of a phase difference measurements (with parameters $m_g=0$ and σ_g) and at change of number of navigation satellites NS from which signals are accepted.

Simulation of results

Dependence of a spherical error of determination of geographical coordinates from errors of navigation definitions is given in table 1

Table 1

σ_k, м	0	1	10	100	1000
mS, рад	0	$3.8 10^{-8}$	$3.8 10^{-7}$	$3.8 10^{-6}$	$3.8 10^{-5}$
sS, рад	0	$2.2 10^{-8}$	$2.2 10^{-7}$	$2.2 10^{-6}$	$2.2 10^{-6}$

Data from table 1 shows that the statistical definition of spherical error geographical coordinates are increasing in direct proportion to the growth of navigation definitions errors.

The dependence of the spherical error of determination of the geographical coordinates of the phase measurement errors are shown in table 2.

Table 2

σ_g, deg	0	0.5	1	2	3	4	5
mS, rad	0	$6.8 10^{-3}$	0.012	0.023	0.032	0.042	0.052
sS, rad	0	$4\cdot 10^{-3}$	$7.4 10^{-3}$	0.013	0.019	0.026	0.031

Analysis of the data from table 2 shows that in the case of phase errors observed directly proportional relationship.

The dependence of the spherical error of determination of the geographical coordinates of the number of satellites is shown in table 3.

Table 3

NS	1	2	3	4	5	6	10
mS, rad	136	0.048	0.024	0.023	0.021	0.018	0.014
sS, rad	508	0.031	0.014	0.012	0.011	0.01	0.007

Data from table 3 shows that the determination of the geographical coordinates of the spacecraft can be carried out in the presence of signals from 2 navigation satellites.

The system consists of navigation receivers, antenna array, sensor of the phase difference of navigation signals on the array elements, gyroplatform with 3 gyroscopes and calculator software solves the problem of determination of the geographical coordinates of the spacecraft, even if in the zone of visibility are less than 4 navigation satellites.

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Noise-protective screen

The analysis of one of the technical solutions for the creation of acoustic comfort in the instrument compartment in particular the carrier rocket. It is shown that the change in cross-section, and stiffness of the screen elements allow to increase the dissipation of sound energy to a level that is specified in the passport.

This construction refers to Mechanical engineering and can be used in aviation and rocket-cosmic technics for protection the facilities, pressure cells and biological objects from high power noise.

There is a known noise-protective screen (NPS), which includes a body with one-sided layer of sound absorbing material, and a case, in the shape of, distantly allocated under the body, perforated sheets (see, A.c. USSRP № 1582193, G10 K11/16, 1990).

The drawback of this NPS consists in the structural complexity, this sets conditions for the availability of a big amount of features in the NPS.

There is also a well-known NPS, that includes tough cylindrical case with length way apertures in side walls, placed on the protected body of a glass shape and allocated with an air gap, outside the body, and also a washer [1].

The drawback of this NPS is in deficient acoustic protection efficiency. This sets conditions for walls of the case to have a small inflexibility, because of aperture availability in the walls; the propagation of sound waves in the air gap between case and body occurs without obstructions.

Among known engineering solutions the most acceptable, by its construction, technical essence and attainable result, is the NPS, (look, e.g., the patent of France № 2652938, G10 K11/16, 1991, or its summary on the page 11 in the magazine "The inventions of the world", "Musical instruments and acoustics", Moscow, release 97, № 1) which includes a body and an elastic hermetic casing (mattress is filled with a special gas and equipped with a facility for securing the circulation of the gas in the cavity of casing).

The drawback of this NPS consists in a small acoustic protection efficiency.

This can be explained, by two dominant causes. The smooth surface of casing, which does not secure the crossing between reflected from the surface sound waves, underlies the one reason. The other reason lies in the fact, that the casing is filled with gas. That is why the cavity is permeable for sound waves.

The other drawback of the NPS is a necessity, for its work, in the availability of gas with special features and apparatus for its admission, and the gas circulation supply in the casing. This sophisticates the construction, extends the material consumption and outer dimensions.

The third drawback of the NPS is in a low reliability; when the tightness of casing disturbs then the working-capacity of the NPS completely loses.

Underlie the proposition there is the assigned task to improve the NPS. The improvement can be reached by changing the form of casing and the shape of its cavity. Consequently the rise of the sound protection efficiency is secured at the synchronous simplification of construction, at the decline of materials consumption, outer dimensions, and the growth of reliability.

The assigned task can be solved in consideration of such fact that the NPS includes a body and a hermetic casing, allocated on its surface. According to the invention, the casing is made of hollow hoops, allocated in alignment, gathered endwise with apertures without an air gap, where the air is removed.

The difference of the NPS is that hoops have the shape of coils, fitted to each other.

The realization of casing in shape of hoops, allocated in alignment, gathered endwise without an air gap, secures the crossing of, reflected from its surface, sound waves, and raises the level of sound energy dissipation in the air, adjoined to the hoops. Consequently, the acoustic protection efficiency grows.

The air, removed from the hoops, transforms their cavities into absolutely tight for sound areas, through the lack of any substance that will be able to relay sound waves in it.

In the issue, the hermetic casing turns, partially, or, completely, into non-transparent for sound waves, this reduces to the furtherer acoustic protection efficiency rise.

At the same time, the air removal from the hoops, eliminates the necessity of using the gas and its server, this simplifies the construction, reduces the material consumption and outer dimensions.

Therewith, the execution of casing in the shape of air-free hoops raises the reliability, because during the depressurization of one (or some), hoops continue to work.

The hoops implementation in the shape of coils reduces their amount in the casing. Such construction simplifies the manufacture and is very important for bulky objects, for example rockets. For small-size objects, coil shape secures the casing receipt, by means of coiling the block on the body of object (pipe) of a proper length.

The NPS is schematically introduced on the fig.1, the general form; on the fig.2 – the A location on the fig.1; the variant of the NPS fulfillment on the fig. 1; on the fig. 3 is the version of fulfillment of the NPS.

The NPS includes the body 1 of glass shape. On its surface there is the hermetic casing 2. The casing 2 is made in alignment in the shape of hollow hoops 3 that are gathered endwise without air gap, from cavities 4 of this hoops the air is removed. The hoops 3 on the surface of the body 1 can be allocated into one line 5 or into some, for example, into the lines 6 and 7 (fig. 2). The allocation of the hoops 3 into two lines secures the casing 2 of total wall K thickness with C diameters of contacting hoops cavities altitude overlapping. It additionally increases the acoustic protection efficiency. The hoops 3 are made of metal or other material, which has a sufficient inflexibility and high sound reflecting ability, for example, of polyvinyl chloride. The space between hoops can be filled with the sound absorbing material 8. The hoops 3, besides plain form (fig. 1and fig. 2), can also possess (fig. 3) the shape of the coils 9, which, in addition, contact with each other, by the ends 10, during their gathering.

Such form of hoops simplifies the manufacture of bulky casings, for example, casings for cargo bays of rockets.

For using, the NPS is installed on the protected object 11, for example, a gyroscopic facility, and is fastened on the basis 12.

The principle of the NPS operation is following.

When the intensive sound field P, its waves, work on the NPS, namely, the waves 13, 14, 15, obtaining the bulging surface of the coils 3 of the casing 2, partially, reflect from it in the shape of the waves 13', 14', 15', that crosses with the waves 13-15 and, in addition, between each other. This increases the number of sound waves cross points in the acoustic field. The growth of sound waves cross point number reinforces their energy dissipation in the environment.

Other group of the sound waves 13-15 penetrates into the walls of the hoops 3 and sharply brakes, by the non-air cavities 4. And, consequently, this group, intensively, dissipates through the material of coils at the expense of the inside friction. The availability, on the way of the sound waves 13-15 of the non-sound-penetrating for them, cavities 4, especially in the casing 3 between two lines 6 and 7 of hoops (fig. 2), and the additional dissipation of sound energy, in the issue of reflected sound waves crossing, leads to the significant growth of acoustic protection efficiency. The NPS with some lines of hoops is almost non-penetrating (non-transparent) for sound waves.

Also in the NPS, besides growing of acoustic protection efficiency, the necessity of using a special gas, a device for its supply, and circulation falls away. This simplifies the construction, reduces the resistance, decreases the materials consumption and outer dimensions, by, simultaneously, the reliability raising.

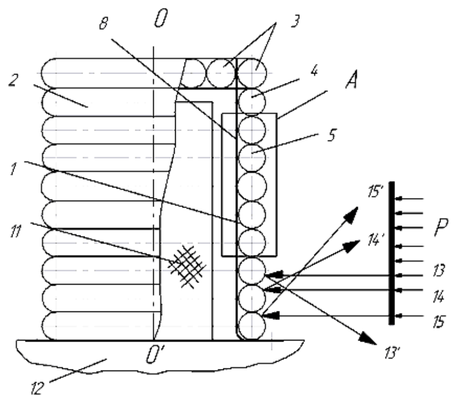

Figure 1

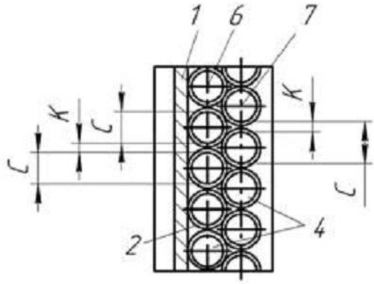

Figure 2

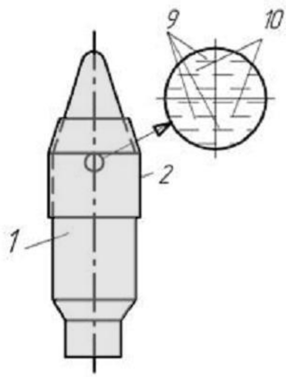

Figure 3

The invention can be used for protection from the aerodynamic noise of chambers with useful load of carrier-rockets, pressure cells and gyroscopes in hydro equalized platforms and in integrators of lengthwise accelerations of rockets, in aerospace complexes for multiple using, in heavy planes, biological objects etc.

Conclusions

Thus, the screen in the form of a corrugated tube, is effective for noise-suppression and thus quite simple to manufacture.

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The nature of resonance features in the suspension of the gyroscope due to diffraction effects

It reveals the nature of the appearance of liquid in the static part of suspension of the floating gyroscope area of energy activity, which are caused by sound waves penetrating differentiation. Formed the outlines of the premises of the "caustic zone"

We choose as the research object two-stage float gyroscope. In the case when the geometric dimensions of the cylindrical body floating gyroscope, for example, class DUSM or DUSU considerably exceed the sound wavelength in the suspension device of liquid in the static portion excitation zone may be observed, i.e. an area where a sufficient degree of accuracy the condition of coincidence of the incident wave track speed with the speed of the waves excited in the shell. There is, therefore, focusing energy penetrating acoustic radiation, which takes the form of caustic surface (from the Greek kaustikós -. stinging, burning). This surface is the envelope of the acoustic beams emanating from the same point of the cylindrical body of the float device as a consequence of its longitudinal and transverse vibrations. The result is a sharp concentration of the energy of sound waves inside liquid in the static of the suspension, accompanied by a significant increase in the sound pressure level [1, 2].

We expand some aspects of the nature of the emerging power of the past focus acoustic radiation. For the purpose of clarity, let us study the mechanism of action in the middle of the frames. For simplicity, assume initially that the float inside absent. Thus, the cylindrical body DUSU sound wave from outside affects R. It generates circumferential vibrations in the material $U_{\varphi}(t,z,\varphi)$, which extend in the direction parallel with the speed V_{np}, that is, on the side surface of the housing and bending, radial vibrations $W(t,z,\varphi)$ in plane with the frame rate V_{nn} [1].

Let us analyze first of all the mechanism of action the district wave. Considering the side of the body shell DUSU large wave sizes, i.e. having properties $1\rangle kR$ (k - wave number), possible to consider a single element as the inner surface of the frame plate of zero curvature, velocity of longitudinal waves which coincides with the circumferential speed of the shell V_{np}.

If the velocity of the longitudinal wave V_{np} speed of sound c_0 in the fluid, i.e.

$$V_{np} > c_0 ,$$

then running along the parallel wave will radiate into the liquid sound wave, and its direction will be the vector rate V_{np}, angle α, defined by the expression:

$$\sin\alpha = \frac{c_0}{V_{np}} .$$

As a result, much of the sound wave energy will concentrate near the circle of radius r_1 [2]

$$r_1 = R\cos\alpha .$$

For example, if we assume for concreteness radius of the inner cavity of the body equally DUSU $R = 1{,}50\, sm$, material of the body considered aluminum ($V_{np} = 6400\, m/s$, $V_{nn} = 3080\, m/s$), liquid in the static suspension, for example, glycerol ($c_0 = 1923\, m/s$ at a $t = 20\ ^0C$) and a frequency of ultrasonic beam *f*= 42 kHz, then wave size of the internal cavity of the housing DUSU will be determined by the formula:

$$kR = \frac{\omega}{c_0} R = \frac{2\pi f}{c_0} R \approx 3{,}43$$

Therefore it is possible to obtain

$$\alpha = 17°30^{/}$$

Where:

$$r_1 = R\cos\alpha = 1{,}43\ \left(см \right),$$

That caustic surface is the inner surface of the housing at a distance from DUSU 0.7 mm.

Obviously, if while $V_{np} = c_0$ then $\alpha = \frac{\pi}{2} rad$ traveling along and parallel wave will radiate a sound wave into the fluid, which crosses the axis of suspension of the float.

Thus, it disappears aberration and caustic surface will become a locus of the points of concentration of energy located on the longitudinal axis of suspension.

Similarly, if $V_{nn} = c_0$, then $\beta = \frac{\pi}{2} rad$ and caustic not formed by surface transverse wave body.

For the same reason, the transverse wave (flexural wave in the radial direction) will result in a concentration of energy near the circumference of radius r_2:

$$\sin\beta = \frac{c_0}{V_{nn}} \approx 0{,}67 ;$$

$$\beta = 42° ;$$

$$r_2 = R\sin\beta = 1{,}68\ \left(sm \right) .$$

Since the radius of the float of 2 cm, it is obvious that the radius of the caustic surface disappears, and the surface radius - will remain (Figure 1). Caustic surface radius clearly delineates the field of acoustic shadows in liquid in the static part.

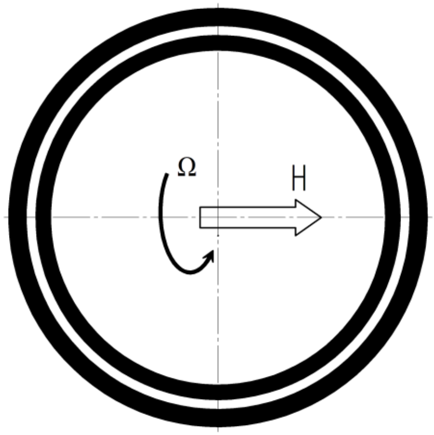

Figure 1. Focus penetrating radiation energy in liquid in the static path of the float suspension.

It is obvious that by choosing appropriate housing material and liquid can influence the nature of the surface caustics zones (from the Greek zone - Surface between any boundaries, which is characterized by certain features). Or, for example, make them discrete-continuous [3].

If you use the methods of acoustic radiation, it is possible to classify the phenomenon is considered as a sort of aberration (from the Greek aberration - deviation from normal) of the sound waves. Aberration – free structures have been known to the caustic surface becomes a point and thus in this case will be located on the longitudinal axis of the float housing gyroscope.

The irradiation of the body of the float device sufficiently broad beam sound that way and observed under operating conditions in the form of reverberant space unit control units (PCU), matching the resonance can occur for both transverse and for the district of waves.

In addition, part of liquid in the static suspension may also occur radial band sound radiation energy concentration as a result of interference phenomena. They take the form of alternating dark (acoustic shadow) and light stripes, but not intensive such as surface radius, r_1 and r_2 [2].

As shown by experimental studies, caustics surface zones in the frame plane confocal interior of the housing. Thus, circular in this case the caustic confocal with the inner circumference of the frame of the device housing.

Conclusions

Thus, under operating conditions the float gyroscope may have additional errors, caused by resonance effects in polyharmonic suspension of gyroscope, which involves the need to create acoustic comfort for navigation and pilot equipment.

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Noise-protective case to fight the penetrating acoustic radiation

It analyzes the work Noise reduction enclosure based on passive methods of struggle with penetrating acoustic radiation the operational mode of the flight product. The efficiency of the slotted screen to create a comfortable environment in the control unit of the device. The technical solution has significant novelty and patented in Ukraine.

This device attributes to Mechanical engineering and can be used in aviation and rocket-cosmic technics for protection facilities and pressure cells from noise of high power. There is a known noise-protective case (NPC), which includes a body and an inflatable elastic casing, hermetically connected to the body. This casing is filled in with gas, the velocity of sound propagation in this gas transcends the velocity of sound propagation in the air (look, e.g., the patent of France № 2852938, G10 K11/16, 1991, or its summary on the page 11 in the magazine "The inventions of the world", "Musical instruments and acoustics", Moscow, release 97, № 1).

The drawback of this NPC consists in a low reliability: when the tightness breaks, the NPC loses its working capacity.

There is also a well-known NPC, which includes a rigid body of glass shape, put on the protected object, a cylindrical screen, that is allocated with an air gap, from outside of the body, and also a thickening washer [1].

This NPC is the most suitable, because of its technical essence and the attainable effect.

The drawback of the NPC consists in its deficient sound resistance, consequently, the acoustic protection efficiency reduces.

Mentioned drawback can be explained, by fact, that case sidewalls possess a small inflexibility, and propagation of sound waves, in the air gap between screen and body passes without barriers.

At the root of proposal there is a problem of the NPC improvement, by selecting the optimal screen aperture sidewalls form. This will secure the growth of proposal's inflexibility and the accessory energy dissipation of sound waves. Consequently, the sound resistance raises, then the acoustic protection efficiency increases.

This problem can be solved, by improving the NPC. The NPC includes a cylindrical body of glass shape, a screen, which is allocated with an air gap, outside the body, with rectangular elongated apertures in sidewalls, and also a washer. The screen is equipped with ledges that overlap the air gap in width.

The screen rigging with radial ledges increases a sound energy dissipation, due to the rising of inflexibility and the accessory braking of sound waves in the air gap. All above mentioned promotes growing of the NPC sound resistance, so the efficiency of acoustic protection raises.

The NPC is introduced on the fig.1 (a), general form; on the fig.1 (b) – look from the top of the fig.1 (a); on the fig. (c,d) – the variants of forming (location) of ledges.

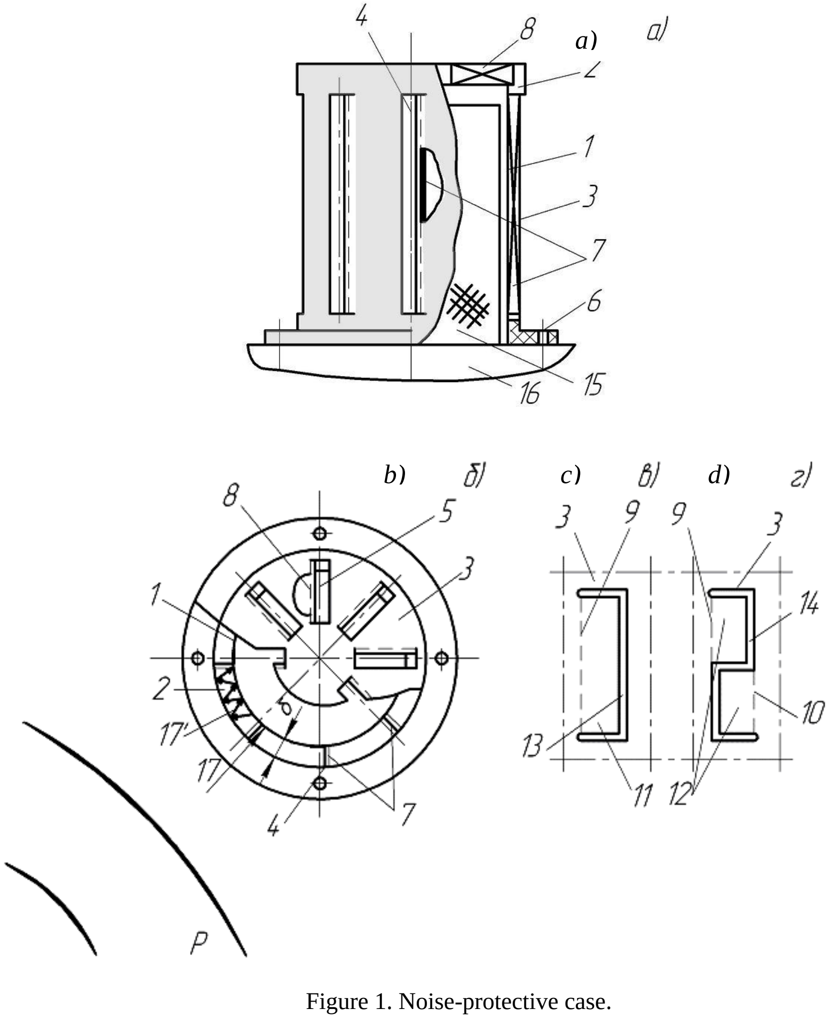

Figure 1. Noise-protective case.

The NPC includes the cylindrical body of glass shape 1, outside it there is the air gap 2 and the screen 3 with rectangular elongated apertures 4 on the lateral surface, and apertures 5 on the end surface. The body 1 and the screen 3, allocated in alignment, and linked with each other with the help of damping, for example, rubber cushion 6. The screen 3 is equipped with radial ledges 7, 8, that are situated on its cylindrical and front sidewalls and overlap the air gap 2 in width "δ". Ledges 7, 8 can be derived, when apertures 4, 5 are forming, by the way of flanging (bending) along one 9 (fig.1.2(c)), or along both 9, 10 (fig.1.2 (d) long borders of each aperture of tabs 11, 12, which are made after gashes 13, 14 are done. The implementation of ledges 7, 8 of flanging shape simplifies their making and secures the growth of screen inflexibility, and, in such way, it is used for supplemental sound energy dissipation in the air gap 2. When in use the NPC is installed on the protected object 15, for example, gyroscopic mechanism, and is fastened to the basic 16.

The principle of the NPS operation is following.

When there is an influence of the floor P in sidewalls of screen 3 on the NPC, then compound forms of bending vibrations appear [2]. As the result of it, one part of sound energy absorbs at the expense of internal friction, the other passes through sidewalls of screen and body, and considerably weakened reaches the protected object 15. In connection with the fact, that ledges 7, 9 are made of flanging shape and can be deformed together with sidewall, they even a part of, emerging in sidewalls, bending efforts (deformations). This sets conditions for growing of sound energy propagation (absorption) that, in addition, raises the general sound resistance of screen walls.

Besides mentioned higher, part of sound energy, that influences the NPC, penetrates through the apertures 4, 5, and obtains the outside surface of the body 1, for example, in the form of the sound wave 17 beam. After the reflection of the sound wave from the body surface, a part of this energy conveys along the air gap 2 and, obtaining the ledges 7, 8, partially, absorbs by them. This generates an accessory sound resistance of the NPC.

Thus, the rise of the NPC sound resistance by the screen inflexibility growing and, in addition, the sound energy dissipating by radial ledges, increases the sound protection efficiency.

The invention can be used for the protection from the aerodynamic noise of pressure cells and gyroscopes in the hydro stabilized platforms, and the integrators of lengthwise rocket accelerations, in aerospace complexes (systems), for multiple use "MACS" or "Svityaz", on the heavy aircrafts Ant-225 etc.

Conclusions

Thus, passive acoustic techniques are quite effective and in demand on the aircraft. Slit screen has the feature that is used in the process of sound proofing it uses bulk nonlinearity of the resonant level.

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Development of aeronautical industry and engineering in Costa Rica

The objective is to inform the international community of the achievements that Costa Rica has been reached in aeronautics and how the Costa Rica Institute of Technology, University at the forefront in the region has been getting involved as co-founder of Costa Rica Aerospace Cluster.

It was in the early twentieth century that begins in Costa Rica the operation of air transport, with the coming of the first plane arrived disarmed to the port of Limon on 1 January 1912, which was the first to cross the Central American sky; He was followed by a Bleriot airplane piloted by Jesse Seligman, covering about 7,000 ms in the Llano Grande de Mata Redonda.

The first Latin American Air Navigation agreement was approved by Law No. 36 of November 22, 1928. Performing the first commercial passenger flight on December 29, 1928, a Pan American Aircraft type of Sikorsky, this landed in La Sabana.

On November 13, 1929, with the Decree No.19, it was created the General Directorate of Civil Aviation under the Ministry of Public Security on the following grounds:

"The existence of a Department in the Administration to take charge everything related to the receipt and dispatch of aircraft, as well as make regulations and appropriate steps to ensure proper control and proper functioning of air traffic is indispensable"

On March 2, 1932 began operating the first local air transport company: National Air Transport Company (E.N.T.A) under a contract made with the Government of Costa Rica for the transport of cargo and people at the local level; which it was established in Costa Rica to operate places: Limón, San Isidro del General, Puntarenas and Liberia.

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In 1933 the company was founded National Airline to operate at local level.

On April 30, 1937, the Government decided to build the International Airport La Sabana, which was officially inaugurated on April 7, 1940, becoming the one of the first milestones in the development of aviation in Costa Rica.

On January 16th, 1939 through the merger of E.N.T.A and National Airline, born ENTA-AEROVIAS consortium. This was subsequently acquired by the company "Transportes Aereos Centroamericanos (TACA). The Company held a monopoly on local air services for nearly a decade.

On October 16, 1945, Costa Rica signed a contract with PANAMERICAN, in which is created the "Lineas Aereas Costarricences S.A" company (LACSA), constituting its capital as follows: 40% of the shares by the Company PANAMERICAN, 40% to private partners and the remaining 20% to the Costa Rican

State. His concession allowed it to make domestic flights until 1949, the date on which the Government granted authorization to operate as a national flag Air Company with regular flights abroad.

By Decree No.173 of September 17th 1948 a Board of Civil Aviation under the Ministry of the Interior and Police, but was created autonomous in their technical functions, in charge of the preparation was entrusted a bill to fix the authority, duties and procedures, both technical and administrative levels, a National Directorate of Civil Aviation. The Board developed this project with the advice of the International Civil Aviation Organization (ICAO), the Attorney General of the Republic and from information legislation in civil aviation made in more advanced countries in this field. As a result of its action Law No. 762 of October 26, 1949, published in the Gazette No. 240 considered the first General Civil Aviation Act promulgated national character.

With this Law all matters relating to air transport is defined and the Directorate General of Civil Aviation is created as dependence on the same board. In 1963, with the creation of the Ministry of Transport, the Directorate General of Civil Aviation becomes part of the dependences of the new Ministry.

On March 2, 1958 was officially inaugurated the facilities of the airport "El Coco"; today called Juan Santamaria International Airport, under the government of Jose Figueres Ferrer. The new airport was receiving large aircraft such as the DC-6 and Convair 340. Small aircraft continued landing at the airport of La Sabana because they had their hangars lined up on the north side of La Sabana. This airport stopped working on December 21, 1975 when the Tobias Bolanos Palma International Airport was inaugurated near Pavas.

In this decade new aeronautical companies with small planes offer their services to remote areas of the country that then had no other means of transportation, so many airfields are conditioned, allowing bringing development to many of these communities.

Also, in order to provide service aircraft maintenance and conversion of the company TACA founded an independent corporation: Latin American Aeronautical Services SA. (SALA). The company performed these works with such high quality that deserved international recognition. In 1963, there was the bankruptcy of the company which led to a group of former employees founded the Cooperative Air Industrial Services R.L. (COOPESA), with participation of the state as shareholder, through Law No. 3319 of October 17, 1963 and to this operation.

On May 14, 1973, the new General Civil Aviation Law No. 5150, currently in force as a regulator of the Civil Aviation of Costa Rica is issued.

Currently the country has 200 airports between which are the international and national levels, as well as airfields government, municipalities and private organizations.

On 25 July 2010 the National Council of Aerospace Research and Development CONIDA is created. Created by Presidential Decree No. 36102, has been led by the Ministry of Science, Technology and Telecommunications (Micitt) and has become the benchmark and advisory body for aerospace development of the country, reaching all sectors of society: government, academia, private sector and civil society.

Are active members of this Council, the Ministry of Foreign Affairs (Foreign Affairs), the Foreign Trade Promoter (PROCOMER), the Costa Rican Coalition for

Development Initiatives (CINDE), el Tecnologico de Costa Rica (TEC), the People's Bank of Development community of Costa Rica (BP) and the Central American Association of Aeronautics and Space (ACAE).

The CONIDA has defined its vision to position Costa Rica on the aerospace development map by promoting international participation, and strengthen their endogenous capacities.

On March 8, 2016 with the aim of placing Costa Rica on the world map of the aerospace industry, a group of 25 companies in sectors such as electronics, metalworking and specialized services joined to form the Costa Rica Aerospace Cluster (CRAC). This group aims to position the country as a solutions provider for the international aerospace industry.

On 25 May 2016 the National Council of Rectors CONARE, umbrella organization represented by the rectors of all public universities in the country, recognized in all its scope, the first specialty engineering in aeronautical grade level approved in the region by a public university. This is how the Costa Rica Institute of Technology, promoter of this specialty in engineering, is preparing to open its doors to new students of this new career, from 2018.

Conclusions

Although the development of aeronautical engineering in Costa Rica and the Central American region was stalled by internal political affairs for many years, it is good to emphasize that the MRO internationally recognized, was founded in Costa Rica, as was the company SALA (Aeronautical Services from Latin American) in 1960 and became COOPESA, in 1963. Since then aeronautical engineering was stagnant until 2010, with the decree No. 36102 the state begins to support this type of industry.

The Costa Rica Institute of Technology, through its Institutional Commission for Aeronautical started working since 2008, when the first meetings with officials CINDE and PROCOMER took place, with the aim of organizing companies were within the country and they provided a service to the international aviation industry. Thus it was encouraged that entrepreneurs know and positive synergies that could boost the aviation joint development be created. In addition, with the main objective of creating niches of possible workplaces for graduates of a new career that was to begin formulating future. Thus it is how, under the leadership of PROCOMER, begin in 2010 to have meetings between companies, academia and government, with the Tecnologico de Costa Rica's first university as a strategic partner interested in developing the aviation industry in Costa Rica which today has become one of the most dynamic industries in the country.

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Navigation and ballistic support spacecrafts

The problematic tasks of navigation and ballistic support spacecrafts taking into account movement on high-elliptic orbits are considered. The brief summary of possible approaches to the solution of problematic tasks is carried out.

The solution of problems which are solved by the spacecrafts including cleaners of space debris, forces to resolve constantly all new tasks of navigation and ballistic support.

The space ballistics solves the following main tasks:

- the choice of orbits or trajectories of spacecraft at all stages of flight;
- the calculation of the components of management changing an orbit of

spacecraft for achievement of the task which is carried out by it.

Space navigation, at the same time, shall provide flight on an orbit and solve the problems connected with targeting of spacecraft, i.e.:

- determination and forecasting of the actual orbit;
- estimation of results of forecasting;
- accomplishment of maneuvers for maintenance set or error corrections of an orbit [1].

Now autonomous navigation systems are used, for navigation of spacecrafts. The autonomous navigation system allows to increase the accuracy and efficiency in comparison with a ground segment of management and to reduce costs for navigation and ballistic support flight of spacecraft.

Two operating modes of the onboard autonomous system of navigation and orientation are characteristic of spacecraft with correction of parameters of orbits: on passive and active parts of the orbital motion. On passive part of the orbital motion, function of the solution tasks of navigation and orientation can be assigned to the space navigation system and the block of astrocorrection in case of a supporting role of strapdown inertial system of navigation and orientation, and also a plotter of a local vertical. On active part of the orbital motion these tasks shall be completely assigned to onboard inertial system of navigation and orientation [2].

At longer passive parts of the orbital motion, autonomous spacecraft navigation uses satellite navigation systems (GNSS).

When flying spacecraft on high, and especially high-elliptic, orbits using of GNSS, is connected with a number of features.

First of all, unstable radionavigation field. Directional patterns of antennas and parameters of the navigation radio lines GNSS are picked up in such a way that provide the continuous radio navigation field, in a way that provides a continuous radio navigation field when visibility is not less than 4 navigation satellites only at altitudes of about 2000 km. For a spacecraft to geosynchronous and highly elliptical orbits (HEO), the most probable number of visible navigation satellites does not exceed four. At the same time there are considerable intervals of time when any navigation satellite doesn't get to a zone of radio visibility of the spacecraft. Using signals from the side lobe pattern of the transmitting antenna of the satellite navigation signal at the threshold of detection of 30 dBHz does not change the nature of the distribution.

Further it is necessary to consider reducing of the power level of signals of navigation satellites for the spacecraft. So, if for the international space station (ISS) it makes 39 - 50 dBHzs, then for the high-elliptic device Molniya 3-50 – 22 - 52 dBHzs.

Value of the Doppler effect caused by movement of the spacecraft and navigation satellite defines the range of search of a signal in frequency and parameters of follow-up systems. Doppler frequencies of Fd and speed of their change of sFd for ground customers are equal to Fd = +-4.5kgts, sFd =-0.8…0 Hz/c, for the Molniya 3-50 - Fd=+-50 kHz, sFd =-50 … 20 Hz / c [3].

The task of development of methodology of design and creation of autonomous system of navigation for artificial satellites of Earth was solved in work [4]. The architecture of onboard equipment, methods of primary and secondary processing of navigation signals is developed. But questions of flight of the spacecraft in high-elliptic orbits weren't considered.

A number of approaches to the solution of problematic tasks of navigation and ballistic support of spacecraft are known.

For support of reception of the navigation satellite signals by an onboard complex of the spacecraft in a high-elliptic orbit it is offered: to use special antenna arrangements with different directional patterns and antenna power gain, more sensitive receivers, to provide satellite radio navigation systems an additional radiator of a navigation signal in the side, opposite to Earth [5].

In work [6] is developed original algorithms to determine the spacecraft state vector and the principle of operation of the navigation receiver.

Novelty of work consists in the offered methods and algorithms of determination of a state vector of the spacecraft using laws of dynamics are direct when processing primary measurements of pseudo-speed and pseudo-range.

The aprioristic knowledge of behavior nature of the service parameters presented by model in the form of autoregression of the 1st order became a basis for the created algorithms.

The algorithm is based on minimization of the functionality containing the weighed squares of discrepancies of the measured and design values, the weighed increments of values of the official parameters on an interval between measurements and a square of the weighed deviation a priori of the given phase vector from its design value.

The weighed increments of values of service parameters consider aprioristic information on behavior of autoregressions.

The control block of the navigation system changes operating modes of the navigation receiver depending on the changing situation.

In an onboard complex of the spacecraft “Rakurs – DK1” periodically obtain one-stage components of a state vector and then specify them by statistical processing by method of dynamic filtering with use of the Kalman filter [7].

The autonomous navigation system can is under construction based on the integrated astro-satellite system. At the same time the integrated Kalman filter with entering of a separate set of the covariance matrix for each source (navigation and the star tracker) the navigation system [8] is upgraded.

For compensation of insufficient number of the visible navigation satellites, necessary for obtaining navigation information in the course of functioning of the spacecraft in geostationary and high-elliptic orbits, as an additional source of navigation data it is offered to use inter-satellite measurements [9].

Navigation support shall provide determination not only state vector, and also spacecraft orientation angles. One of possible methods of attitude control along with traditional gyrocompasses and infrared sensors of the reference directions, and also solar and astrosensors, is use of GNSS signals. For this purpose onboard it is necessary to set several receiving antennas, the navigation receiver and the navigation processor [10,11]. Such set of equipment onboard allows to determine coordinates of space debris in case of convergence of spacecraft with it with additional installation of a laser rangefinder [11, 12]. Perhaps also to receive the posteriori statistics used for setup of the Kalman filter and rejection of the anomalous navigation measurement [13].

For determination and forecasting of the actual spacecraft orbit there are methods on one-stage measurements by the navigation receiver of a state vector and with use of a method of Lambert-Euler [1]. As have shown researches [14], big accuracy is provided by the second method. These methods allow to determine parameters of the osculating orbit on the set point of time. At the same time, the spacecraft is subject to the perturbation action rejecting an orbit from a Keplerian orbit.

There is a number of forecasting methods of a state vector of spacecraft on the basis of numerical integration of the differential center-of-mass motion equations of spacecraft taking into account perturbations [15]. However these methods require considerable computing costs. The method in work [16] is more interest.

The main point of a method consists of the following procedures. The state vector of spacecraft S_i on a time point of t_i is determined a parameters vector P_i of a Keplerian orbit and true anomaly v_i on this time point using GNSS. The same procedures is made on the measured state vector $S_i + 1$ on time point $t_i + 1$ with determination of $P_i + 1$ and $v_i + 1$. Then using values of spacecraft coordinates are measured at the moments t_i and $t_i + 1$ to solve Euler-Lambert's task and the parameters vector P_p of a Keplerian transfer orbit is defined. Procedures are carried out on algorithms, the reference to which has been given above.

The obtained data allow to calculate gradients of change of parameters in initial and transfer orbits and to determine orbit parameters on time point $t_i + 1$ with real perturbations. Use of a method demands check of the acceptability of those assumptions at which it is formalized.

The short review of possible approaches to the solution of problematic tasks of navigation and ballistic providing spacecrafts shows that there is a sufficient base for further improvement of methods of his realization, including, at a solution of the problem of cleaning of space debris.

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UDC (045)

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Activities of the National Aviation University in "UKRAINE" project of Horizon2020 to foster EGNSS implementation in aviation sphere in Ukraine

Some of the activities of the National Aviation University in "UKRAINE" project of Horizon2020 to foster EGNSS implementation in aviation sphere in Ukraine are describes in this paper.

Introduction of the UKRAINE project

The objective of the UKRAINE (UKraine Replication, Awareness and INnovation based on EGNSS) project [1], in line with *GALILEO-3-2014 Call* of Horizon 2020, was to foster application development through international cooperation and to create a broad acceptance of EGNSS in Ukraine, creating at the same time opportunities both for knowledge building and at commercial level. And one of the expected impacts of the UKRAINE project with respect to the aforementioned objectives was preparation of the Ukrainian aviation market to the extension of EGNOS.

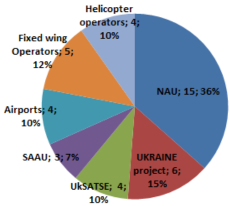
The partnership of the project consists of nine organizations coming from four EU countries and one non-EU country: the coordinator, Valdani Vicari & Associati Srl, Italy; National Aviation University (NAU), Ukraine; TeleConsult Austria GmbH, Austria; Advies de With GCV, Belgium; Nacionalniy Tehnichniy Universitet Ukraini Kiivskiy Politehnichniy Institut, Ukraine; State Space Agency of Ukraine, Ukraine; VVA Europe Limited, United Kingdom; Pildo Consulting SL, Spain; Ovinto CVBA, Belgium.

NAU activities in scope of UKRAINE project

Aviation workshops

Two aviation workshops have been help in NAU: "A PBN Implementation Workshop", April 29, 2015 and "Implementation of EGNOS based approach procedures in Ukraine" March 16, 2016. The main topics discussed during the workshops were the following: GNSS Systems for aviation; Introduction to PBN; Flight Validation of PBN procedures; Advantages of PBN implementation, experience, lessons learned; Ukrainian PBN implementation plan; Experience of NAU in investigation and application of GNSS technologies in Ukraine; GNSS interference monitoring - securing critical infrastructure for aviation; Current state on EGNOS extension to the territory of Ukraine (videoconference call from European Commission), LPV procedures - how to analyze the costs / benefits; The progress of PBN implementation in Ukraine: general overview and challenges.

In addition to presentations, the event also included open discussions and debates between representatives from UkSATSE, NAU, Zhulyany Airport and PildoLabs about different aspects related to PBN implementation and possible cooperation.



The representatives from the following Ukrainian and European organizations participated in the workshop: NAU, Advies de With, TCA, Pildo Labs, KPI, VVA Brussels, European GNSS Agency (GSA), European Commission (EC), Ukrainian State Air Traffic Service Enterprise (UkSATSE), State Aviation Administration of Ukraine (SAAU), International Airport Kyiv (Zhulyany), "MASTER-AVIA" company, "EUROPE AIR" company, Global Air company, Aviation company "Business Jet Travel", Personal Aviation Company "Ukrainian helicopters", State Aviation Enterprise "Ukraine", International airport Odessa.

Fig.1. Participants of the Aviation workshops in NAU

These workshops have been an opportunity for all the attendees (see group photos at fig. 1) to better understand the concept of PBN, the existing references and supporting cells together with the roles of EGNOS within PBN. Its goal was to provide support to Ukraine towards the implementation of EGNSS enabled operations in the civil aviation sector, in particular enhanced by EGNOS, and to establish negotiations with correspondent Ukrainian aviation stakeholders.

The UKRAINE project has obtained a positive feedback from Pieter de Smet (EC) mentioning it is the first research project with important Ukrainian participation in Horizon 2020 research and innovation programme in the area of satellite navigation. The workshops were held in a friendly atmosphere between the participants and laid the foundation for successful implementation of GNSS and EGNOS based approach procedures in Ukraine due to involvement of all important aviation stakeholders at the very beginning stages. It was agreed during the meeting that NAU will be a platform for communication and local coordination at the project level of further activities related to PBN procedures implementation in Ukraine.

RIMS efficient implementation investigation for Ukraine

NAU has performed the analysis of the factors influencing the efficiency of RIMS functioning and the definition of the optimal placement of RIMS at the territory of the Ukraine.

In scope of this task the experimental research of GNSS signal quality was made to define the best position for the RIMS station placement in Kyiv region during the period from January till March 2016. Four potential locations of RIMS implementation have been investigated: Kyiv Zhuliany airport; Main center of special control (Horodok of Zhytomyr region); State Enterprise "KyivPrylad", and NAU.

It has been discovered that the measurement sessions with antennas placed on the roof of high buildings (at State Enterprise "KyivPrylad" and in NAU), had been characterized by slightly higher fluctuations in the signal level and multipath level at low elevation angles of satellites. The measurement sessions on the territory of the airport Kyiv Zhuliany and on the territory of the Main center of the special control contained abnormal portions of measurement. These abnormal measurements have been observed for the satellites with different elevation and azimuth angles, and therefore could not be explained by limited visibility. In the result of analysis if has been defined that the most preferable location for RIMS deployment is the territory of the airport Zhulyany under the condition that additional study should be performed on the detection of the interferences' sources. A bit worse conditions of GNSS signals' reception at the territory of NAU and Horodok. Accommodation of RIMS EGNOS antenna on the roof of the building of "Kievprylad" is considered impractical due to the significant restrictions of satellites visibility.

Analysis of the placement of RIMS stations in the WAAS and EGNOS [2, 3] networks has shown that the distance between stations, placed in effective range, is about the same, ranging from 450 to 800 km. The smaller distance is due to the terrain difficulties, which forces to place the stations closer, than expected. After analyzing the topology of RIMS stations in WAAS and EGNOS networks, and using the PEGASUS and SBASSimulator software, the number and best position for RIMS stations on the territory of Ukraine has been defined. The optimal variant of RIMS placement is Kyiv – Kharkiv – Mariupol (fig. 2). Such configuration provides full coverage of EGNOS service area for Ukraine.

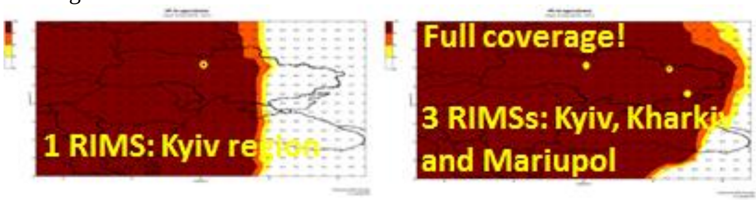


Fig.2. Results of simulation with 1 and 3 RIMSs EGNOS stations in Ukraine

Fig.3. Measurement sites for RIMS optimal place investigation: Zhuliany airport and Boryspil airport

During the period from January till March 2016 the works on definition the place of RIMS EGNOS implementation in Kyiv region of Ukraine have been performed. In scope of these works the measurement sessions in potential RIMS locations have been performed and the measurement information has been analyzed. Five potential locations of RIMS implementation have been investigated: Zhuliany and Boryspil airports (fig. 3); Horodok of Zhytomyr region; State Enterprise "KyivPrylad", and the territory of NAU.

Analysing the measurements at airports it should be aid that the restrictions to the signals receptions were absent; the receiver tracked all planned satellites. Typically, the average signals multipath level didn't exceed 45 cm at the L1 and L2 frequencies. The maximum value of multipath levels at low elevation angles did not exceed 1.5 m. These two positions could be considered as candidates for RIMS host places.

Analysis of the possibility of generic materials adaptation for ANSPs and airports for Ukraine

The growth of aviation and the urgent need to reduce fuel consumption and emissions demand increased airspace and airport capacity and a focus on providing the preferred trajectory (route and altitude) to each aircraft. Aircraft operators also require efficiency gains via approaches with the lowest possible minima and the significant safety benefits of vertical guidance. In fact, controlled flight into terrain (CFIT), in the absence of vertical guidance, is still a frequent accident category, at least for some segments of the aviation community. Another key goal is to reduce the effects of airport noise on populated areas. GNSS-based services can meet these goals and have already provided significant safety and efficiency benefits to aircraft operators. The PBN Manual (Doc 9613) [4] together with other generic materials of ICAO, EUROCONTROL, EASA, CANSO provide the guidance necessary to implement GNSS-based navigation services.

NAU has developed the report, which presents the results of the analysis of generic materials of ICAO, EUROCONTROL, EASA, CANSO and other aviation bodies with the guidelines for Air Navigation Service Providers (ANSPs) and Airports how to implement the RNP APCH procedures starting from NPA based on GNSS only and then down to LPV minima, which could be as low as 200 ft, with the aim to ensure harmonized solutions and a common approach according to the Single European Sky (SES) Regulation.

PBN Best Practice Guide for ANSPs [5] summarized the benefits for the main stakeholders: airports – improved access, potential for reduced infrastructure costs, community economic benefits, environmental benefits; ANSPs – improvements in safety, reduced service costs, service improvements; airlines – enhanced safety, improvements in efficiency, better schedule reliability, opportunities for broad cost reductions, reductions in CO_2 footprint; communities – environmental benefits such as reduced impact from aviation operations via CO_2 emissions and noise exposure; also reduced passenger airfares, flight times, and flight diversion disruptions.

In scope of this report the analysis of flight plans for major Ukrainian airports for the period from January 2015 to May 2016 have been done to identify the percentage of flights with capability to perform RNP APCH. At the fig. 3 it can be seen the example of such analysis for Boryspil airport for 2015 year.

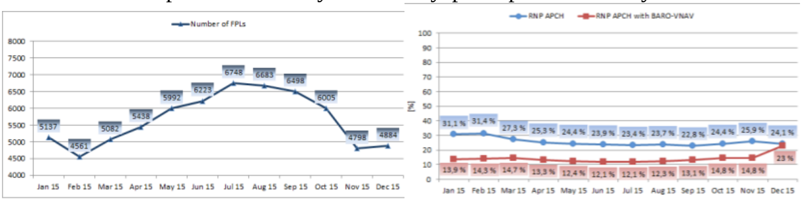


Fig.3. Boryspil airport statistics for 2015 year: general number of flight plans (left part); percentage of flights with RNP APCH capability (right part)

The analysis of the flight plans of major Ukrainian airports has shown that the average number of flights in all analyzed airports, except Kharkov, has decreased in 2016 compared to 2015 year, but despite this the percentage of readiness of operators to use PBN capable approaches for airports RNP APCH in 2016 tends to growth.

UKRAINE project has received funding from the European GNSS Agency under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 641517.

Conclusion

NAU actively participated in different tasks of "UKRAINE" project of Horizon2020. Some of its activities have been described in this paper. The project in general and NAU facilitated a bit the preparation of the Ukrainian aviation market to the extension of EGNOS.

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Properties of novel protease of *Streptomyces* sp. required for fuel ethanol production

New protease isolated from Streptomyces sp. 12 was studied. The maximal specific proteolytic activity of purified protease was 538 U·mg of protein^{-1}, Mr is about 35.6 kDa and optimal conditions of hydrolysis give effect at pH 8.0 and temperature 50 °C. Study of the substrate specificity permits to use enzyme in fuel production

Today protease attracted the attention of researchers because they perform a wide variety of complex physiological functions. Their importance in the implementation of metabolic and regulatory functions is confirmed by the fact that they are present in all forms of living organisms. Intracellular proteases play a critical role in the regulation of metabolism, while extracellular proteases catalyze the hydrolysis of proteins that are found in the extracellular environment and transform them into a form that can easily penetrate inside the bacterial cell. They can be also used in fuel production from corn starch granules. It's known that in fuel ethanol production, energy used in the cooking step is 10 to 20 % of the total energy content. The granular starch hydrolysis (GSH) process is claimed to save energy and reduce capital cost by eliminating cooking. Corn starch granules are embedded in the protein matrix. Bonds holding the matrix protein together can be lost by treatments with alkali or reducing agents, such as mercaptoethanol or sulfite. The protein matrix can be digested by proteases more rapidly than zeins. The proteases have an effect of endosperm structure [1]. Starch granules in corn are encapsulated by endosperm-associated proteins in a protein matrix. Proteases degrade the protein matrix surrounding the starch granules and help release starch that increased mash specific gravity and improved germ recovery in the enzymatic wet-milling process. In addition, proteases increase fermentation rates by hydrolyzing proteins into free amino nitrogen (FAN) [2]. FAN produced by a protease could be substituted for an exogenous nitrogen source (urea, inorganic ammonium ions, or amino acids) needed by yeast during fermentation. Adding proteases could reduce granular starch hydrolyzing enzymes usage and eliminate addition of other yeast nutrients.

Among the producers of protease the soil microorganisms occupy an important place. They belong to different taxonomic groups, but most of them are represented by micromicetes and streptomycetes [3]. Literary sources indicate that streptomycetes have the potential to decompose various natural polymers such as chitin and pectin. The interest of these producers is also caused by that they are able to produce proteolytic enzymes with different substrate specificity, which was shown [4], are safe for use in the manufacture of food and drugs (FDA-approved or GRAS).

Previously [5] at the Department of Biochemistry of microorganisms of Zabolotny Institute of Microbiology and Virology of NASU as a result of screening 45 strains of *Streptomyces* sp. isolated from the rhizosphere of various plants were selected *Streptomyces* sp. 1 2, which have the highest proteolytic activity.

The aim of this study was an optimization of the cultivation conditions of *Streptomyces* sp. 12, which provide a maximum synthesis of proteases to obtain a purified preparation of the protease, to investigate its substrate specificity, physico-chemical properties and functional groups of the active site.

Optimization of cultivation conditions using single-factor experiments were carried out on the base medium of the following composition (g/l): K_2HPO_4 – 1; $MgSO_4{\cdot}7H_2O$ – 1; NaCl – 1; $(NH_4)_2SO_4$ – 2; $CaCO_3$ – 2; starch – 10; microelements salt solution ($FeSO_4{\cdot}7H_2O$ – 1, $MnCl_2{\cdot}4H_2O$ – 1, $ZnSO_4{\cdot}7H_2O$ – 1) – 1 ml. Total caseinolytic (proteolytic) activity was quantitatively determined on tyrosine, which is formed by hydrolysis of casein under the action of the investigated enzyme. Collagenase activity colorimetrically is determined by ninhydrin. The number of units of activity equals to the amount of μmol L-leucine, which is freed from collagen after 5 hours at 37 °C. To isolate and purify of the enzyme it is used precipitation by $(NH_4)_2SO_4$ (90% saturation), chromatography on neutral and charged TSK-gels. The homogeneity of the enzyme preparation was determined in native system by gel-filtration on Sepharose 6B ("Pharmacia", Sweden). Investigation of the influence of pH and temperature of environment on the activity of purified protease of *Streptomyces* sp. 12 was performed in the temperature range from 6 to 80 °C and a pH of 5.0 to 11.0.

It is established that optimal sources of carbon, nitrogen and minerals in the nutritious medium are corn meal, $(NH_4)_2SO_4$ and $CaCl_2$ respectively. The growth of *Streptomyces* sp. 12 was carried out in submerged conditions during 3 days in 200 ml of the optimized nutritious medium at initial value of pH 7.0, temperature 37° C, 220 rpm. The specific proteolytic activity was 62.7 U·mg of protein^{-1}, which is 4.8-fold higher than in the control (base medium). Similar to our results there are the data of study of proteases of other actinomycetes *Saccharomonospora viridis* SJ-21 [6].

Using fractionation by sulphate ammonium, gel-filtration and ion-exchange chromatography on TSK-gels – Toyopearl HW-55, DEAE 650(M) and Sepharose 6B, *Streptomyces* sp. 12 protease with specific activity 538 U·mg of protein^{-1} and yields 35.8 % was isolated. With the use of proteins-markers have been shown (Fig. 1), that the molecular weight of investigated protease is about 35.6 kDa. The literature often describes the extracellular proteases of streptomycetes with a molecular weight of 14 and 70 kDa.

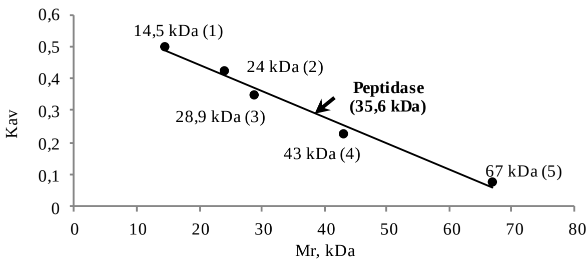

Fig. 1. Determination of molecular weight of *Streptomyces* sp. 12 protease in the native conditions (calibration plot): Kav – distribution ratio; proteins-markers: lysozyme (1), trypsin (2), proteinase K (3), peroxidase (4), bovine serum albumin (5)

It is shown that enzyme displays highest activity toward collagen and less activity toward casein, albumin and gelatin (fig. 2). This may be due to the affinity of protease to Gly or Pro, which are prevalent in the structure of collagen molecules.

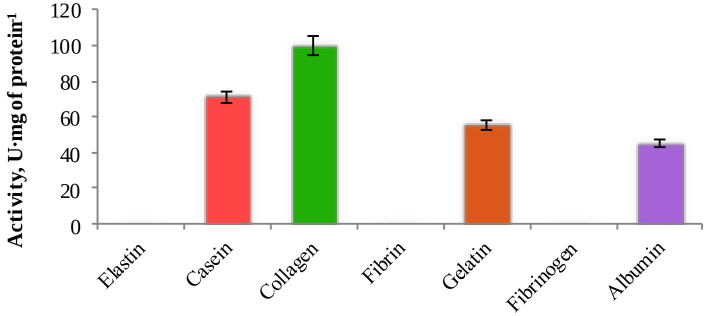

Fig. 2. Hydrolysis of protein substrates by *Streptomyces* sp. 12 protease

Conducted by us studies of the influence of group-specific chemical reagents (0.01 M) showed that tested enzyme is metalloprotease with optimal conditions of action on collagen at pH 8.0 and temperature 50 °C.

So far as the major corn zein amino acids are Pro, Glu and Ala give a possibility to suppose a perspectivity of usage of *Streptomyces* sp. 12 protease in fuel ethanol.

Conclusions

Thus, studied protease of *Streptomyces* sp. 12 with high collagenase activity which is alkaline and thermo stable enzyme may be suitable to use for fuel ethanol production to degrade the protein matrix and help release starch.

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Soil pollution with heavy metals and *Plantago major L.* on the territory adjacent to airfields

The content of heavy metals in soils and medicinal plants which were collected in the territory, adjacent to airfield "Zhulyany" in Kiev region, airfield in Nizhyn, Chernihiv region. Established technological factors concentrations of heavy metals in soil samples and intensity of migration of pollutants from soil to plants using biological absorption coefficient.

The urgency of the issue of determining the degree of pollution with heavy metals is determined that the pollutants have a negative impact not only on the components of the biosphere, but also on health.

Wild grasses are a valuable natural resource that plays an important role in the functioning of natural ecosystems and are a source of plant food and medicinal plant.

Among the pollutants, which in large quantities released into the environment and can accumulate plants, especially a group of heavy metals because research and resource harvesting plant material must be accompanied by a chemical analysis for contaminants.

For long-acting sources of pollution is a significant increase in gross content of microelements. Soil contamination accumulates while neutralizes the toxins through complicated adsorption processes. The study of environmental pollution toxicants - an important area of research because of accumulation of heavy metals in soil and plants - one of the indicators of air pollution.

To establish the degree of contamination of soils with heavy metals and plantain (Plantago major L.) were taken soil samples and plantain leaves. Samples were collected on the territory adjacent to the airport, "Juliani" Kyiv region and Nijinsky airfield Chernihiv region.

Plantain collected on doslidzhuvalnyh territories with the requirements set out in pharmacognosy [1] and methods of sampling of soil and plants [2].

The content of heavy metals (Cd, Zn, Pb, Cu) in soil was determined using 1N HCl in plants - HNO_3 (1: 1) atomic absorption spectrophotometer C-115 [2]. To assess the contamination of soils used technological factor concentration COP [3].

To determine the intensity of migration of heavy metals from soil to plants used for biological absorption coefficient KBP [4].

The analysis of heavy metals in samples of soil and plantain collected near the airport "Juliani" Nijinsky and airfield are shown in Tables 1 - 2.

Table 1

Analysis of heavy metal content in soil samples

Place soil sampling	Cu		Zn		Pb		Cd	
	mg/kg	Кс	mg/kg	Кс	mg/kg	Кс	mg/kg	Кс
airport "Zhulyany"	5,37	0,26	12,8	0,26	12,68	1,27	0,34	0,68

Nijinsky airfield	2,4	0,12	19,46	0,4	12,7	1,3	0,17	0,34
Background content	20	–	50	–	10	–	0,5	–
MPC 55	–	100	–	32	–	3	–	

Table 2

Analysis of heavy metals in samples Plantago major L.

Place of sampling	Cu (мг/кг)		Zn (мг/кг)		Pb (мг/кг)		Cd (мг/кг)	
	1x	Кбп	1x	Кбп	1x	Кбп	1x	Кбп
airport "Zhulyany"	5,93	1,1	27,9	2,1	4,22	0,33	0,6	1,76
Nijinsky airfield	8,34	3,4	28,52	1,4	6,94	0,54	0,52	3
MPC	5,0	–	10,0	–	0,5	–	0,03 –	

Where 1x - element content in ash plants

The research found that the content of Zn, Pb and Cd in soil samples did not exceed the norm. Because Ks calculation found that the figure for Cu, Zn and Cd does not exceed one and varies between 0,12-0,68, that vyluhovuyutsya these elements from the soil. Only Pb COP> 1, and And so is the process of accumulation.

The results showed that the content of heavy metals in plant material exceeds the maximum dopustyni concentration, it indicates a high level of accumulation of metal ions. Heavy metals accumulate in intensity plantain are as follows: Cu> Zn> Cd> Pb. Property plantain accumulate heavy metals can be used as one of the methods phytomonitoring environment.

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The use of dandelion root (*Taraxacum officinale* Wigg.) as non-traditional raw materials in technology of functional beverages fermentation

In the process of research the extracts of dandelion (Taraxacum oficinale Wigg.) high in inulin were extracted. It can be used to prepare fermented beverages as a source of carbohydrates during the fermentation. There were selected the optimum conditions for extraction of inulin from roots.

Inulin is a polysaccharide consisting of residues of β-D-fructose contained as the spare substances in the dandelion and some other plants belonging to the family Asteraceae. In recent years a growing interest in inulin as prebiotic, a component of the protective environment during freeze-drying. Chemically synthesized derivatives of inulin significantly reduce the surface tension and can be used as Surfactants [2].

Inulin is a source of fructose, which can act as a sweetener in the food industry in the production of fermented beverages.

The roots of the dandelion is the raw material base for procurement of high-molecular inuline muktasana. Thus, according to the literature, its content in the roots in the autumn is approaching 40 % [1].

Also in the autumn in the roots of the dandelion accumulates a large number of other carbohydrates (18 %) [1], in particular, fructose and sucrose, proctozone that are a mixture of oligomers and polymers in which the molecules of fructose linked by the formation of β-2,1-bonds, and as the end groups are usually glucose molecules [1].

We studied the effect of temperature on the extraction of carbohydrates, including inulin from the roots of the dandelion. The extraction was performed at 40 °C, 50 °C, 55 °C, 60 °C, 65 °C, 70 °C, 75 °C, 80 °C. After extraction determination of total carbohydrates in the extracts was performed by standard methods [1]. The results of the analysis shown in Fig. 1.

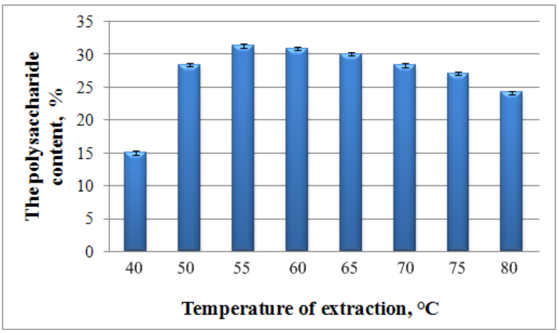

Fig. 1. The effect of temperature on the extraction of polysaccharides from the roots of dandelion (*Taraxacum officinale* Wigg.)

Considered temperature interval from 40 to 80 ºC. At temperatures below 55 ° C was observed a gradual increase in the concentration of total sugars from 15 to 32 %, in the temperature range from 60 to 70 ° C, these values were almost constant, and at values above 70 ° C decreased to 24 %. Thus, we have established that the optimum temperature of extraction is 55-60 ºC. The decrease in the concentration of sugars at temperatures above 70 ° C may be due to their partial oxidation or decomposition under the action of temperature [2].

The obtained extract was concentrated to a solids content of 40-50 %. Ready-made concentrates can be used to prepare fermented beverages as a source of carbohydrates during the fermentation.

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Impact of hypobaria and air pressure fluctuations on the initial stages of *Beta sativa* growth as an object for prospective artificial ecosystems in extraterrestrial conditions

The possibility of using Beta sativa in advanced life support systems for operation in extraterrestrial environments considered. The results of study of the hypobaria effect on growth of Beta sativa samples in different periods of development are discussed.

At the beginning of the last century, a prominent theorist Konstantin Tsiolkovsky predicted that "future technology will enable to overcome gravity and travel throughout the Solar system" [1].

In order to provide long-term space flight and possible colonization of space objects is important to use ecological systems to sustain crew. The simplest ecological systems consist of three groups of organisms: producers decomposers and consuments. Crew members are Consumer of highest order. Producers are photosynthetic plants and bacteria that are able to accumulate nutritional carbohydrates, using solar energy and carbon dioxide – the end product of human metabolism. In the conditions of space flight plants also perform an important function of cleaning water by transpiration from the surface of plant leaves. Decomposers are microorganisms that are able to recycle quickly and safely wastes of human and unused green biomass of plants to form water, electricity and organic fertilizer. However, accumulation of microorganisms decomposers biomass in closed systems or spacecraft or planetary facilities will reduce the reliability of such systems and raise environmental risks to humans [2, 3]. Therefore, in parallel with the task of developing life support systems, researchers faced the issue of ecological safety of extraterrestrial exploration of natural resources and environmental protection of Solar system [4].

The study of near-Earth space, Moon, planets and other objects in the Solar system show a growing demand for renewable resources and minimizing the volume of resources delivered from Earth. Plants had taken place in studies even in appearance of the first space programs. A special attention deserve the results of scientific school of Academician J.I. Hitelson [5]. Such plants that can be used for food, for example – rice (*Oryza*), onions (*Allium*), salad *(Latucca*), wheat (*Triticum*), cucumber (*Cucumis*) and others received most attention of researchers [6 – 8]. Logendra et al [9] offering *Beta vulgaris* or Swiss chard cultivation for the first lunar and planetary stations, primarily for food purposes.

Among the properties of beet *Beta sativa*, can be distinguished the following, which are not dependent on growing conditions and other properties, primarily connected to external extraterrestrial conditions. Among the first – social acceptability: Western culture is inherent in the use beet leaves in food. In the west beet variety known as Swiss chard (or chard) is popular, leaves of beet are widely used in European and American cuisine. In Ukraine, Eastern Europe traditionally preferred consumption of beet root crops. Roots of *Beta sativa* is commonly accepted source of raw materials for sugar production and nutrient components sources of carbon and minerals for cultures of industrial microorganisms.

Extraterrestrial conditions include the impact of many factors: hypobaria, hypoxia, microgravity, the absence of a magnetic field, radiation, changes in the daily rhythm, temperature. Under conditions of closed artificial ecosystems outside the Earth it is impossible to eliminate all of these factors and completely reproduce the conditions of the Earth, that there is a problem of artificial ecosystems adaptation to the extraterrestrial conditions.

Hypobaria – reducing of atmospheric pressure the external factor affecting the plants mainly through hypoxia – a decrease in the partial pressure of oxygen pO2 with atmospheric pressure. In mountain climate plants are able to adapt to the reduced pressure and hypoxia. However, extraterrestrial conditions include significant deviations from even mountain conditions. For example, on Mars atmospheric pressure is about 1% of terrestrial and atmospheric composition, lighting, temperature and insufficient humidity indicate the need to create an artificial environment, isolated from the adverse natural environment Such an artificial environment should be thermally isolated, equipped with artificial lighting also protected from loss of water and air that is hermetic. As for the gas composition and atmospheric pressure in this artificial environment – these factors can vary within certain limits. The content of carbon dioxide and oxygen in the air is also can be affected by the plants through photosynthesis The pressure can be reduced to a level that would not harm the plants, provided sufficient oxygen concentration and at the same time would have reduced the pressure gradient compared to the environment. This approach allows saving some essential components – water, energy and air volume of which in the extraterrestrial conditions is limited.

Researchers [10–12] studied the influence of different levels and atmospheric pressure pO_2 on plants in different periods of development. Most attention was paid to germination and initial stages of plant development. According to [12] hypobaria at adequate levels of O_2 and CO_2 is not harmful to germination and vegetation, but it can slow down the reproductive phase of plant development. Considering the fact that the full life cycle of plants is not always possible to reproduce in the extraterrestrial conditions, and that the reproduction of the full life cycle is not necessary to obtain useful components – oxygen, raw, foods. Such an approach we consider appropriate. Thus, for *Beta sativa* only the young leaves that formed during the first 12 weeks of the growing season suitable for food, root crops (on Earth) require months for maturing, and only in the second year of growth flowering and seed formation occurs.

Thus, on the one hand a full cycle of development and reproduction of plants is appropriate and necessary for the closed artificial ecosystems, on the other hand – the initial stages of ontogenesis of plants may also be industrially important.

In closed environments artificial air pressure can be maintained at a certain level, but the following factors: a technical operational human interruption, random degermetization, temperature fluctuations and others – can lead to sudden changes of pressure. In this case, the effect of such fluctuations on samples of *Beta sativa*, grown under conditions of hypobaria were studied.

To simulate a closed artificial environment 50 kPa pressure was selected that represented approximately 0.5 of atmospheric pressure. According to studies [11] such pressure does not interfere germination and growth, but further reduction in air pressure can inhibit plant growth. The authors [13] that worked with the same pressure with samples of cyanobacteria, noted the following reactions: reducing the intensity of biomass growth, increased carotenoid synthesis and decrease the synthesis of chlorophyll and phycocyanin by cells as a reaction to the lack of oxygen.

Such conditions were applied to the samples of *Beta sativa* and a comparison with samples not exposed to hypobaria was performed. Hypobaria addition to the attention was paid to how the plants respond to sharp pressure fluctuations – quick admission of air to atmospheric pressure and subsequent rapid evacuation of air back to the level 50 kPa.

For research were taken ordinary seed of *Beta sativa* from various Ukrainian producers. Comparative tests were carried out at different periods of plant growth: germination and vegetation – formation of roots, shoots and leaves. Seeds were germinated in Petri dishes filled with silicone and in the soil. Petri dishes or pots with seeds with sprouts of *Beta sativa* were transferred to desiccator and pumped air out by rotary vacuum pump to a level of 50 kPa. Pressure was measured by the manometer.

The comparison were carried out with samples of *Beta sativa* cultivated simultaneously in full atmospheric pressure (sprouting and the formation of leaves). Also, samples grown in normal conditions, were subjected to hypobaria impact and

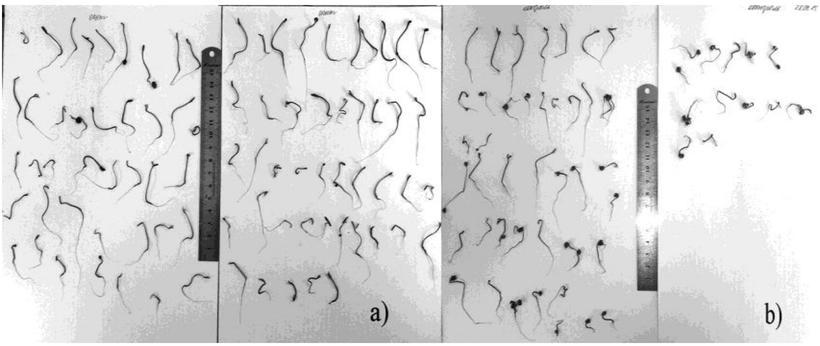

Fig. 1. germinated seeds of *Beta sativa*: a) test - pressure 50-60 kPa;
b) comparison - pressure 101 kPa.

pressure fluctuations.

Germination of seed of *Beta sativa* in hypobaric conditions was more successful – germination up to 90% (Fig. 1a), compared with 50–60% in the comparison (Fig. 1b) which result can be explained by improving of oxygen diffusion [11].

It is should be noted that in plants of genus *Arabidopsis* were identified genes specifically regulated by hypobaria or hypoxia, and the genes regulated by the action of both stresses. These studies indicate that plants which have evolved on Earth have the genetic resources for adaptation to extraterrestrial conditions and artificial ecosystems [14].

In the simulation of artificial ecosystems for extraterrestrial conditions essential is the ability of plants to change its metabolism quickly and restore normal physiological state and growth after sudden environmental conditions changes. The sharp increase in pressure (from 0.5 to 1 atmosphere) after the air inlet caused the visible effect – in 2–3 week old sprouts of *Beta sativa*, grown *in vitro* at 50 – 60 kPa pressure, leaves was losing turgor, leaves started to wither , but after reducing the pressure – plants recovered and returned to normal. In other words as a result of compression inverse phenomenon of the pressure stress occurred.

Revealed that small hypobaria does not harm the germination of seeds and sprouts growth of 2 – 3 week old *Beta sativa*, while there is a slight elongation of roots and shoots during germination, ie at the stage of germination hypobaria of 50 kPa resulted in increasing the number of sprouted seeds and increasing the length of the primary roots and shoots. Similar results were observed by authors [11] in cases where growth was not inhibited by hypoxia. Also on the stage of sprouting roots of *Beta sativa*, germinated under hypoxic conditions did not have side branches, whereas in comparison test – at normal pressure side branches of roots were formed.

Conclusions

Summarizing all the above, it may be concluded that Beta sativa is a promising object for closed life support systems in extraterrestrial conditions. The plants do not lose viability under reduced pressure and its fluctuations. Established a rapid restoration of normal physiological state of sprouts of 2–3 week old *Beta sativa*, grown in vitro at a pressure of 50 – 60 kPa, after exposure to baric stress as a result of compression followed by decompression.

For further studies of *Beta sativa* growth in hypobaric conditions perspective are determination of biologically active compounds in the biomass and gas control of closed artificial ecosystems, in particular – oxygen and carbon dioxide.

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The study of the processes of accumulation of biomass of algae *Chlorella vulgaris* and *Monoraphidium tortile* for production of biofuel

Developed methods of extraction of natural aquatic ecosystems and methods of cultivation of crop associations of green algae. For cultural, morphological characteristics using the methods of reseeding of algae cells on solid media, dedicated algologic cells of green algae: Chlorella vulgaris and Monoraphidium tortile. Conducted cultivation of pure cultures in the periodic conditions deep and surface methods. It has been established that Chlorella vulgaris specific growth rate is 0.28 $x10^6$ of cells/ml per day, the maximum capacity – 43.8 $x10^6$ of cells/ml per day, the lipid component is 14-22 % for dry weight respectively. For Monoraphidium tortile the specific growth rate and 0.30 $x10^6$ of cells/ml per day, performance to 65.1 $x10^6$ of cells/ml per day, the lipid component makes up 56.8% of dry mass. Comparing these characteristics showed that the investigated culture meet the criteria for the selection of algae for biofuel production.

Modern aviation is one of the main consumers of fuels of petroleum origin in the form aviation fuels and jet fuels. Most of the Park of civil aircraft equipped with jet engines (DWP), working on jet fuel. For ten years (1992-2002) the consumption of fuels for the PRD grew by 21%. Aircraft ship are responsible for more than 2% of global CO_2 emissions. Besides CO_2, exhaust gases of aircraft (LA) contains a number of other components, negatively influencing both human health and global climate change on the planet. By 2050 air transport will be the source of 20% of all harmful substances emitted to the air in the world. In this regard, in recent years, quite acutely the question of greening the aviation industry, namely reducing emissions of greenhouse gases such as CO_2, CH_4, and others, as well as reducing the toxicity of exhaust gases of the aircraft. One way of solving this problem is the search and introduction of alternative aviation biofuels. Intensive use of oil and gas in the twentieth century. caused an acute need for new renewable and environmentally friendly alternative sources of energy and fuel. Scientists worldwide are exploring the creation of biofuels, in particular biodiesel as the most promising source of energy. As plant raw material for biodiesel production lipids used oil plants, bacteria, yeast, filamentous fungi and microalgae. The advantage of microalgae - producers of biomass as raw material is a high lipid content, high rate of growth, the possibility of directed biosynthesis, the use of growing photobioreactors and open waters, industrial waters of various industrial wastes. However, with 45 thousand known species of microalgae, only about 30 species can accumulate in cells of an increased amount of lipids (20 to 80% by weight of dry substance) [1].

Methods and materials

The main criteria for the selection of algae:

1. The ability to accumulate increased amounts of lipids
2. The performance culture.
3. High speed growth.
4. Contaminants culture.

Selection algotest of water in the city Kyiv, at Truhanov island, lake Babyne. For a more complete qualitative study of species and taxonomic (number of genera, families, orders, classes and divisions) diversity of algae, as well as analysis of rare sampling conducted using plankton nets. Most useful is Aptshteyn's net (small) - length 55 cm cone diameter inlet – 25 cm. The material is a mesh silk mill or gas. A plankton net Strain certain amount of water (100 dm^3). The volume of the sample is determined from the intensity of phytoplankton. [2]

Analyzed algotest under the microscope and find out what kinds of algae in the water sample. For cultivation we have chosen strains of algae from two species of green algae, *Chlorella vulgaris* and *Monoraphidium tortile* within 10 days. Lipid composition: Chlorella vulgaris - 14-22% and *Monoraphidium tortile* – 56,8% [3]. Isolation and cultivation of algae was carried out in environment of Bold and Tamiya [4].

Composition of media are presented in mg/l in Tables 1 and 2

Tables 1

Composition of Bold's environment:

$NaNO_3$	750 mg/l
$MgSO_4*7H_2O$	75 mg/l
NaCl	25 mg/l
$CaCl_2*2H_2O$	25 mg/l
KH_2PO_4	175 mg/l
K_2HPO_4	75 mg/l
$FeSO_4*7H_2O$	2,5 mg/l
Micronutrients:	15 ml
H_3BO_3	2,86 mg/l
$MnCl_2*4H_2O$	1,81 mg/l
$ZnSO_4*7H_2O$	0,22 mg/l
$Co(NO3)_2*4H_2O$	0,15 mg/l
NH_4VO_3	2,3 mg/l
$CuSO_4*5H_2O$	0,01 mg/l

Tables 2

Composition of Tamiya's environment:

KNO_3	5000 mg/l
$MgSO_4*7H_2O$	2500 mg/l
KH_2PO_4	1250 mg/l
EDTA (III)	37 mg/l
$FeSO_4*7H_2O$	3 mg/l
Micronutrients:	1ml
H_3BO_3	2,86 mg/l
$MnCl_2*4H_2O$	1,81 mg/l
$ZnSO_4*7H_2O$	0,22 mg/l
$Co(NO_3)_2*4H_2O$	0,15 mg/l
NH_4VO_3	2,3 mg/l
$CuSO_4*5H_2O$	0,01 mg/l

Selection culture was performed by plating on agar taken algotest method Drygalski in Petri dishes and the method of line sowing. Inoculum culture and selected *Monoraphidium tortile* conducted a periodic basis with the filing of CO_2 on the environment Bold in conical flasks volume of 1000 ml (volume 200 ml Environment) [5]. Algotest cell culture performed on luminostatic clock with fluorescent-lit and temperature of 26 - 32 °C, light intensity of 100 $\mu mol*m^{-2}s^{-1}$ and a constant bubbling with continuous supply of CO_2 through the compressor (*Fig. 1*). The initial amount of inoculum was 5 million cells/ml. The growth of biomass direct evaluated daily by counting the number of cells in a cell Goryaeva.

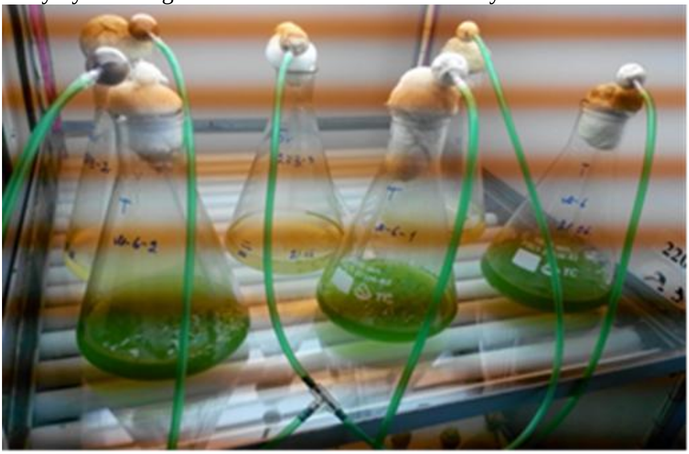

Fig.1.Cultivation of selected crops Monoraphidium tortile in the periodic setting of CO_2 on the environment ever again.

The results of the experiment on the cultivation of algae in the periodic conditions to determine the dynamics of growth in the number of cells in 1 ml of the medium shown in *Fig. 2*.

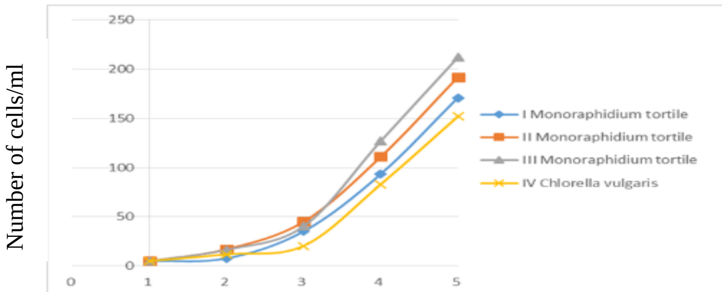

Fig. 2. The growth in the number of algae cells

As can be seen from *Fig.2* the lag-phase is characterized by a period of adaptation of the algae culture to the new environment and the increase in the number of cells is negligible. The duration of the period took more than one day, depending on the differences of the conditions in which cells were to be submitted to the environment and new conditions.

In the logarithmic phase (log-phase) growth in the number of cells, the specific growth rate of cells, depending on the light conditions under low-density culture unchanged. This period is characterized by the constancy of specific growth rate (μ_m = const). So, for the logarithmic phase of growth applied, the density of culture from time to time, for the unlimited growth of the biomass:

During linear growth, it is possible to find the magnitude of the maximum output, which is equal to the tangent of the slope of the linear section of the growth curve:

$$P_m = \frac{B - B_e}{t - t_l}$$

P_m – maximum capacity (cells per day);
I_n – biomass (number of cells);
B_e – density of cell culture at the beginning of the linear phase, t_l.
t - t_l – total time of culture growth.
The specific growth rate of culture was calculated by the formula:

$$\mu = \frac{P_m}{B}$$

μ_m – is the specific growth rate (cells/ml per day);
P_m – maximum capacity (cells per day);
B – biomass (number of cells);

This portion of the curve in logarithmic growth phase allows to trace the change in specific growth rate with culture time [6].

Kinetic characteristics of growth of culture of *Monoraphidium tortile* to growing conditions in intensive conditions (temperature, concentration of the medium, light) are presented in Table. 3.

Table.3

The specific growth rate and productivity of the culture of Monoraphidium tortile and Chlorella vulgaris

Test №	Logarithmic growth phase		The phase of linear growth	
	Specific growth rate, μ, cellsx10^6/ ml per day	Performance culture, P_m, cellsx10^6/ml per day	Specific growth rate, μ, cellsx10^6/ml per day	Performance culture, P_m, cellsx10^6/ml per day
I *Monoraphidium tortile*	0,43	4,43	0,95	54,6
II *Monoraphidium tortile*	1,20	13,23	0,30	58,3
III *Monoraphidium tortile*	1,04	21,54	0,30	65,1
1V *Chlorella vulgaris*(str.189)	0,86	7,2	0,28	43,8

Thus, studies have shown that the strain of algae *Monoraphidium tortile* grows well and develops under the given cultivation conditions. The strain is characterized by a minimum period of adaptation, a high growth rate and productivity, the better photosynthesis absorbs carbon dioxide from the atmosphere than *Chlorella vulgaris*. (str.189).

As a result of the experiments and the comparison of the studied strains we have determined that *Monoraphidium tortile* more promising and highly productive strain-producer of biomass for biofuel than *Chlorella vulgaris* 189) as the lipid composition of *Chlorella vulgaris* - 14 - 22% and *Monoraphidium tortile* – 56.8%.

Conclusions

- Spent methods of allocation of natural aquatic ecosystems and methods of cultivating crops Associations green algae.
- For culture, morphological characters using the methods of replanting algae cells on solid media, pure color algological cell green algae: *Chlorella vulgaris* and *Monoraphidium tortile*.
- Cultivating pure cultures in terms of periodic deep and superficial methods. It is established that *Chlorella vulgaris* specific growth rate is 0.28 $x10^6$ of cells/ml per day, the maximum capacity – 43.8 $x10^6$ of cells/ml per day, the lipid component is 14-22 % for dry weight respectively. For *Monoraphidium tortile* the specific growth rate and 0.30 $x10^6$ of cells/ml per day, performance to 65.1 $x10^6$ of cells/ml per day, the lipid component makes up 56.8% of dry mass.
- Comparing these characteristics found that explored culture meet all criteria for biofuels.
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Characterization of *Pantoea agglomerans* endotoxin as potential components in air and settled dust from commercial aircraft cabins

In this study, endotoxin of Pantoea agglomerans was isolated, purified and chemically characterized. LPS contained significant amount of carbohydrates (42.0 %), traces of protein, and nucleic acids. The predominant monosaccharide in LPS are glucose (40.5 %) and rhamnose (38.6 %). Lipid A in the studied strain contained 3-OH-$C_{14:0}$ acid (32.7 %).

In recent years much attention has been paid to the quantification of suspended in the air or dust a number of biologically active substances, in particular, endotoxins. Endotoxins, also called lipopolysaccharides (LPS), are a major component of the outer membrane of Gram-negative bacteria. They are composed of a hydrophilic polysaccharide moiety, which is covalently linked to a hydrophobic lipid moiety (Lipid A) (1). LPS from most species is composed of three distinct regions: the O-antigen region, a core oligosaccharide and Lipid A. The lipid A is the most conserved part of endotoxin and is responsible for most of the biological activities of endotoxin, i.e. its toxicity and pyrogenicity (2). The O-antigen is generally composed of a sequence of identical oligosaccharides (with three to eight monosaccharides each), which are strain specific and determinative for the serological identity of the respective bacterium (3).

Endotoxin is always present in outdoor air. Measured levels have ranged from 0.01-5 EU/m³ (and more) of outdoor, with geometric means generally in the 0.02-0.5 EU/m³. Endotoxin concentrations in outdoor air near farming activities can be much higher, reaching levels in excess of 1,000 EU/m³. In residential and other supposedly "clean" environments, measured levels of airborne endotoxin are rare. Concentration ranges for the few available studies are in the range 0.5-2,500 EU/m³, with the higher part of the range possibly indicating unusually high levels. Most residential measures are dust concentrations, which range from 8,000-250,000 EU/g of dust. Repeated measurements of endotoxin in residential dust tend to be correlated. The presence of a dog in the house tends to be strongly correlated with endotoxin concentrations in dust.

In occupational environments where organic material is handled, or water is a part of the manufacturing process, airborne endotoxin measures are important and air samples should be collected in both the occupational environment and in outdoor air.

The commercial aircraft cabin is a non-manufacturing, non-agricultural indoor environment. Approximately 198 000 flight crew work on scheduled commercial aircraft in the United States (6). A recent National Academy of Sciences of USA report concluded that insufficient data on exposure to biological agents, including endotoxin, were available on commercial aircraft (7). To address this data gap, endotoxin levels in air and dust were measured on commercial aircraft flights as part of a larger National Institute for Occupational Safety and Health study of commercial aircraft cabin environmental quality.

The occurrence of endotoxins in blood may provoke high fever, septic shock, or even death as a result of impaired organ functioning or a systemic inflammatory response. Endotoxin exposure has been associated with worker health effects in sectors as diverse as the cotton industry, animal husbandry, and wastewater treatment (4, 5).. The inflammatory properties of inhaled endotoxins are implicated in several types of occupational pathologies. In exposed workers, the inhalation of endotoxins has been associated with both respiratory and general symptoms such as fever, coughing, irritation of the respiratory system, and chest congestion. Endotoxin inhaled by humans or animals causes inflammatory reactions in the lungs. The reactions are initiated by the activation of alveolar macrophages and other cells lining the airways, followed by the release of inflammatory mediators and an influx of neutrophils into the lung. Depending on the inhaled dose, endotoxin is believed to evoke organic dust toxic syndrome, chronic bronchitis, mucous membrane irritation, or to aggravate the adverse pulmonary reactions caused by exogenous allergens. It is known that LPS are responsible for a host of toxic effects that occur in patients infected with Gram-negative bacteria, including fever, disseminated intravascular coagulation, and hemodynamic changes, which may lead to multiple organ failure characteristics of the septic shock syndrome. It is interesting the fact that the pilots and passengers can inhale for a long time endotoxins that have different toxic effects on the human body. In some cases, the human body is able to resist the negative effects. But with weakened immunity, endotoxins getting into the body, can cause different kinds of inflammatory processes, allergies or asthma.

As endotoxin, which is in the air or in the dust of the aircraft may adversely affect the human body, it is of great interest to study its chemical composition and biological activity. Thus, the aim of our study was to obtain, chemical identification and serological characterization of lipopolysaccharide. The object of the study were lipopolysaccharide from bacterial cells of *Pantoea agglomerans* type strain 8674.

Pantoea agglomerans - gram-negative bacterium that belongs to the *Enterobacteriaceae* family, whose relationship with the typical genus *Escherihia* is 25%. This is quite of a great affinity compared with other genus and families, such as *Budvicia, Pragia, Moellerella* and *Xenorhabdus* (from 1 to 7%). *P. agglomerans* (synonyms: *Erwinia herbicola*, *Enterobacter agglomerans*) are widespread in nature as commensals, epiphytes, or endophytes associated with many plants, warm-blooded animals, insects, and represents a significant occupational risk because of its endotoxic and allergenic properties. They were transformed into pathogens causing rots, leaf blotch, and galls in plants and opportunistic infections in humans and animals. The transformation of bacteria into host-specific, gall-forming pathogens occurred due to the evolution of the unique plasmid of pathogenicity, pPATH. Lipopolysaccharides are known to play a key role in the host-pathogen interactions in both animals and plants. Specific features of the LPS structure can be importance, in particular, for a more accurate understanding of all the processes that occur in the human body by inhalation endotoxins.

LPS from *Pantoea agglomerans* 8674 (LMQ 2565=NCCPPB 2971, type strain) was extracted from dried cells with 45% aqueous solution of phenol at 65-68 ^{0}C; aqueous fractions were dialyzed sequentially against tap and distilled water for phenol removal. The amount of carbohydrates was determined by the method of

Dubois. The results were assessed spectrophotometrically (490 nm) by color change resulting from the reaction of phenol with sulfuric acid. The content of carbohydrates was determined in accordance with the standard calibration curves plotted for glucose. The content of nucleic acids and proteins was analyzed by the methods of Spirin and Lowry with the Folin reagent, respectively.

Identification of neutral monosaccharides was carried out after hydrolysis of the preparations in 2 N HC1 (5 h, 100 ^{0}C). Monosaccharides were analyzed as polyol acetates on an Agilent 6890N/5973 inert chromatography-mass spectrometry system equipped with a DB-225mS column. Determination of the fatty acid composition was performed after hydrolysis of the LPS preparation in a 1.5% solution of acetyl chloride in methanol (100 ^{0}C, 4 h); the fatty acid methyl esters were analyzed on an Agilent 6890N/5973 inert chromatography-mass spectrometry system with a HP-5MS column.

The O-antiserum was obtained to heated *P. agglomerans* cells (2.5 h, boiling water bath). The rabbits were immunized intravenously five times with 4-day intervals; cell concentration was $2{\cdot}10^9$ cells/mL (from 0.1 to 1.0 mL). The antigenic activity of LPS was studied by the method of double immunodiffusion in agar according to Ouchterlony.

It was found that LPS yield in *P. agglomerans* was 6.8%; it exceeded the average values typical of the other members of *Enterobacteriaceae* (5%), but was lower than that in some *Pseudomonas strains* (up to 32%).

The LPS preparations were characterized by a rather high content of nucleic acids (up to 30%), which might be due to the LPS extraction procedure applied. After purification of the preparation by ultracentrifugation (three times at 104 000 g, 4 h), LPS contained significant amount of carbohydrates (42.0 %), traces of protein, and nucleic acids.

The LPS of *P. agglomerans* 8674 was characterized by predominance of glucose (40.5 %) and rhamnose (38.6 %); it contained galactose (5.9 %) and ribose (6.2 %) whereas the amount of rhamnose. The heptose content of LPS was 8.8 %. The amount of 2-keto-3-deoxyoctulosonic acid (KDO), typical LPS component of gram-negative bacteria, was 0.4 %. Thus, the isolated LPS contained all the monosaccharide components typical of this group of glycopolymers.

The LPS was shown to include fatty acids with chain lengths from 12 to 16 carbon atoms; lipid A in the studied strain contained 3-OH-$C_{14:0}$ acid as the predominant component (32.7 %) as well as $C_{12:0}$ (8.2 %), $C_{14:0}$ (28.3%), $C_{16:1}$ (27.4 5) and $C_{16:0}$ (3.4 %).

Traits of the LPS composition determine serological specificity of microbial cells due to the presence of antigenic determinants which can be recognized by the cells of other organisms. Immunochemical properties of LPS were studied using the polyclonal O-antisera obtained from the rabbits immunized with heat-treated cell suspensions of *P. agglomerans* strain; LPS isolated from the studied strain served as antigens. The O-antiserum titers determined by the ring precipitation reaction. Reaction of double immunodiffusion in agar by Ouchterlony showed that the studied LPS exhibited antigenic activity in homologous systems. It is known that a method of serological cross reactions can be used in taxonomy of bacteria. The antiserum to the type strain *P. agglomerans* 8674 interacted not only with the homologous strain, but also with LPS from strain 7960a, which indicated the presence of common antigenic determinants in these strains. It should be noted that the LPS from the type strain *P. agglomerans* 8674 interacted also with antisera to the other two strains (7960a and 8606). The results obtained are indicative of immunochemical heterogeneity of the species *P. agglomerans*.

Conclusions

Thus, we have been isolated and studied lipopolysaccharide of *Pantoea agglomerans* type strain 8674. Chemical identification of lipopolysaccharide showed that it was characterized by relatively high yield, content of carbohydrates, KDO (2-keto-3-deoxyctonate acid) and heptose. As a direct reaction lipopolysaccharide interacted with homologous antiserum, it shows that they are O-antigens of bacteria. *Pantoe aagglomerans* strain was heterogeneous for monosaccharide and fatty acid composition and displayed antigen activity. The LPS of *P. agglomerans* studied strain can be considered as a potential harmful component of air and settled dust from aircraft cabins.

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Interleukin 7 properties and prospects of its clinical application

The main functions of cytokines, namely interleukins, were investigated. The possibilities and prospects of interleukin 7 obtaining and application in the clinic are shown.

Communication between different cell types of immune system is critical for its correct functioning. Unlike most other mammalian cells which spend their lives organized into organs and tissues, the cells of the immune system are peripatetic.

Cells of the immune system require communication networks that can, as required, act locally or at a distance, specifically or globally, and transiently or in a sustained manner. The networks that allow such sophistication in the mammalian immune response exploit an extraordinary variety of cell membrane-bound and soluble messengers. Cytokines are the best characterized messengers among them.

Cytokines are small protein molecules (usually smaller than 30 kDa) that are of great importance in signals transferring between cells in multicellular organisms. They differ from hormones by the mode of the action and by the specificity of production places (true hormones are produced by endocrine glands, tissue hormones – by almost all types of cells in multicellular organism, and cytokines are produced by different cells such as B and T lymphocytes, macrophages, mast cells, and also endothelial cells, fibroblasts, and various stromal cells). But sometime cytokines are referred to as hormones. Their actions are both diverse and overlapping and affect diverse and overlapping target cell populations. Cytokines have immunomodulatory and other capabilities, modulate the balance between humoral and cell-based immune responses, regulate the maturation, growth, and responsiveness of cell populations. Cytokines include chemokines (affect directed cell migration, adhesion and activation), interferons with antiviral activity, interleukins including lymphokines (have great variety of actions), haematopoetins (promote cell proliferation and differentiation), tumour necrosis factors (regulate inflammatory and immune responses), and transforming growth factor beta family that regulate the functions of immune cells.

Interleukins belong to cytokines. Leukocytes are the first found cells producing interleukins; now it's known that mostly interleukins are synthesized by T lymphocytes, monocytes, macrophages, and endothelial cells. Interleukins help the development and differentiation of T and B lymphocytes, and hematopoietic cells.

Interleukin 7 (IL-7) is a representative of one of the biggest classes of cytokines, interleukines. It is a single chain 25kD glycoprotein containing 4 α-helixces that are internally disulfide cross-linked. Production of IL-7 has been detected from multiple stromal tissues, including epithelial cells of thymus and bone marrow. Additional sites of IL-7 production include intestinal epithelium, keratinocytes, fetal liver, adult liver, dendritic cells, and follicular dendritic cells. Thus, IL-7 is essentially a tissue-derived cytokine, with stromal and epithelial cells of various locations as the primary sources, whereas bone marrow–derived dendritic cells appear to be relatively minor sources of IL-7.

IL-7 serves as a growth factor for early lymphoid cells of both B- and T-cell lineages. IL-7 has crucial importance for correct functioning of the human immune system. Absence of functional IL-7 in organism can cause combinatorial immunodeficiency. Thus, it can be potentially used as effective therapeutic agent for therapy of patients with immunodeficiency diseases.

IL-7 signals through the common cytokine gamma chain (γc). IL-7 also uses a second component, the IL-7 receptor alpha chain (IL-7Rα) (CD127). Signaling through the IL-7R requires both IL-7Rα and the γc component. Interaction between IL-7 and IL-7R leads to initiation of subsequent phosphorilation events which result in increasing of proliferative and antiapoptotic molecules synthesis and decreasing of pro-apoptotic molecules synthesis. Thus IL-7 acts as factor which stimulates T-cells proliferation and differentiation.

IL-7 has a trophic action on lymphoid progenitors, maintaining viability of precursor cells independent of cell division. In addition, IL-7 promotes recombinations of variable, junction and diversity genes encoding antibodies. IL-7 was originally discovered based on its activity in inducing proliferation of murine pro-B cells. It is now recognized that IL-7 plays a critical role in the development of both T and B cells in mice, and of T cells (but not B cells) in human. IL-7 effects on the development and function of lymphoid populations are not limited to B cells and T cells. IL-7 also influences the development and function of dendritic cell populations and mobilizes myeloid populations. But T-cells are the main targets for IL-7.

So, IL-7 plays an important role in T-cells lymphopoesis. IL-7 maintains the survival of early thymocytes during the "triple negative" stage of development (without CD3, CD4, CD8 receptors) through the anti-apoptotic factors modulation. In addition, IL-7 contributes to the expansion of T-cell precursors. The processes of positive selection and negative selection shape the population of thymocytes into a peripheral pool of T cells that are able to respond to foreign pathogens and are immunologically tolerant towards self antigens. The end result of IL-7 action is that sufficient numbers of T-cell precursors undergo T-cell receptor (TCR) rearrangement before the massive cell death that occurs during positive and negative immature T-cells selection. Although IL-7 is best known for its effects on T-cell populations developing, IL-7 also potently modulates mature T-cell function. First, IL-7 co-stimulates for T-cell activation by enhancing proliferation and cytokine production. Second, IL-7 tends to induce type 1 of immune responses because it potently upregulates interferon-γ and IL-2 production, only weakly induces IL-4 production, and synergizes with IL-12 in inducing T-cell proliferation and interferon alpha (IFN-α) production, in part by IL-12R on mature T cells activation. A third major effect of IL-7 on mature T cells is the inhibition of programmed cell death.

Due to the myriad of effects described above it is possible to make a conclusion that IL-7 can represent some therapeutic benefits. As it was elucidated the main target of influence of IL-7 is T-cells. Thus it can be probably used for treatment of diseases associated with T-cell depletion. So, strategies of cancer and HIV therapy, severe immunodepletion after organ transplantation with the help of IL-7 are being elaborated. Also IL-7 can be probably used as adjuvant during vaccination.

For now there are a lot of laboratory investigations in this direction and only a few clinical ones. For instance, in athymic T-cell–depleted hosts, the systemic administration of IL-7 dramatically enhances the number of T cells recovered following adoptive transfer. Systemic administration of IL-7 has also been used in cell carcinoma model in which a 75 % reduction in pulmonary metastases was observed concomitantly with increases in the total number of body T cells, NK cells, B cells, and macrophages. The combination of IL-7–induced effects on mature T-cells and the down-regulation of transforming growth factor beta (TGF-β) production by IL-7, raises the prospect that local production of IL-7 within the tumor microenvironment might augment proliferative and cytolytic capacity of infiltrating lymphocytes, thus increasing tumor immunity. In summary, the countless effects make IL-7 an attractive molecule for local tumor immunity inducing. Gene therapy techniques that can induce IL-7 production in the tumor microenvironment in the presence of co-stimulatory molecules may be particularly potent at inducing antitumor immune responses. Thus far, all of these studies have been performed in mouse models; future studies are indicated to determine whether these promising results can be translated for use in humans. Also recombinant human IL-7 (rhIL-7) is being widely investigated as therapeutic agent. Strategies of its application were approbated on mouse models and a few clinical investigations were carried out. Therefore investigation of all unelucidated aspects of IL-7 mechanism of action, and elaboration of methods of its quantification are the challenging tasks for molecular biology today. It is important also to elaborate cheap and highly-sensitive method of recombinant human IL-7 obtaining to have possibility to administrate it into human organism. The most appropriate way to deal with a latter task is that with the usage of modern genetic engineering technique.

Consequently, after numerous laboratory stadies of IL-7 effects and mechanisms of action clinical studies began. It was elucidated that IL-7 plays an important role in T-cell pool expansion. Also it counteracts to immunosuppressive factors. It is well tolerated by human organism. Using glycosilated IL-7 it is possible to increase its half-life period. But effectiveness of such therapy in long perspective is purely investigated. Furthermore, IL-7 therapy has some limitations. For example, IL-7 usage during HIV therapy probably may enhance HIV replication. So, investigation of this therapy expediency is very important task for today.

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Overcoming stress. The outputs of the stress state

It substantiates the need for a withdrawal from the stress and protect from it. There were lists of the system and mechanisms of protection from excessive stress. Attention is paid to dietary antioxidants. Considered in compressed form antioxidant vitamins, phenolic compounds of plant origin, trace element selenium, bee products, etc. It is emphasized that the world of plants it is an inexhaustible source of biologically active substances including anti-stress substances.

Despite the prevalence of extreme urgency and stress and its effects on human health, the safety of operators and flight crew, the safety of aircraft passengers, etc., it is necessary as much as possible to highlight the state of the problem.

During the almost 80 years that has elapsed since the formation of Hans Selye's concepts of stress as the general adaptation syndrome, science has made giant steps forward to a full understanding of the stress-response mechanisms of living systems. However, there are still many "blank spots", not enough clarified the details of the mechanism. Now we know that every stressor acting on any level of the organization of living, directly or indirectly – through hormones trasmitery, cytokines – inevitably disturb homeostasis, a living system makes the transition to a more intense mode of life, the more intense metabolism. This necessarily increases the oxygen consumption of mitochondria, redox homeostasis is shifted more or less strongly and continuously in the direction of increasing oxidation processes, increasing the concentration of radicals and peroxides.

Stress is a natural physiological state, as the state of peace of mind, and the same is necessary for normal life. The demand for the output of stress, especially in the defense of it, there are not so often, namely in two cases: when the stress lasts too long, and when the force of the current stress agent is too large and exceeds the capacity of the body's reserves. In other words, only needs to be protected distress ("bad" stress); evstres (short-term mild to moderate "good" stress) does not require any protection, no way out of it [1]. All living human systems have a number, a hierarchy of systems and mechanisms for the protection from excessive stress, the mechanisms to overcome it [2].

A. The peripheral system.

1. *Antioxidant Protection*: antioxidant enzymes; proteins that intercept heavy metals; water-soluble and fat-soluble antioxidants; hormones; steroids, bioflavonoids.

2. *Protection from toxins and xenobiotics*: cytochromes P450; membrane proteins of multiple chemoresistance; glutathione S- transferase enzymes and others.

3. *Stress proteins*: ubiquitin, heat shock proteins (HSP 08/10/20) HSP 40, 50, 60, 70, 90, 100 (110).

B. Central heating mechanisms.

1. *Central braking gamma-aminobutyric acid (GABA-system).*

2. *The system of opioid peptides.*

3. *Hormones, neuropeptides, neyrosteriny*.

All these anti-stress protection mechanisms are very effective especially in terms of short-term and not too severe stress. They actually hold the physiological stress in the normal range, and they contain oxidation processes. They ensure a successful adaptation to the most common types of stress, not only successfully overcome them, but also training, a gradual increase of stress resistance by repeating mild to moderate stress. Serious and very long-term stress are accompanied by depletion of domestic reserves and the anti-stress mechanism. In these cases, external assistance is needed in the form of antioxidant, membrane-protective, vitamin, metabotropic and other drugs, as well as dietary antioxidants[3].

Nutritional antioxidants

Antioxidant vitamins - ascorbic acid (vitamin C), kotoferoly (vitamin E), retinol, retinal, retinoic acid (vitamin A) enter the body with food, mainly vegetable, and become an integral part of the internal antioxidant defense.

Phenolic compounds of vegetable origin without being vitamins, yet effective antioxidants. They enhance and prolong the effect of ascorbic acid, protect it from oxidation. In conditions of prolonged physical and mental stress, persistent smoking need for food increases antioxidant 2.5- 2 3 times from 50 to 75 mg to 150-200 mg per day of ascorbic acid tocopherol from 10 to 25 mg / day of beta-carotene (provitamin A) from 2.4-3 mg 5,2-6 mg. It will be appreciated that an excess dietary antioxidants not only beneficial and harmful enough, it may even enhance the oxidative processes in the body caused by stress. It is also important to remember that dietary antioxidants are particularly useful and effective when they come in the form of natural systems as part of fresh fruits and vegetables. Then they fully absorbed and act effectively. Net vitamins, lack of natural protection, easy to lose activity - oxidized, degraded in the body, their effect is reduced. Therefore, use of drugs and pharmacy vitamin complexes meaning mostly during seasonal shortages of fresh fruit and vegetables there from February to May, and courses for 20-30 days, with weekly intervals.

Phenolic compounds and vitamins are contained in berries (blueberries, strawberries, strawberry, red and black currants, gooseberries), fruits (apricots, citrus fruits, apples, pears, plums, cherries), vegetables (fennel, garlic, onions, cabbage, broccoli, brussels, red and white cabbage , lettuce, spinach, sorrel, beet red and white, etc.). The intense the color of vegetables, berries and fruits indicate about high contain of vitamin and antioxidant value [4].

But the most potent source of antioxidant is tea, especially green as well as black. Very useful to drink cocoa and chocolate. Coffee also has antioxidant and anti-stress activity, but it is not recommended to drink more than 3-4 cups a day. The active antioxidants found in grapes, wine. Among the antioxidants of natural origin highly effective ubiquinol (ubiquinone, a component of the respiratory chain of mitochondria). Synthesized it and our body, but it is received from the outside in the form of nutritional supplements and medications, it is very useful in terms of muscle fatigue, overloads, heart disease.

The trace element selenium is a powerful antioxidant, cardioprotective and anti-cancer drug. Seafood (shellfish, seaweed, sea fish), broccoli are rich of selenium. The daily requirement for selenium is 70 mg, with stress increases to 200 mg. As a therapeutic drug in the form of sodium selenite, ebslena etc., it is prescribed for cardiovascular and oncological diseases. In areas where little selenium in rocks and soils, plant and animal foods are also poor in selenium, and it will negatively affect the activity of this important antioxidant enzyme glutathione peroxidase like, and some other proteins. On the other hand, it is also undesirable overdosage calculus [5].

Critical role of regulators redox homeostasis, the maintenance factors, oxidation-antioxidant balance in cells carry the thiol compound with free sulfhydryl groups. Of these, the most important glutathione; He also is a cofactor of important antioxidant enzymes. Food sources of glutathione and precursors are sulfur-containing amino acids: cysteine, cystine, methionine, complete proteins.

High anti-stress activity have bee products: pollen collected by bees, propolis, honey. In oriental medicine since ancient times as a means to combat fatigue and stress, a prophylactic and therapeutic use metob mummy, ginseng, eleuterekok, golden root, Chinese magnolia vine, devil, sweet. The world of plants is an inexhaustible source biological active substances, anti-stress including.

Currently, the pharmaceutical industry produces a lot of anti-stress drugs, which are widely used in medicine and aviation, for example, glitsised, Allora, neo-Pasito, valerian extract, and others.

Conclusion

All of the anti-stress protection mechanisms are very effective especially in terms evstres. They provide a successful adaptation to the "good" stress and not only successful to overcome them, but also training. Distress accompanied by depletion of Interior reserves and anti-stress mechanisms. In these cases, the "bad" stress needs outside help in the form of antioxidant, membrane-protective, vitamins and other drugs, as well as dietary antioxidants.

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The technology of neutralization of the microflora that is disposed to ruining fuel-oil materials

In the article the infection reasons and the methods of neutralization of the microflora that influences the quality and performance abilities of the fuel-oil materials are analyzed. As a result, the most effective methods were chosen.

Among 15000 existing microorganism species approximately 200 species are disposed to hydrocarbon destruction [5]. Nowadays the study of the hydrocarbons bio-destruction is quite actual but still slightly investigated. This problem becomes more and more significant as aviation and astronautics switch to biofuel that is even more liable to destruction. The researches proved that the fuel microorganisms are so ubiquitous and different that they are able to accommodate themselves to the nourishment conditions and different types of oil products, so it is impossible to destroy them completely. That is why the mentioned problem will constantly draw the scientists' attention and demand a big expense.

The main types of the microorganisms that provoke biological damage of oil products are *Pseudomonas,, Micobacterium* and the fungi *Cladosporium, Aspergillus, Penicillum, Alternaria* and others. At the same time, more ofter than other microorganisms the bacteria *Pseudomonas aeruginosa* and *Cladosporium resinae* «kerosene fungus» are detected in the oil products [4]. Fuel bio-damage is connected with the microboilogical fermentative oxidation of the hydrocarbons with the creation of organic acids that posses superficially active substance. The main condition of the successful evolution of the microflora in the fuel is the presence of water with the mineral salts remnants and the optimal temperature [3].

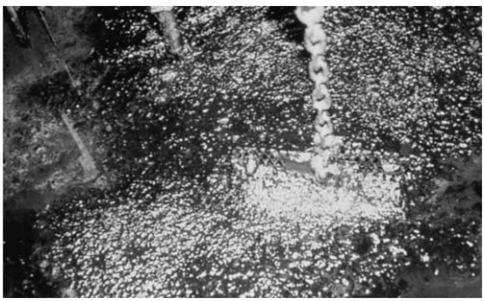

Fig. 1. Example of sludge build-up at the bottom of a fuel storage tank.

It is known that hydrocarbons have the linear molecular structure and are more destructively inclined than their branched isomers. Aliphatic (paraffinic) hydrocarbons are usually less bioresistant than the aromatic ones. That is why the fuels that contain mostly paraffinic hydrocarbons are more disposed to destruction by the microorganisms than those which contain a large amount of aromatic compositions [2].

In most cases microbiological destruction of the paraffinic hydrocarbons starts with the oxidation of the final methanol group into spirit and then, through aldehyde, to the corresponding fatty acid. The process continues by the means of the β-oxidation of fatty acids, when at every chain cycle the length of the fatty acid shortens for two carbonic atoms. As a rule, the ferments that take part in this process possess a low specifity and may be engaged in the destruction of the hydrocarbons with the different amount of carbonic atoms. [3,5].

The indicators of the microflora presence in the jet engine fuels:

- Presence of the biomass clusters such as lumps of sticky slum and formations similar to felt in the water sediment;
- Presence of the lumps of sticky slum on the inner walls of the tanks;
- Corrosive damage of the fuel tank surface;
- Clogging of the pump filters and nets in the tanks with the sticky mass;
- Fuel deterioration including acidification, changing og the fuel smell and colour, mycelium and slime pollution;
- Progress of metal corrosion at the bottom, where the water mud clusters, especially at the boundary line fuel-water[5];

Bio-damage protection methods can be divided into mechanical, physical, chemical, biological and combined. To the mechanical ones we refer: vacuum potting, flushing, air, -and liquid filtration; to the physical methods: raying, heat-treatment in atmosphere or under duress; to the chemical ones: biocide-treatment; to the biological methods – use of antibiotics i antagonist microbes; to the combined ones: combination of the mentioned methods [1].

The use of antimicrobial (biocidal) additives is an effective method of POL protection as they do not worsen the fuel field-performance data. Biocidal chemicals search is based on the analysis of the microbiological hydrocarbon disintegration process. Being aware of the process patter and checking connections one after another, one can reveal «metabolic deadlocks» - products which are toxic for the cells that either accumulate or break the process or turn it into another direction. In all the cases such compositions reveal the characteristics of the active inhibitors of the microbiological process for decontamination of the fuel systems and stores after fuel drain. They oppress microorganisms' vital activity and prevent biological corrosion of the fuel trunks [5].

Oil product microorganisms possess the high capacity to accommodate to different life conditions. That is why it is impossible to neutralize them completely. Bio-destruction protection provides the following measures: filtration; centrifugating; agglomeration with the succeeding filtration; flotation; use of ion-exchanging pitches; electrohydraulic precipitation; ultraviolet, - and X-ray, - or ultrasound treatment; use of biocide additives [5]. Sterilization and washing off of the volumes used for oil products storage and transportation prevents the oil products from the stagnations and accumulation in the pipelines [2].

Table 1[3]

Suppression of microbial growth influenced by various additives, %

Fuel additive	Conce-ntration	Mix-tre of fungi	Clado-sporium resinae	Pseudo-monas pyocya-neum	Mycobac-terium lacticolum
The mixture of aliphatic amines	0,1	100	100	100	100
Dimethylamino-methylparahlorfenol	0,5	60	80	100	100
Trialkylphenyl ester of phosphinecyclo-hexyl	0,5	40	40	80	80
T-1 fuel without additive	-	Abundant growth			

The use of biocide additives is considered to be the most effective method. A range of biocide products is suggested for the fuel and lubricants protection. Most of these compositions also have anti-corrosive and anti-wear properties and may be used as multifunctional additives to diesel oil. In addition, lubricants and oils are protected by the various fungicides such as metalorganic compositions that contain mercurous stannum compounds, trybutylstannumoxide (0.1 ... 0.5%) and hexylresorcinum (0.5 ... 1.0 %), diphenylamine (0.1 ... 0.3%).

Conclusion

It is important to highlight that jet fuel performance properties depend on the presence of microorganisms. The fuel that they affect is of little use and can be a threat to flight safety.

Among the variety of methods that help to neutralize microorganisms from fuels and lubricants the most effective one is use of antimicrobial (biocide) additives, which almost completely destroy unwanted organisms, as well as comprehensive study of the fuel by using inhibitors in combination with fuel filtering through the filters with the surface wetted by the same inhibitor.

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Justification of requirements' to large -scale mapping with use of unmanned aircraft systems

In the article the requirements to large-scale aerial mapping areas using unmanned aircraft systems and methods of processing materials such mapping.

Introduction. Topographic - geodetic surveying enforcement and other works in some cases requires large-scale topographic plans. For example, the state land cadastre plans need the following scale: in the cities of republican and regional subordination - not less than 1: 500; in the cities of regional subordination and villages - not less than 1: 1000; in villages - 1: 2000 [1]. To ensure the required accuracy of the accounting unit display area points margin of error imaging network and landmarks nearest points regarding state geodetic network shall not exceed, in the cities of republican and regional subordination - 10 cm; in the cities of regional subordination, in villages - 20 cm; in villages - 40 cm. The error of the relative position of adjacent points limits should not exceed 0.1 mm wide plan. Similar requirements for topographic - geodesic design versatile software works construction and other areas [2]. Get a large-scale plans advisable under certain conditions through the implementation aerial mapping using unmanned aircraft systems (UAS), which at present successfully used armies of different countries to solve many military tasks (reconnaissance, patrol and photography areas, delivering ammunition and cargo, identifying locations air defense enemy forces, etc.).

Analysis of the current state of problems and justification of the research tasks. Traditional methods of large-scale aerial mapping from satellites, planes or helicopters to enforce land use and other works have certain disadvantages. You can not always get quality satellite images from the archives through the cloudy atmosphere, and receiving aerial photographs to order takes time and is not cheap. At present the most accurate satellite materials aerozniman can receive images with a maximum resolution of nadir 0,5 m, which does not meet the accuracy creation of topographical plans scale 1: 2000 - 1: 500. Aerial mapping aircraft and helicopters require significant costs for their maintenance and refueling, removal company, leading to its rise in price. Aerial mapping from satellites, aircraft and helicopters are not very cost effective when mapping small land and during the regular monitoring of various objects (pipes for various purposes, power lines, highways, agricultural fields, etc).

According to UVS International (the leading international organization unmanned systems) unmanned aerial vehicles (UAVs or drones) are produced in more than 50 countries. In the Russian Federation serially produced several types of UAV, tested and suitable for the performance aerial mapping such Ptereo-E4, Dozor-50, ZALA 421- F [3]. Ukraine also developed and produced a number of models of UAVs for various purposes: multi "Falcon", altitude A-10 "Phoenix," a family "Strepetova", maneuverable A-12 "Hurricane" (adapted for actions in populated areas because it can maneuver between buildings), A-5 "Orlando" for the conditions of high mountains and large expanses of water and more. Engaged in designing, manufacturing and import UAV Ukraine in various research institutes, design bureaus, large industrial enterprises, as well as several private entities.

For aerial mapping mainly used unmanned aircraft or helicopter type with petrol or electric motors, maximum take-off weight up to 50 kg, with a semi-automatic or automatic control. Military experts perfected the technology aerial mapping using UAVs and getting them the necessary photos and video, but topography - geodesic support of construction, surveying and other work materials requires topographical greater precision and scale. Under certain conditions aerial mapping using the UAVs can be compared with traditional methods aerial mapping following benefits: efficiency and profitability receiving aerial photographs; removing areas of relatively low altitudes and thus obtain high-resolution aerial photographs; ability to perform aerial mapping inaccessible areas; aerial mapping of emergencies in areas without risk to the health of pilots and other employees.

Deterrent to widespread use of UAVs aerial mapping is relatively high at the time of accident (for most types of modern UAV to reduce their cost and weight set autopilot simplified design, they have information systems on dangerous ground tall objects and avoid collisions with them, ground, and this leads to the loss of the aircraft and its equipment); lack of regulatory and legal framework for the use of UAVs in the airspace of the country; no issues of certification, insurance; lack of practical experience in aerial mapping.

Problem solving. Aerial mapping areas using UAVs is not fundamentally different from classical aerial mapping of airplanes or helicopters, but has the features that will be specified later. Flight of UAVs unstable height and direction, to influence its trajectory winds, turbulence of the atmosphere and other disturbing factors. As a result, power aerial photographs obtained from UAVs may have good detail, brightness and contrast, but low quality photogrammetric terms of standard application packages for photogrammetric processing of aerial photographs. So aerial mapping using UAVs to obtain high-quality large-scale plans require strict compliance to ensure the geometric parameters of removal.

UAVs for large-scale aerial mapping areas, in addition to UAVs, the ideal scenario to have onboard complex control (usually a drive autopilot and flight information), payload and ground station control [3].

Autopilot tasks include: automatic flight control of the UAV on a given route and, in particular; compliance estimated altitude and flight velocity, angles stabilize orientation; ensure successful forced landing in case of engine refuse and other serious problems UAV; control onboard systems and payloads, such as camera stabilization and temporal coordinate and synchronize the camera shutter, release a parachute and more. Payload refers to the camera, video camera, thermal imager, infrared camera, onboard computer etc. The functions of the ground control station is tracking the flight, the transfer of the necessary commands and receiving data.

On the UAV is desirable to set type digital camera Canon, having a reliable electronic control system and high resolution. We know that the camera resolution is measured by the number of lines in one millimeter (l/mm). Modern aerial photolens are in the middle image resolution 150 l/mm, and lens distort makes 1-2 microns, which is already on the verge of geometric optics. These lenses are rightly called bezdystorsiynymy. The resolution of digital cameras is measured by the number of pixels in one inch (written as dpi). Pixel regarding sensor - charge-coupled device (CCD) means the size of its sensor. If the transfer resolution 150 l / mm precision measurements possible, we get 6,7mkm. This means that the size of the CCD sensor has to be just such a value. At present, the firm began to produce such a CCD, and so it became possible to create and use digital aerokamery such a high resolution. At present, also using modern computer technology with its current capabilities solved the problem of reading information from the CCD and the accumulation of it on the appropriate media. On the amount of information speaks following calculation: aeroznimok format 230 x 230 mm with a pixel size 7 mkm contains information about the volume of 1 gigabyte (GB). When it comes to the rapid accumulation of information during the flight and the hundreds of thousands of images, the problem becomes clear.

If for reasons of cost and limited opportunities in the damage of "hard" emergency landing UAV to establish consumer camera, it should be calibrated, ie, to determine the exact value of the focal length, the position of the main points of his lens distortion. In aeroznimanni desirable to disable auto focus, and camera focus set at infinity. Because of small flight altitudes (300 - 1000 m) and large UAV flight speed (70 - 150 km / h.) sutter speed when going off to reduce fuzziness aerial photographs should be set 1/200 s or less.

For rigorous photogrammetric processing of aerial photographs and obtain maximum precision large-scale orthophotos due to lack of stability of the UAV flight aerial mapping should be performed with high longitudinal and transverse overlap of aerial photographs. Project should aerial mapping of longitudinal overlap of aerial photographs along route 80%, and between routes - 40% [4]. These values overlaps prevents gaps phototriangulation blocks in the processing of aerial photographs.

Implementation aerial mapping from small heights when the ground very quickly, "escapes" from the board VAV requires strict compliance with certain requirements. The use of GPS navigation improves quality aerial mapping [5]. Aerokamery latest generation combined with GPS in a single system, which allows you to fully automate the process aerial mapping. In these systems use dual-frequency GPS-receiver that works in DGPS; so near the mapping facility established terrestrial base station. This differential treatment to avoid ambiguity in the definition of coordinates VAVs after appropriate mathematical treatment. Note that modern systems can record aerokamery position with high accuracy that meets the requirements of large-scale mapping. The use of GPS in the aerial mapping allows: aerial routes to the project (coordinates routes are set and entered into the computer); the event optimize the bass on aerial route (turns, change course, change altitude, etc.); VAVs output at a given point in space where it is necessary to perform aerial mapping; record the coordinates of the center during a projection exposure with high accuracy (5-10 cm).

The latter possibility is very important and is as follows. If the flight fixed spatial coordinates of the centers of projections (linear elements of external orientation), it significantly affects the photogrammetric technologies simplify work

[6]. In this case the block to build a network of triangulation can or no reference points (without bindings field of aerial photographs) or with a small number (2 - 4 points to 100 images), which significantly reduces aeroznimalni work.

Preferably combined with GPS inertial navigation system (INS). INS consists of a gyroscope (angular performs during slope stabilization aerokamery VAVs) and accelerometer (determines the change airspeed VAVs). Combining GPS and INS essentially complementary. It is known that the stability of hits GPS is quite high in a large period of time, but in the short period of time there may be some difficulties, mainly due to loss of signal from the satellites during navigation maneuver. INS opposite - make a good impression in short time intervals, but in large time periods distorted by the influence of so-called gyroscopic effect and systematic errors of accelerometers that tend to accumulate. Combining GPS and INS gives additional effect: in short time intervals INS "corrects" your GPS, and at long time intervals GPS compensate for systematic errors INS. Integrated navigation system (GPS + INS) are an integral part of modern digital aeroznimalnyh complexes. They also allow you to fix the camera shooting angles to within fractions of degrees satisfying solution photogrammetric tasks.

Working materials aerial mapping using VAVs may perform using standard photogrammetric software packages (Delta / Digitals, DPS PHOTOMOD, etc.). Instability VAVs flight, it turns again when the route can lead to significant (triple or more) aerial photographs overlap, causing some complications using standard photogrammetric software packages. These and other complications for special occasions aerial mapping be extinguished manually directly performer works.

Conclusions and suggestions.

1. Under certain conditions aerial mapping using VAVs may be appropriate when large-scale mapping of small plots of land to perform surveying work during the regular monitoring of various engineering and the environmental, agricultural fields, etc.

2. Due to possible instability UAV flight for maximum accuracy (eg, 1-2 GSD) created orthophotos need: aerial mapping design with high longitudinal and transverse beams aerial photographs (respectively 80% and 40%); ensure availability opoznaki routes or even some aerial photographs; used for removal of calibrated cameras with high resolution, providing exposure 1/200 c or less and have a fixed focal length; complement and coordinate the work aeroznimalnoyi camera work dvohchastotnoho onboard GPS receiver with differential mode of measurement, inertial navigation systems and computers; perform rigorous studies of aerial mapping to control all its stages and, if possible, use standard packages with photogrammetric software.

3. Further extension of VAVs for large-scale mapping of areas possible with a combination of efforts both VAVs manufacturers, including manufacturers of full board photogrammetric equipment and software developers photogrammetric processing of aerial photographs. On the one hand should be increased enforcement of geometrical parameters aerial mapping and practical experience of its implementation. On the other hand the desired reduction requirements for inputs for standard packages photogrammetric software processing of aerial photographs.

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The concept of state regulation of the circulation of agricultural land and the possible prospects of its development

The approaches to the definition of the market for agricultural land. The essence of the definition of "land market". Principles of forming land market. The concept of state regulation of agricultural land in Ukraine. Characterized the market of agricultural land and the possible prospects of its development, based on international experience.

The land is a key element of national wealth and the basic means of production in agriculture. She - a necessary condition for the existence of human society. The greatest value up farmland - the main source of food and the foundation of food security. The development of agriculture in general and agriculture, depends largely on how well organized will use and legal protection of land.

The development of a market economy in Ukraine provides for the development and establishment of a land market and their involvement in the market circulation. Without land market in terms of market transformation and it is impossible to ensure the market transformations in agriculture and increase the efficiency of agricultural production.

Questions of state regulation of land involved scientists: P. Kulinich, A. Martin, A. Wind, A. Miroshnichenko, B. Spout, S. Serdyuk V. Kvasha and others. But several questions remain insufficiently studied.

In this regard, very urgent detailed examination of state regulation of land, the legal framework circulation, circulation management mechanisms, regulation of the process of state and municipal property development and circulation of agricultural land.

For disclosure of the above issues, you should closely examine what is government regulation. According to the Encyclopaedia regulation, a set of targeted forms, methods and areas of influence used by government to organize a system of social and economic relations in order to stabilize and adapt the existing political system to changing conditions. [1] Under state control should understand the process of influence of public authorities on the subjects of the land market through the development and approval of decisions to ensure harmonization and control of legal relations. The instrument of this regulation should be understood as a set of regulations that govern socio-economic processes. A subject of circulation of land should be considered as an economic category.

According to the Land Code of Ukraine land is part of the earth's surface with prescribed limits, specific location, defined on her rights. [3]

As economic resource land can be characterized by the following features [13, p. 160]:

1. Earth is a unique resource, which substitutes just can not be. Earth as an economic resource can not recreate artificially. It is a gift of nature, which requires substantial investment in the improvement and protection.

2. Land is completely immobile, serves as a place for life and the basis for productive activities.

3. Land varying fertility and different location. Earth does not wear out, but rather improves the management of their fertility and can be used indefinitely.

4. Land resources are limited in number. In all countries, including Ukraine, the area for mineral rights, particularly agricultural land steadily declining since developing city built facilities, housing, infrastructure, soil erosion occurs.

Agricultural lands are characterized by specific features, namely:

1) agricultural land is a strategic resource for food security and food independence of every society, in terms of total globalization becomes particularly important because agriculture products are unique and no replacement for human;

2) agricultural land provide employment peasants economic activity, protect the country from the negative effects of urban processes;

3) the functional role of agricultural land for each society is growing due to increased world population and growing problem of food self-sufficiency";

4) legal registration of transactions in the land market requires mandatory state registration and complex, expensive legal registration. This requires the presence of the state in the process of regulating the market [5, p. 202];

5) land is not playing, it is impossible to create artificially, it is limited in space, the proposal this land is fixed.

The notion of a land market of agricultural land in modern literature is interpreted based on different approaches. Several scholars see it as part of the real estate market (I. Kolesnik, I. Krekoten, Pavlov, Yu Hvesyk), others as a legal category (A. Danilenko, N. Sharafundinova) or as a cost-organizational and legal environment (A . Martin, J. Manko).

Another option is the definition of land market definition proposed by M. Fodorovym, which states that "land market - a system of land relations, which are regulators ownership (possession, use, disposal), the possibility of transfer of rights (lease, sale, pledge et al.), competition (free choice of sites), and monetary evaluation of land prices that are freely composed." This definition focuses on the fact that the land market provides a definition of the market price based on supply and demand, as well as recognition of land capital.

In his work Mr. Pushkarenko gives a broad definition of land market, he believes he is a system of economic relations with regard to sale and lease and security of natural resources. [6, p.24]

From the above we can conclude the land market - a sector of the economy, where economic relations are realized on the sale, mortgage, lease and exchange of land, effectively carry out economic activities and the use of economic resources from an environmental point of view.

The concept of the agricultural land market in our country, has its objective the following tasks: to ensure effective and efficient use of land to form a relationship to the land as particularly valuable goods, and ensure effective management therein.

The principles of forming agricultural land market are: compulsory social orientation of the land market in the implementation of the economic interests of farmers; gradual inclusion of private farmland in market circulation; strict government regulation of land market, a system of price and tax leverage state on market turnover of land.

Often both in domestic and in foreign scientific literature, identification of market turnover agricultural land and agricultural land. In our opinion, the most correct view when the market agricultural land is part of market turnover (turnover).

Modern agricultural land market in Ukraine is on the way of its development. The rental market is the main way of redistribution of agricultural land between owners and users. For sale and purchase market is frozen since 2001 due to the introduction of a moratorium on the alienation and change of purpose of agricultural land. It was originally introduced for 5 years, but the term has continued several times. Today its term expires Jan. 1, 2017.

Another prerequisite for lifting the moratorium should be the adoption of the Law of Ukraine "On circulation of agricultural land," which should define the rights and restrictions on the circulation of agricultural land. We are talking about limiting the number of market constraints on the accumulation of land ownership, preferential right to purchase more.

Prospects for the sector of the market economy could become global experience in these matters. For most countries have passed this way, and the result was formed a number of models of market purchase and sale of agricultural land.

Considering the sale of agricultural land world literature reveals a number of questions about the consequences of the introduction of various restrictions on the land market. It gives quite a clear vision for effective market model that can adapt to different characteristics and circumstances. This model includes three main areas:

1. Introduction restrictions on the market of sale of agricultural land.

2. Providing the benefits of flexible forms of incentives (taxes, fees) on inflexible administrative restrictions.

3. Compliance decentralized approach in identifying patterns and limits market [7].

World practice has shown that the introduction of restrictions on market sale rarely give the desired results. Restrictions were effective, but entailed no cases compliance or distortion. The results of the Government's measures to regulate the market of agricultural land was an increase in transaction costs, which negatively affected the market participants. Universal restrictions may also be ineffective, lead to bureaucracy that would be interested in maintaining restrictions.

As for the introduction of flexible forms of stimulation relations, it is the most important way in which government can help to improve the functioning of the market, by removing market distortions, reduce transaction costs and improve the functioning of financial markets. In addition, experience has shown that appropriate use is only temporary moratorium on the sale of or restrictions on the accumulation of very large tracts of land (to prevent monopolization) in situations of rapid restructuring or creating market.

A decentralized approach in identifying patterns and limits market allows to locate and to balance the social and economic aspects of the land market locally. But the effectiveness of this approach is performed subject to transparent mechanisms for decision-making and community responsibility for the results of their decisions.

If locally transparency is not possible in this case, the best policy is the complete absence of restrictions.

Based on international practice, this study suggested follow this approach to model definition and limits agricultural land market in Ukraine - namely, to transfer power and authority on the formation of the market of agricultural land to local authorities, preferably at the district level on such issues as market opening the definition of who can be the buyer, the establishment or extension of time constraints, the establishment of taxes, fees and benefits.

Typically, the land market is local, as provided active involvement of local councils and communities can balance the social and economic aspects of the market introduction of agricultural land.

The task of the government should be to ensure transparency of the process of decentralization of powers to ensure the responsibility for decision-making. The transfer of authority to the district level is appropriate, but always involving communities in decision-making. This approach is consistent with the policy of decentralization that is currently underway in Ukraine.

At the level proposed law to regulate the following points:

1. Set the maximum transitional period during which the temporary restrictions may apply on the participation of foreigners, legal entities operate duty rate and the temporary boundary size of land owned.

2. Set limit restrictions on the accumulation of very large tracts of land and prevent land monopolization of local markets.

3. Establishment of taxes to prevent aggressive speculation in the land market and maintaining its purpose.

4. Restrict access to the market of agricultural land only on the basis of a special mode of land use. This includes protection and sanitary zones, lands with special land use related to national defense and security, environmental protection, cultural heritage and objects of life. In other cases, all decisions, including the Participation of Foreigners should be taken by local authorities and the community. For example, the law could impose a ban on sale of land with / agricultural land to foreigners in the border area. [10]

5. Establishment of a monitoring system of land relations in Ukraine to reduce the information deficit market participants and transparency of land relations in Ukraine.

Conclusions. The involvement of land into market circulation, the formation of a civilized market of agricultural land is very complex, gradual and lengthy process. The establishment and functioning land market, the market turnover of agricultural land made on the basis of market mechanisms of regulation of land relations, which are fixed by law. The effectiveness of these processes depends on the level of government regulation.

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Problems of community land ownership formation

We have reviewed the stages and the legislative framework for delineation of state and community land ownership. We have analyzed the problems associated with formation of community land ownership. We have suggested the areas for completion of formation of communal ownership to community land.

The formation and development of local governance in the country, the reforming of land ownership, the constitutional recognition of the rights of people to exercise their powers by direct will expression and through government agencies and local governments led to the introduction of the land ownership of local communities of villages, towns, cities, districts in cities. Article 13 of the Constitution of Ukraine stipulates that local authorities, as public authorities, on behalf of the Ukrainian people, exercise the rights of a land, and Article 142 specifies that the land which is in community ownership of local communities is the material and financial basis of local governments, along with other resources.

Local authorities, on behalf of local communities, acquire necessary powers for management of land resources and independence in disposal of land. Their economic and legal responsibility and interest in rational use and protection of land resources, safety of land, socially oriented use of land are increasing.[3]

The formation of the legal framework for land ownership institution has passed quite a long period of time. Despite the fact that the aforesaid ownership was offered in June 1996, the composition of community land ownership and basic requirements for the delimitation of state and community land remained unsettled until a new Land Code of Ukraine came into force on January 1, 2002.

In addition to the definition of peculiarities of community ownership functioning, the 2002 Land Code contained a number of other novels as well. In particular, it defines the principles of formation, status and ways of exercising the right to land ownership. Any restrictions as to the size of plots privately owned by people for construction and maintenance of houses and outbuildings, for personal farming and gardening, cottage and garage construction were abolished.

The private ownership of land for people to be engaged in non-agricultural business was introduced. The operation of private ownership for legal entities was standardized. The ownership of land (except agricultural land) for foreign citizens, foreign legal entities, persons without citizenship and foreign states was introduced.

The issue relating to possession, use and disposal of joint land ownership by citizens, legal entities and local communities was settled.

It was the first time when the right to use someone else's land (right of servitude), the right of neighborhood and restriction of rights to land, and the issue associated with exercising these rights and related compensations were standardized.

The issue associated with the land market operations was outlined. The general procedure for land sales, peculiarities of rights acquisition on a competitive basis (land tenders), for buyout of land plots for public use was introduced.

It was determined what land is community property, as well as the process for acquisition of community ownership by local communities.

In order to make the rights of local communities to land exercisable for the period until a special law regulating delimitation of lands is adopted, the Cabinet of Ministers of Ukraine, by its Resolution No. 1100 dated January 8, 2002, approved "Temporary Procedure for Delimitation of Land in State and Community Ownership" [5]. The Temporary Procedure clarified and expanded the list of land plots that are transferred to community ownership, and slightly changed the types of categories of land that should remain in state ownership. The functions of the Cabinet of Ministers include the approval of land boundaries in Kyiv and Sevastopol, as well as in cities of national and regional significance. Also, the Government had to approve boundaries of areas in state land ownership that could not be transferred to community ownership. These changes were not supported in practice.

The work related to the transfer of state land ownership to community ownership was entrusted to relevant state authorities responsible for land resources. However, they were unable to complete the work without the development of land management plans.

On February 5, 2004 the Verkhovna Rada of Ukraine adopted the Law of Ukraine "On Delimitation of Land in State and Community Ownership". [2] The Law defines the legal basis for delimitation of land, the powers of state authorities and local governments for regulation of land relations to exercise the rights to land, to ensure the national sovereignty and develop material and technical resources of local governments.

By law, the delimitation must be carried out on the basis of the following principles: provision of national security; combination of state and local interests; equality of land ownership rights of local communities and the state; free-of-charge; reasonableness; achievement of balanced ratio of economic and environmental interests of society, rational use and protection of land.

When delimiting state and community property within administrative units (districts, cities, towns, villages), the role and status of a specific unit in operation of local economy and settlement system. The delimitation of land in Kyiv, for example, takes into account that Kyiv is the capital of the state. It is the political, administrative, moral, cultural, historical, scientific and educational center.

The delimitation of land in small and medium cities is associated mainly with the prevailing formation of community land ownership, while a significant proportion of private land occupied individual housing construction is present.

The distribution by type of land ownership (state, community) in townships and villages, mostly with private land use, is to separate units of public service, transport, enterprises for processing agricultural products, etc. between community and state authorities, enterprises and organizations.

The criteria for classification of lands for state or community ownership are as follows:

– separation of objects by their belonging to state authorities, local authorities, research activities and banking system management bodies;

– economic, historical, cultural and town planning significance of an object;
– functional use of real estate;
– ownership of real estate.

The Law of Ukraine "On Amendments to Some Legislative acts of Ukraine concerning Delineation of State and Community Ownerships" dated June 9, 2012 [1], which entered into force on January 1, 2013, stated that the land in state and community ownership in Ukraine are considered to be delineated since the date of enactment of this Law. However, it has the list of land plots, but their boundaries are not set, i.e. no basic conditions for a land plot formation exist. In it is commonly known that the right to ownership of land and the right of permanent use of land and the right to lease of land emerge as of the date of state registration of rights. [4]

Earlier, it was not enough funds to develop relevant documentation to implement the provisions of applicable law on delimitation of state and community land ownership, and the process for formation of community property was out of control. Now, when the delimitation was completed by law, but the boundaries of delimited plots do not exist, the community land ownership has become largely virtual. Given the absence of necessary funds in the state and in local budgets for performance of delimitation work, it was legislatively decided that the registration of state or community land ownership is carried out simultaneously with the registration of derivative right (permanent use, lease, perpetual lease, superficies). Due to the fact that the provision of land for permanent use, lease and other derivative rights covers annually insignificant areas of land, this registration process completion time is impossible to predict. Thus, the State Land Cadaster does not have any reliable information on state and community land ownership, and its entry cannot speed up, by following the valid legal regulations on combined registration of primary and derivative rights.

Today the area of land occupied by settlements is 7.54 million hectares, of which 3.48 million hectares of land is in private ownership. Thus, 4.06 million hectares in total are subject to delimitation. These include land areas of industrial and transport enterprises, organizations and land of the defense sector, which cannot be transferred to community ownership, which is 155 thousand hectares, the land of government authorities, schools and institutions of science and education is 74.7 thousand hectares, specially protected areas make 24.5 thousand hectares. It is possible to transfer 3.8 million hectares of land to community ownership within settlements. Outside settlements, the land in community ownership makes about 0.5 million hectares (community pastures, cemeteries, landfills for waste storage, etc.). The estimated area of land of community ownership in Ukraine today can make 4.3 million hectares.

For the period from January 1, 2013 to January 1, 2016, the plots of land in community ownership with total area of 52.2 thousand hectares were included into the State Land Cadaster. Thus, the area of state land is set too high by 4.25 million hectares according to the cadaster, and the country almost does not have any land in community ownership (only 0.01% of the total territory).

Conclusions

The situation regarding the delimitation of state and community land ownership is critical. The information on the division of state land by types of ownership does not comply with the law on delimitation of land. A fundamental change in this situation requires the development of concepts for forming property of local communities of medium and large cities and the completion of inventory of land occupied by settlements with inclusion of relevant information on land plots in community and state ownership in the cadaster.

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UDC 338.2

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Economic aspects of space information technologies for environmental monitoring

The necessity of environmental monitoring to improve agricultural production using space information technologies (GIS) of agricultural lands is defined. The value of their implementation are calculated. The main advantages provided by them are determined.

The use of space information technologies (GIS) will optimize production through sustainable use of natural (land) resources, environmental protection and control of agricultural operations. Space information technologies are the basis for resource saving and ecological organic agriculture and, therefore, an integral part of technological safety of agricultural sector [1].

Modern GIS technologies are not only monitoring of natural resource potential for its rational management, but also timely adjustment of farming systems using "precision farming" technologies [2]. The use of such technologies allows increasing the economic impact from economic activities by optimizing anthropogenic load on the environment.

Information technologies for monitoring of agricultural lands are underused in Ukraine, even though the legal basis for land monitoring is provided by Article 191 of the Land Code of Ukraine. The function of monitoring land is assigned to the central authorities at national, regional and local territorial level, that carry out state policy in the sphere of land relations and environmental protection [3].

Using of space technologies for monitoring of agricultural land offers several advantages. They provide high reliability and relevance of data; a wide range of explored territory; high frequency of obtaining of new information; the possibilities for collection, accumulation, generalization and standardization of information data [4].

Aerospace photos, topographic and agrotechnological electronic maps are the main sources of information received and used for monitoring of agricultural lands.

Aerospace photos provide information about the change in the optical properties of the soil surface and have a high clarity of data presentation. With their help, we can make some conclusions about the nutrient content of the soil, determine crop sensitivity to humidity of soil, the quality of crops within a field that can be used as inputs for forecasting crop yields.

In addition to aerospace photos, the topographic maps, land planning schemes, maps and data of agrochemical passport fields, alternating crop rotation schemes, cartograms of agro-industrial groups of soils can be used for monitoring of land. All this allows to achieve high accuracy and reliability of the results [5].

Today the most famous space providers of information technologies are the follows foreign companies: Cropio (USA / Germany), eLeaf (Netherlands), Precision Agriculture (Australia), Astrium-Geo (France), Vega (Russia), and national company MapExpert [6]. Most companies use in their practice accumulated by spacecrafts archive data of different exposure qualities, such as: SPOT 2, SPOT 4, Landsat 4, Landsat5, Landsat 7, IRSP6 LISS-3, ALOS, TerraASTER, IKONOS, QuickBird ObrView-3 , EROS and others. The resolution quality of photos and map scale determine the level of suitability of space photos of these devices (Table 1).

Table 1

Quality of space photos used for mapping of agricultural technologies [7]

Spacecraft	Resolution, meters	Map scale
IKONOS	4	1:20000
Landsat 7	30	1:150000
IRS – 1C	23,5	1:117000
IRS – 1C	5,8	1:29000
SPOT 1-4	20	1:100000
SPOT 4	10	1:50000
SPOT 5	5	1:25000
EROS A	2,4	1:12000
EROS B	0,7	1:3500
QuickBird ObrView-3	1,0 4,0	1:5000 1:20000

Topographic maps are a picture of relief with the ability to determine the level of soil erosion and obtain information about a possible deposit of ground water level and so on. Usage of modern electronic agrotechnological maps of fields are also equally effective method of monitoring of agricultural land in which space-time fixed costs of resources for field works are fixed. These maps provide the efficiency of agrotechnological process at the appropriate time, taking into account soil and climatic conditions of certain fields. Under certain technical conditions electronic agrotechnological map allows to:

- provide an opportunity to record and control all agricultural operations based on accurate baseline data for their implementation;

- assist in carrying out of a detailed analysis of the conditions that affect the development and growth of plants on specifically chosen field;

- optimize the production process in order to maximize profits and simultaneous rational use of resources involved in a particular transaction.

However, services of creating an electronic map of the field cannot be called cheaper because now they can be used only by the large agrarian enterprises. The value and duration of the works on creating of the electronic maps is represented in Table 2.

Table 2

The value of creating an electronic map of the field and duration of the works (for the area of 20 thousand hectares) [8]

Name	Value, dollars USA	Duration, days
High resolution space photo	3,200-6,200	over 30
Low resolution space photo	1,000-3,200	over 30
Hardware-software complex "HeoOblikovets"	10,000	60
Detour of field boundaries	10,000	20
Vectorization of field boundaries	2,400	20
Creation of electronic map	11,200	60

Usually, a high value of introduction of precision farming (37.8 - 43.8 thousand dollars USA), especially the electronic maps of fields, is very costly innovative project. However, those agrarian enterprises, which, nevertheless, dare to use space information technology in their work, will be able to carry out intensive and sustainable agricultural production development in the future.

Taking into account international experience (study of the American Institute of Precision Agriculture) and domestic realities the minimum amount of savings from the introduction of space information technologies has been calculated. According to Table 3 it is over 18 dollars USA per one hectare.

Table 3

Savings in production costs using space information technologies [6]

Cost items	on 1 hectare/year	on 1,000 hectares/year	on 100,000 hectares/year
	dollars USA	dollars USA	dollars USA
Fuel, spent on the detour of field territory	0.15	150	15,000
Wages to employees	0.8	840	84,000
Fertilizers	1.4	1,400	140,000
Control measurements and analyzes	1.28	1,280	128,000
Insurance	0.17	170	17,000
Control of mortgaged crop for the loan	0.2	200	20,000
Costs from too late identifying of weaknesses	8.7	8,700	870,000
Costs of low yields	5.5	5,500	550,000
Total	18.2	18,240	1,824,000

Reduction of fuel costs for inspection (detour) and processing fields and for fertilizer, reduction of staff costs will optimize resource costs, reducing the production costs, and thus increase the profitability of the production process.

Given the cost of creating of electronic maps of the field in 20 thousand hectares (37,800 dollars USA) and the possible amount of savings for the same area of agricultural land (36,480 dollars USA), the costs of enterprises for the implementation of space technologies in production can be considered as justified.

However, implementation of latest achievements in information technologies of land cultivation and crop production is quite problematic for domestic enterprises and pose a threat to the technological security of agricultural sector. The main problems are:

- the lack of clear government policy concerning the space activities in the agricultural sector;
- problems in the creation of effective developments in technologies of remote monitoring of agrarian resources;
- necessity of modernization of machine and tractor fleet;
- significant value of space land monitoring;
- long payback period (5-10 years) of creating of electronic agrotechnical maps of fields;
- low readiness of domestic farmers to change of technical and technological support of agriculture and crop production.

In our view, the removal of these problems is possible only through the development of space activities through interdepartmental coordination of research of the National Academy of Agricultural Sciences, the Ministry of Agrarian Policy and Food of Ukraine and the National Space Agency. This work will contribute to solving the problems of rational use of agricultural land, revealing weaknesses in agricultural landscapes, defining the status of crops and agricultural ecosystems.

The advantage of such cooperation in that the government by attracting domestic scientific staff promote the development of not only the space industry, and actively develop agriculture, with much lower costs and greater synergistic effect. In addition, such projects may be subject to foreign direct investment that are interested in maintaining ecosystems.

Thus, the use of modern space technologies is an objective requirement for successful agricultural practices, because information technologies:

- provide detailed monitoring of land resources and state of crops;
- help to form reasonable management decisions to the prevention of negative consequences of economic activity;
- can improve the efficiency of the use of land and quality of growing of agricultural plant;
- ensure the increase of productivity and reduce of production costs through rational use of fertilizers, pesticides, fuels and lubricants and so on.

In general, space information technologies ensure compliance with requirements of technological, environmental and economic security of the agricultural sector and the environment.

Conclusions

GIS technology can monitor the environment, intensify agricultural production, increase its productivity, improve efficiency of assets, and achieve higher levels of crop capacity due to dosage applying fertilizers and pesticides, which reduce the human impact on the environment. Considering the minimum amount of savings from the introduction of space information technologies, it can be concluded about the feasibility of their implementation in modern conditions in Ukraine.

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Legal aspects of land allotment for road transport

In the article considered the issue of legislative regulation of land allotment for road transport. There fixed specific of the legal status and procedure for allotment and discovered unsettled aspects of the legislation. The author proposed solutions.

Development of the network of public roads has priority for the state [art.14, 1]. According this increases the necessity for plots of land for new construction and reconstruction of existing roads. Therefore, analysis of the legal aspects of land allotment for road transport is important.

Highways are divided into: a) public roads of national importance (international, national, provincial, territorial) and local significance (regional, district); b) streets and roads of cities and other settlements (highways, main streets of the city and district value, streets and local roads); c) departmental (technological) roads; d) roads on private territories. The level of roads determined their constituents.

Land of transport can be in state, communal and private owned, and be objects of a concession [2].

Public roads owned by the state and not subject of privatization. Parts of the streets and roads of cities and other settlements connected to the state highway belong to Single transport system of Ukraine and not subject of privatization.

Public roads that due to the expansion of the boundaries of areas of cities are part of a street road network can be transferred free of charge to municipal property by the decision of the Cabinet of Ministers of Ukraine.

Streets and roads in cities and other settlements are run by local government and municipal ownership.

The departmental (technological) roads and roads on private land are owned by legal entities or physical persons.

Carriageway roads, bridges and overpasses, technical equipments of organization of motion, external illumination on streets and roads of settlements can be transferred for free to the state ownership. They can also be transferred from the state to the municipal property by the decision of local government and the Cabinet of Ministers of Ukraine.

Highways to private land owners can be transferred to the state or municipal ownership by the decision of the Cabinet of Ministers of Ukraine or local government.

Paid public roads remain state owned and not subject of privatization. They cannot be taken from public property.

Placing objects within the easement must be agreed with the owners of the roads.

Features of the legal regime of the land of road transport, responsibilities of landowners and land users for maintenance of land within the easement of roads established Uniform Rules repair and maintenance of roads, streets, railway crossings, rules of their use and protection [3]

The legal regime of land road facilities determined by the Law of Ukraine "On automobile roads" [1].The width and size of parcels of land are allotment for roads in permanent use, depending on the category of road, number of lanes, the height of embankments and other conditions. The sizes are set according to the standards for allotment of land for roads [4]

In the design of roads should take into account the location of agricultural and industrial facilities, water, mineral deposits, utilities, land reclamation channels, zones of radioactive contamination of land. In designing new and reconstruction of existing roads of national importance to pave the road tends to bypass existing settlements.

Land which was provided under a career under temporary buildings, industrial facilities, access roads, should be returned to landowners and land users after construction or reconstruction of roads. They must be re-cultivated.

Permits for placement of small architectural forms of buildings within the red lines of city streets and roads provided the relevant local executive bodies of city councils [5]. Placing these buildings agrees with the police, road maintenance and other interested organizations. Permits for placement of buildings within the easement road (non-urban) roads outside settlements provided appropriate road maintenance organizations. Placing these buildings agrees with the police.

Construction of road service, gasoline filling stations, works within the easement roads are in accordance with the permission of public administration roads. The resolution agrees with the relevant departments of the National Police. Permits are issued paid within 30 days.

All disputes associated with industrial activities at the roads are resolved by the court.

The state commission created for construction and reconstruction of public roads, in the case of alienation of land, located in a private or municipal property [6]. The commission proposes redemption of land at market price. This takes into account the market value of buildings or structures located on this land. The land purchased by the court, if the landowner does not agree with the proposed price.

State management of public roads provided by the State Agency of Roads of Ukraine - (Ukravtodor) [1]. Ukravtodor is responsible for quality of work on the design, construction, reconstruction, repair and maintenance of public roads.

Management of streets and roads of settlements carried out by respective local governments. Management of function and development of departmental (technological) roads carried out by owners – legal entities or physical persons.

The development of standards and regulations on construction, reconstruction, repair and maintenance of roads held by the state roads management in coordination with relevant government authorities on road safety. Adoption of national standards for construction, reconstruction, repair and maintenance of roads carried out by the central executive authority, which provides public policy in the sphere of technical regulation.

Financing the construction and reconstruction of roads, which are of national importance and the operation of a Single transport system of Ukraine can be realize from the general fund of the State budget. In the law of the state budget is made a separate entry about this. Capital repair and maintenance of streets and roads of settlements and other roads that are part of national roads can be at the expense of local budgets on a contractual basis. Financing for construction, reconstruction, repair and maintenance of streets and roads of settlements realize at the expense of the budgets of settlements and other funding sources, by the legislation. Financing for construction, reconstruction, repair and maintenance of departmental (technological) highways and roads on private territories realize at the expense legal entities or physical persons in the property they are.

Legislation exempt from land tax land road management of public roads according to the list in the Tax Code [art. 283, 6]. However, the area of land recorded with other land road. This makes it difficult to control the actual size of the land that is not taxed.

The procedure for abduction of land for road complex facilities and protection zones of roads is not legally regulated.

It identifies the need of improve legislation concerning the acquisition of land for roads. Need the codification of current legislation on the status and composition of these lands. It should solve the issue of land use regime in the security zones. It should detail the components of highways. It should be improving the law on the use of agricultural land for road construction. We need to clearly define the procedure of approval of location of objects of road transport.

For the decision of problems of land law, land allotment for road transport legislator is planning amendments to the Land Code and other legal acts. The draft law submitted to the Parliament in 2016, proposed to divide the land management and land traffic road.

It is assumed prohibition of transfer of state and municipal property under public roadways into private ownership. Provision standards of protection zones to be established on both sides of the roadbed for normal operation and preventing damage to buildings roads. They should be installed by land management documentation and register as a limitation.

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Features creation of agricultural land use in modern conditions

The implementation of land reform in Ukraine, which began in March 15, 1991, led to fundamental changes in the structure of farms that existed before the reform. These companies were represented mainly by large land-use collective and state farms. Some smaller farms characterized land use research and educational institutions agricultural profile, which mostly survived to this day. Land use people (as farmers up to 6 million) that were give pieces of land in the amount of which usually does not exceed 0.6 hectares.

Formation of land use in the present conditions due to the number of the concluding contracts, territorial distribution of land shares and their area. Some lands and corporations have very large areas of land that are not comparable with the optimal size of farms. They are located within the territories of many rural communities and even rural administrative districts, they do not link their activities with the social sphere of rural areas and do not participate in the formation of local budgets. Nona of the abore corporations, have any prejeds that lend to land productivity accommodations.

The current land law stipulates that land management is made mandatory, and its object is "the area of land ownership and land use or individual plots. The organization of land ownership and land use is provided as part of land management projects that provide environmental and economic assessment of crop rotation and streamline land, with highlights that measures of agricultural lands and streamline land ownership developed to be used.

Thus organization of private land leased enterprises, farms and other agricultural enterprises, which use the land on lease, must be preceded by environmental and economic substantiation of crop rotation and streamline land or developed as a part of land management projects.

On what basis the land formation shaud be given?

First of all ACT Sustainable Rural Development (respective jobs, the share in local budgets, socially rural development, improving engineering and social infrastructure). So flood land boundaries coincide with the boundaries of territorial communities of villages and towns, and their size to be needed considering the optimal size of agricultural enterprises, something recommended for the main course - the agricultural regions. The functioning of these enterprises should should be interuine the interests of local communities that will stop the "extinction" of villages to keep rural way.

In the formation of land use should solve the current problems encountered in the process of land reform. The main and most difficult challenge is the consolidation of agricultural land.

Some developers legislation on market development farm lands, agricultural land turnover to be seen in the main task of land consolidation in the exchange of land between owners for the purpose of consolidation , elimination of shortcomings in land use, determination of affiliation belts , field roads, others about of objects remaining in the collective property and not subject to sharing. It certainly will improve the conditions for the effective use of land. However, not solve the main problem - the formation of arrays that would be attractive to investors and ensure the application of advanced technologies for growing crops. The problem of the formation of such arrays can be solved in two ways: either through the purchase of state land shares for the citizens of the state budget, ie through appropriation of land, or by forming land common property instead of individual fields within the rotation to be forming a leaving the requirements of ecologically safe agriculture. The second way, in our opinion, is more appropriate, considering that most of the land owners shares so far alone did not use them, and receiving rent, rates and terms of payment under joint ownership may be more reasonable and controlled.

Privatization of land as the core land reform thus be saved, and the state budget (up to 200 bln. uan.) Can be used for other public purposes. The infrastructure for agricultural production (economic courts, current brigade building, etc.), shelterbelts, former collective farm forests, field roads that remained in collective ownership, it is appropriate to transfer to the state or municipal ownership and arrange the transfer of their lease relevant businesses or farms.

Implementation of this proposal will increase the area of land common property by 3-4 % due to field roads that have been designed to access each land (share), but they do not function as plot boundaries in kind does not exist, and cultivation is carried out within specific fields, land masses etc.

It should solve the issue of unclaimed shares lots and lots escheat and incorporate them into the land holdings within which these sites are located.

Difficult question remains streamlining land after land reform. Conversion of arable land in the conservation of other lands (hayfields, pastures), occupying it under afforestation and other degraded and unproductive lands require the necessary legal and financial support from the state. Placement of industrial buildings, hydraulic structures, etc. erosion of farmland occupation should be funded by the respective companies and households, as well as state and local communities.

For the purpose of agricultural production and improvement of agricultural land within the land ownership and land use for efficient agricultural production, that can be used in management and protection of lands, creation of favorable ecological environment and improvement of natural landscapes Law of Ukraine "On Land Management" provides for the development of land management projects that provide ecological and economic assessment of crop rotation and streamline land.

These projects land under the Act define:

a) placement of industrial buildings and structures;

b) organizing land ownership and land use crop rotation with allocation based on environmental and economic conditions , the formation of engineering and social infrastructure;

c) determine the types and rotation based specialization of agricultural production;

d) drawing up schemes rotation of crops in rotation;

e) design field crop rotation;

f) the development plan for the transition to the accepted rotation;

g) transfer in kind (on location) fields projected rotation.

However, the development of the project as a part of measures to protect the land is not envisaged . This issue is resolved in later adopted the Law of Ukraine "On amendments to some legislative acts of Ukraine concerning the conservation of soil fertility " of June 4, 2009 and approved in November 2011 the Cabinet of Ministers of Ukraine order of development projects to land formation.

The above procedure involves environmental and economic grounds not all components of the project land, but only the design decisions related to the fields of crop rotation, ordering land, land protection measures and plan to switch to the accepted rotation. Aside projects were left including the placement of buildings and structures; of land ownership and land use, the justification of which in modern terms when lands continue to reform in the country, there is an urgent need

Conclusions

1. Consolidation of land in present conditions can be carried out through the purchase of state land to private property of citizens , and by the reorganization of personal private property in a joint share ownership according to law. The second way has many advantages for its implementation should develop and implement appropriate pilot projects in major areas of the country.

2. Creation (organization) of agricultural land use on the basis of scientific necessitates amendments made to the legislation, development of standards and guidelines on these issues

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The impact of air transport on the qualitative state of land resources: problems and ways of their solution

The analysis of the impact of air transport on the qualitative state of land resources of Ukraine, and also according to the state of lands and environment in the whole of the existing negative factors. Problem Z clarified the main issues that arise as a result of such actions. Confirmed and Substantiated the necessity to take measures for the protection of land resources and the environment.

Development of aviation science and technology is indisputable evidence that the prospects will occupy a position of air transportation. In the last decade the world volume has been steadily increasing annually at a rate of between 5 to 7%. And although, according to statistics the services of air transport enjoys today, only 7% of the population of our planet, the data on the transport of eloquent evidence of the fact that to travel by air, the maximum saving your time, prefers a very large part of humanity. Air transport will play an increasingly prominent role in our society and civilization in general.

But, on the other hand, a steady increase in traffic volumes air transportan today leads to pollution, deterioration of a qualitative condition of land resources and environment with products of combustion of aviation fuels and lubricants. The average length of stay of these pollutants in the atmosphere and in the soil cover is approximately 2 years. Harmful substances are emitted by air account for approximately 40% of all emissions. In addition, noise exposure and electromagnetic pollution also have a negative impact. In this regard, the search for new solutions to reduce the environmental impact of air transport is relevant.

Consider the basic problems that arise due to the influence of negative factors of air transport on the qualitative state of land resources and the environment in General.

Some modern kind of transport, which is a very important component in the world economy, has a rather negative impact on the quality of the environment and, particularly, on land resources as the basis for conducting any business activities. First of all, one of the main negative factors is the chemical pollution of the environment and a fertile layer rontogianni gases of internal combustion engines that leads to such concepts as the toxicity of the soil, which is ten times impairs fertility and reduces the amount of nutrients [1].

Of course, the negative impact on the environment, in addition to aviation and other modes of transport, in particular road. This type of transport plays a significant role in human life, but is also one of the most significant sources of air pollution. Especially its negative consequences iteleport within large cities.

Regarding the effect of air transport is its negative impact no less, and even a few more, although the fleet is much smaller than a car, but the effect on the atmosphere of only one aircraft is equivalent to the effect of almost 8 thousand cars. So you can imagine what the situation would be if humanity used only air transport. The specificity of the influence of air transport on the environment consists in a significant noise impact and emissions of pollutants, as noted earlier [1].

One jet airplane, consuming within 1 hour and 15 tonnes of fuel and 625 tons of air releases into the environment of 46.8 tons of carbon dioxide, 18 tons of water vapor, 635 kg of carbon dioxide, 635 kg of NOx, 15 kg of sulphur oxides, 2,2 solids. The average duration of stay of these substances in the atmosphere is approximately 2 years. The greatest pollution occurs in the area of airports during landing and takeoff of aircraft, and also during warming up their engines after a while spreads over an extended area. This action leads to considerable anthropogenic pollution of land, namely a fertile layer of ground soot, sulfur oxides, lead and petroleum products. The result is a decrease in the level of fertility, the deterioration of the qualitative state of land resources, and in turn, grow agricultural products. All these factors reduce the land which would be suitable for farming. Another description for the problem is the contamination of groundwater and decitabine of water in the surrounding area [3].

The concentration of harmful components in the exhaust gas of aircraft engines in the air and the speed of their distribution on the territory of the airport largely depends on meteorological conditions. In this direction, and most clearly shows the influence of the wind speed. Other factors - temperature and humidity, solar radiation, although affects the concentration of pollutants, but this effect is more pronounced and white, and has a complex dependence.

Estimation of total quantity of main pollutants in air environment controlled area of the airport of civil aviation as a result of its production activities (excluding air pollution specialized road cotransporter and other terrestrial sources), shows that on a plot area of approximately 4 km2 each second of the day released into the atmosphere 1000-500 kg of carbon monoxide, and 300-500 kg of hydrocarbon and 50-80 kg of nitrogen oxides. Such quantity of harmful substances in an unfavorable combination of weather conditions may lead to the increase of their concentrations to high values. In turn, a consequence of such negative processes there is another dangerous form of soil degradation – wind erosion anthropogenic-disturbed surfaces.

At certain airfields, the result of careless storage and fuel consumption, the concentration of oil in these waters reaches 12 ml/l at the rate of 0.05 ml/l, tableprefix 240 times. On such land, dying plants, and naukologiya to 30 % of the crop, with spamagent messepreise.

In extraordinary and emergency situations, the aircraft are forced to merge in the air, excessive fuel to reduce landing weight. The amount of fuel used by the plane for the 1st time ranges from 1-2 to 50 thousand liters. Fuel what Part evaporated, dissipated into the atmosphere without dangerous consequences, though, which is vaporized reaches the surface and ponds and can cause severe local pollution. The amount of fuel reaching the earth's surface in the form of droplets depends on air temperature and height of discharge. Even at temperatures over + 20° C on land may fall to a few percent of the used fuel, especially when discharging at low altitudes.

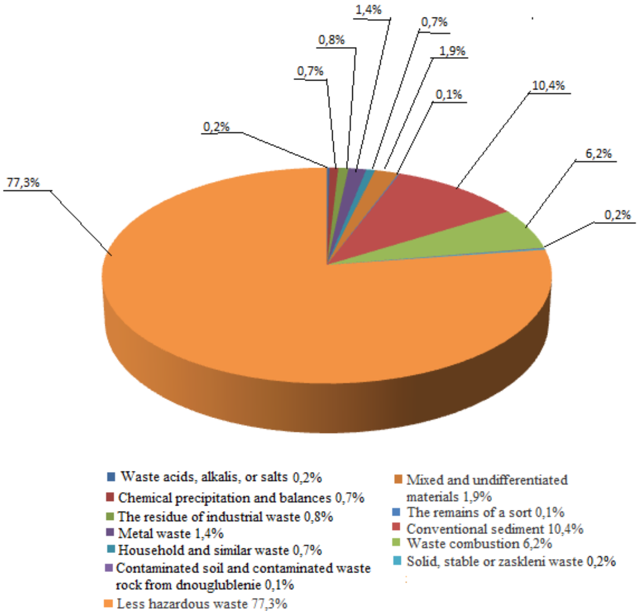

Fig.1. A comparative analysis of the amount of waste and harmful substances (%)

Analyzing the data presented in Fig.1, we see that the combustion wastes released into the environment and adversely itivity to preserve the integrity of agrarlandschaft ranks third among the anthropogenic hazardous waste at 6.2%, which again confirms the existence of problems and the necessity of finding optimal solutions [4].

Another very dangerous and harmful is the impact of air transport is the formation of radactive substances and their possible emissions. And this process is as follows. When flying in the lower stratosphere dvigun supersonic aircraft emit nitrogen oxides, which leads to oxidation of ozone. In the stratosphere there is an intensive interaction of sunlight with oxygen atoms. The result apart into separate molecules, the atoms that join to remaining oxygen molecules to form ozone. The increased area of the ozone concentration, the so-called ozonosphere, which is located at altitudes of 20-25 km, plays a very important role for the Earth. Absorbing almost all the UV radiation, ozone, thus, protects against the death of living organisms. Therefore, in places where the ozone concentration is significantly reduced in the consequence of the so-called oxidation is the risk of penetration of radioactive substances into the atmosphere and gradually settles to the lithosphere. It is known that such substances decades contained in the soil and negatively affect the interaction of nutrients and soil fertility in General [2].

It is advisable to conduct events and search for new methods, which would reduce the negative impact of air transport on the environment and particularly on land resources.

To decrease the specific content of toxic substances in exhaust gases along with the improvement of operated types of gas turbine engines creates a new GTD with new designs of combustion chamber, injection system the fuel-air mixture, compressors, which provide the most advantageous mixing ratio of fuel and air, better mixing and atomization of the mixture supplied in the chamber and more complete combustion. Creates a new chamber where fuel is burned in two stages in different zones one of these zones provides the best combustion mode, the low-thrust is acceptable, taxiing (in this case, the fuel in one area is not served), and the second zone together with the first allows to optimize the combustion process in the takeoff, climb, cruising flight I. In the latter case, the combustion process in the second zone is at a lower temperature thus reducing the NOx.

The hydrogen production cost is quite expensive, however, in a recent research it was found dostosowana to 400-seat subsonic passenger aircraft, designed for a range of some 10,000 km, hydrogen may be economically more beneficial than synthetic aviation kerosene [3].

It is characterized by high speed of flame propagation, the wide limits of stable combustion, Flammability is good, no soot when burning. Moreover, liquid hydrogen has a huge hedonismresort, more than any other liquid fuel. The main disadvantage of hydrogen as an aviation fuel are its low density and low boiling point, so that he needs on the plane is very large fuel tanks with a heavy insulation system.

Therefore, the main measures to reduce the negative impact of air transport and maintenance of appropriate environmental policy are: modernzation fleet by replacing old power-consuming aircraft types on toplevelitem; reducing energy intensity of operations by the introduction of resource-saving processes and technologies; optimization of the route network and the use of new piloting technique that reduce noise and emissions from aircraft engines into the atmosphere; disposal of waste to minimize their impact on the environment, with emphasis on the recycling of raw materials ("recycling"), as the most effective method of waste disposal; monitoring and analysis of operations and processes to identify new opportunities for improving their environmental performance; the use of indicators of ecological effectiveness as one of the criteria when selecting suppliers and contractors; raise awareness of employees in the field of environmental protection, the motivation for their careful use of all resources, fostering a culture of recycling.

Conclusion

Reviewed and pronoune the specifics of communicative nature and analysis of pollution transport, as well as suggesting possible ways to reduce emissions and legal mechanisms of the state control of carrying out all necessary measures to achieve rational use of natural resources in the area of environmental protection from the effects of air transport. Based on this analysis we can conclude, that before the main exploiters of air transport (airlines) have an important task to minimize the impact of transport on the environment. Therefore, many airlines are developing plans of environmental policies.

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The problems of the use of project cart-roads ways of their solution

The analysis of the modern state of the use of project cart-roads is conducted in research. It is educed, vagueness of legal grounds in relation to disposing of district state administrations by project perspective roads. The ways of decision of problems of project cart-roads are offered

The concept of "land share (share)" was introduced paragraph 2 of the Decree of President of Ukraine of 08.08.1995 № 720/95 «On the procedure for sharing land transferred to collective ownership of agricultural enterprises and organizations", which provided that "the right to land share (share) are members of collective agricultural enterprise, agricultural cooperative agricultural company, including pensioners who used to work there and are members of the enterprise, cooperative societies, according to the list attached to the state act for the right to collective ownership of land "[1].

The existence of rights to land shares (shares) was subsequently recognized by law (paras. 15 to 17 of the Transitional Provisions of the Land Code and the Law of Ukraine "On the order of selection in nature (on district) land owners of land shares (shares)"). The right to land (share) occurred in the Member collective agricultural enterprise since the emergence of collective ownership of land and share consistent person in the lands transferred to collective ownership of the legal entity. Article 25 of the Land Code also provides for "the determination ... land (share)" during the privatization of state and communal agricultural enterprises, institutions and land, with subjects such right recognized employees of enterprises, institutions and organizations, state and municipal employees educational, cultural, health located on the territory of the Council and pensioners among them. This object sharing is "the difference between the total area of land that were in constant use agricultural enterprises, institutions and organizations, and the area of land that are in state or municipal property (forestry purposes, the water fund, reserve fund)."[2].

In the process of land reform 6.7 million. Ukrainian villagers received land shares (shares), most of which have already implemented ownership allocating land plots in kind. Now villagers mostly use to provide various agricultural enterprises concluding with its lease agreement land.

Transfer to the nature of the land share (share) citizen carried out after the preparation of "Plans division of land collective ownership of land shares (shares)". In preparing the plan determined by the order of the division of land collective property subject to the limitations caused by technological and ecological features of their use. In order to clarify agricultural land company, subject to the division of land shares (shares) in kind, defined areas that is essential for the creation of shelter forest belts and protective forest plantations, construction of erosion of hydraulic structures, creation of a network of field roads and so on. Calculation of the area of land share (share) is held under the guidelines [9]. Design allocation of land plots (shares) held the light direction and steepness of slopes, condition of soil. Must projected convenient and rational network of access roads to the land width of 5 m with access to the existing road network [10].

It is interesting that the majority of owners land plots acquired by them as a result of the allocation of land in kind (shares), transfer land plots leased to the same tenant. Tenant processes them only with array processing and design entrance road as arable land. However, now legal relationships for their use and charge for its use are not fully resolved by applicable law.

Try to deal with who the owner of the project access roads and with whom to enter into lease agreement land.and that the purpose of these lands.

According to paragraph 2 of Article 22 of the Land Code of Ukraine to agricultural land include:

a) agricultural land (arable land, perennial plants, hayfields, pastures and fallow);

b) non-agricultural land (farm roads and trails, shelter belts and other protective plantings, other than those classified as land for forestry purposes, land under farm buildings and yards, the land under the infrastructure of wholesale markets of agricultural products, earth interim preservation etc.). "

Thus field paths related to non-agricultural land consisting of agricultural land. These lands are not subject to sharing. However, different areas fate of land is different. Some projects indicated the withdrawal of that project path field is collectively owned. Sometimes members of collective agricultural enterprises in its decision handed design access roads to reserve lands.

So mostly, there is a situation where the projected field roads do not become the subject of land ownership (shares) and be used as agricultural land under farm roads and trails, while being a reserve or reserve lands of the village, town or city council, it have no legal documents such land.

We believe the bottom there are two solutions to this problem:

1) Recognition that the project access roads - collective Actually, since the present Code of this form of land ownership not advisable to design access roads to pass common property land owners a single array. In the lease of roads agricultural farm land owners would receive more revenue.

2) Recognition of the legislation, and recommendations that access roads - reserve lands. Resolution of these grounds by law within settlements goes to the village councils and outside the village district state administration.

In the lead proektnyz field roads can be a problem with the definition of purpose of land. In our opinion the correct option is "for other agricultural purposes" (code 01.13), but due to lack of practice, local officials may propose other options. The worst thing in this situation is that the position of various bodies can be inconsistent with each other.

When making lease rights field paths should also consider that getting the appropriate lease land outside the settlement is only through the process of land sales by auction Article 134 of the Land Code []. Currently valid lease agreements which were concluded by 2008, but most agroformations term contract has expired or flowing soon. Legally impossible to renew the lease or use the land is also not possible. This raises questions feasibility of bidding, if land array processed only one tenant. In our view it would be better to simplify the procedure for transfer of field paths lease agricultural enterprises that handle most of the land.

Today, some landowners have started to cultivate the land on their own, so the area of access roads is reduced and district state administrations recalculation of the rent, which is not less than 3% of the normative monetary value, but not less than three times the land tax. However, new leases project field paths with owners of land do not enter. Also not clear who will pay the rent.

Conclusion.

Today, the legal status of the project field roads in law not approved. There is a confusion of purpose, order of lease of project access roads, the position of the various inconsistent with each other. The ways of solving problems using design field paths.

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The impact of local factors on the size of the regulatory monetary value of land within settlements

In conducting regulatory monetary value of land raises questions about the accuracy of determining the values of local factors. For this reason, has been tasked to investigate the use of coefficients of local factors. As a result, what are the results of research that helped to establish the factors that affect the size of the regulatory monetary value of land.

Implementation of regulatory monetary value in Ukraine based on the basic legislative acts, the Land Code, the Cabinet of Ministers of Ukraine. In particular, under Article 201 part 3 of the Land Code of Ukraine normative monetary valuation of land, land tax, losses of agricultural and forestry production, economic incentives for rational land use and protection and so on. [2] Legal basis of land valuation and professional appraisal activity in the field of land evaluation in Ukraine determines the Law of Ukraine "On the evaluation of land". [7]

Normative monetary evaluation is carried out in several stages, the last of which is to determine the cost per square meter of land use specific functional considering local factors. Analysis of the formation of regulatory monetary value of land settlements at this stage revealed a number of problems. [3] Therefore, the study of the influence of local factors on the size of the regulatory monetary value of land within settlements is very relevant today.

The work of Yu. F. Dehtyarenko, M.G. Lyhohrud, Yu. M. Mackiewicz, Yu. M. Palekha "Methodological foundations monetary value of land in Ukraine," the theoretical and practical aspects of the land under value activities in Ukraine, developed a scientific and methodical approaches to regulatory and expert evaluation of land of different categories. [1] The authors focus on the interaction of monetary valuation and land cadastre, using GIS technology application in the evaluation of urban planning and land use documentation and indicate the method of application of local factors in the calculation of regulatory monetary value of land settlements.

Today, despite the fact that the normative monetary valuation of land in Ukraine is in the process of updating and there is no clear regulation coefficients using local factors during the regulatory monetary value of land within the settlements.

As a result of the research process execution normative monetary value according to the procedure and methodology established that when calculating the regulatory monetary value of a great impact on the value of a human factor (appraiser). [4,6] This effect may be present in various stages of evaluation. First, a division of territory in the assessment districts and determining the cost of development and construction of the territory. Significant effect on the regulatory monetary value of a comprehensive definition of the index value of the territory. Since the evaluation can be subjective.

But the biggest impact are important factors that characterize the location of the land within the economic-planning zones (local factors). This is because they have specifically set value and varies within different.

For research analyzed the technical documentation for regulatory monetary value of land settlement. To show the magnitude of the impact of local factors on the value of regulatory monetary value, was selected land plot of 0.1405, which refers to the estimated 8 district, the first economic-planning zones purpose of land - for the construction and maintenance of residential homes.

According to the cartographic material for land investigated influenced by local factors:

-location of the land area in walking distance to public centers (Kl1);

-location of the land area in walking speed in urban and external passenger transport (Kl2);

- In the zone of elevated highways of city formating value (Kl3);
- Is not equipped with centralized water supply (Kl4);
- Is not equipped with centralized gas supply (Kl5);
- Is not equipped with sanitation (Kl6);
- The location of the land in the sanitary protection zone (Kl7)

The impact of various factors on the values of local magnitude regulatory monetary value of land shown in Table 1.

Table 1

The calculation of regulatory monetary value of land with different local factors

	Indexes	Calculated values			
1	Land area, ha	0,1405			
2	Factor taken into account, functional use 'west longitude, Cp	1,0			
3	Base price, HUA/m2	66,15			
4	Total factor that characterizes urban area value within the village Km^2	1,05			
5	Local factor for the location of economic-planning zones Km3	0,6623	1,3630	0,7711	0,7140
	Kl1	1,04	1,2	1,07	1,1
	Kl2	1,04	1,15	1,08	1,06
	Kl3	1,05	1,2	1,13	1,05
	Kl4	0,9	0,95	0,9	0,9
	Kl5	0,9	0,95	0,9	0,9
	Kl6	0,9	0,95	0,9	0,9
	Kl7	0,80	0,96	0,81	0,8
6		40,68	79,92	48,06	60,68
7		29272,02	78544,0	38489,0	51059,8

Analyzing the results of the calculations presented in Table 1, it can be concluded that the application of the minimum and maximum values of the coefficient value of the land is very different. Since the normative monetary valuation of land used for various types of taxes or rent, this price difference is quite significant and unacceptable. Therefore, we must have a clear definition of the use value of local factors.

Conclusion

Monetary valuation is a direct support land market. It is to establish the assessed value of land in the commission of various kinds of transactions with them.

As a result of studies it was found:

-impacts on the value of regulatory monetary value of land settlements;

-price difference in the maximum and minimum values and proposed local factors;

-scientific and reasonable value of the values of local factors that enable quality to fulfill the regulatory monetary value of land.

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Triterpenoids carboxylic acid derivatives

Presented several pharmacological properties of triterpenoids derivatives of betulinic acid and related compounds, offered a method of extraction form Betula pendula and chemical transformation of this class of compounds into betulonic acid

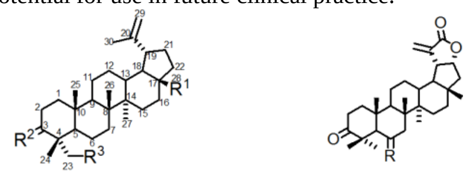
Triterpenoids as a large class of pharmacophoric compounds

Triterpenoids are substances which are abundant in natural green plants sources, such as in extract of bark of birch *Betula pendula.* They are a group of isoprenoid compounds constructed from 6 isoprene units. In terms of the classification of organic compounds they relate to the series of lupane.

Triterpenoids have a wide range of pharmacological activities, of which the most noteworthy are: antiviral, anti-inflammatory, antiulcer, antimicrobial, anticariogenc and most importantly, anticancer activity.

Betulinic acid **(1)** and many triterpenoids of lupane series is known for more than a century, but until recently their cytotoxic activity, specifically on human melanoma cells was unknown.

Thus a number of triterpenoids derivatives of lupane with cytotoxic activity against melanoma cells have been actually developed over the past fifteen years. Betulinic acid has been given most attention, because it was historically the first known triterpenoid active against melanoma. Betulinic acid is currently in the second phase of clinical trials for the treatment of *dysplastic nevus*, and consequently has a high potential for use in future clinical practice.



1: $R^1 = CO_2H$, $R^2 = \beta$-OH, α-H, $R^3 = H$
2: $R^1 = CO_2H$, $R^2 = \beta$-OH, α-H, $R^3 = OH$
3: $R^1 = CH_2OH$, $R^2 = \beta$-OH, α-H, $R^3 = H$
4: $R^1 = COH$, $R^2 = \beta$-OH, α-H, $R^3 = H$
5: $R^1 = CO_2H$, $R^2 = O$, $R^3 = H$

6: R = H, H
7: R = O

Fig. 1 Betulinic acid **(1),** its derivatives and the compounds atoms numbering

Triterpenoids which are used to treat various diseases.

Betulinic acid has also other interesting biological activities, including anti-HIV, anti-inflammatory, etc. Distinctive anti-HIV activity of betulinic acid **(1)** and its derivatives was first described by two independent research groups. Since then where synthesized, published and patented a large number of new derivatives with significant activity against HIV.

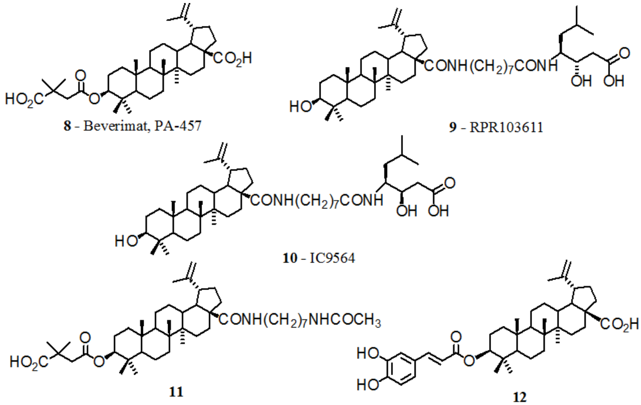


Fig. 2. Patented triterpene derivatives with significant activity against HIV

Among these derivatives **(8-12)** it is worth mentioning 3β-O-acyl-derivatives of betulinic acid suppressing maturation of virus HIV and especially 3β -O-3',- 3'-dymethylsuccinylbetulinic acid **(8),** also known as PA-457, or Beverimat, which is the most developed representative of this group.

2.EXPERIMENTAL PART

2.1. Extraction of initial compounds of triterpenoids lupane series

To the triterpenoids of lupane series belongs betulin **(3).** Betulin is widespread and easily obtained in almost any quantity from birch bark, where it can present up to 35% by weight. For the extraction of betulin are used hydrophilic solvents, hydrophobic solvents and solvent extraction in the supercritical state. The analysis has shown that none of them can be applied to obtain pure betulin for use in the industry for the manufacture of pharmaceutical and food, since these processes use toxic solvents.

We have offered and developed method involving a preliminary extraction of betulin with 94% ethanol directly from the birch bark, the following auxiliary recrystallization from the same solvent; it can help organize the production of this drug from the bark of birch at the national equipment in compliance with high health and environmental standards.

2.2. Scheme of betulin extraction with bioethanol

Birch bark is harvested at the stage of stripping the birch tree trunk. Raw material then is dried at 20 - 35 ^{0} C for 72 hours and crushed to an average article size 1 cm.

Extraction and crystallization of the primary product betulin

Raw material is placed in a vessel equipped with a stirrer, heating jacket, and reflux cooler. Pour into the reactor 94% ethanol. The suspension was heated at reflux with stirring for 2 hours and stirring stopped. The hot mixture is sent immediately through a hot filter into the crystallization vessel, bark chips separated. In the crystallization vessel equipped with stirring and cooling jacket providing temperature near ^{0} 0 C, crystallization is carried out for 2 hours.

The suspension of crystals obtained is released from the mother liquor at a vacuum filter and collected.

Recrystallization of the primary product and obtaining pure betulin substance

The crystalline mass is loaded into a reactor equipped with a stirrer, heating jacket, and reflux, 94% ethanol is poured into the reactor and heated at reflux at stirring for 0.5 hours. Stirring stopped, the solution is sent through a filter into the crystallization vessel equipped with stirrer and cooling jacket to 0 ^{0} C. Crystallization is carried out for 2 hours at stirring. The suspension of crystals is separated from the mother liquor at a vacuum filter.

Drying and packaging of betulin substance

The wet product is dried on filter air at drying cabinets on pallets at 50 ^{0} C for 10 hours at air circulation and mandatory compliance with fire safety regulations. The product is cooled in air to ambient temperature and packed in sealed metal or plastic containers.

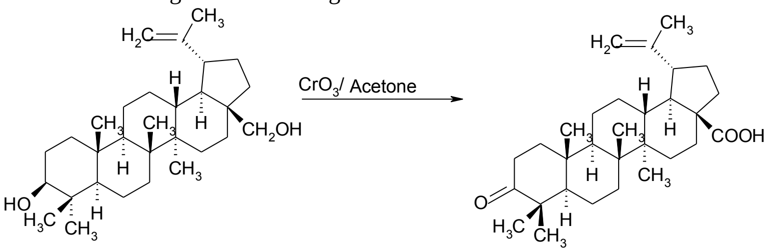
2.3. Synthesis of betulonic acid

The last two decades have given serious hopes of beginning treatment of diseases, drugs based on a series triterpenoids of lupane series. These hopes, of course are related to betulin - (3β, 28-dihydroxy-20(29)-lupen).

Triterpenoids are surprisingly widespread in nature and are readily available in almost any quantity mainly as betulin. Several studies had compared the cytotoxicity of methyl, pivaloyloxymethyl of acetoxymethyl esters of betulinic and betulonic acid on various cancer cell lines, in contrast to the 3β-amino analogs the obtained by reductive amination betulonic acid compounds have shown *anti-MEL-2* activity comparable with betulinic acid.

Some studies have been carried out in vitro to predict potential mammalian metabolites of betulin **(3)**, betulinic **(1)** and betulonic acid **(5)** by utilizing various microorganisms. Betulinic acid have proved to be non-toxic at doses up to 500mg/kg body weight in mice. Betulonic acid **(5)** is more active than betulinic acid (1) against melanoma cell line *MEL-2*, whereas the effect of C-3 ketone carbonyl moiety on melanoma cell lines *G361* and *SK-MEL-28* was small. With respect to betulinic acid (1), betulonic acid **(5)** is also more active against endothelial (*ECV304*), human epidermoid carcinoma of the mouth (*KB)*; Kim et al., 1998), ovary *(PA-1)*, colon (HT 29), prostate (*PC 3*), leukemia (*CEM*) and breast (*MCF 7*) cancer cell lines. Also, betulonic acid **(5)** is less active against human lymphoblastic and human B-cell lym-phoma leukemia (*CEM.CM3* and *BRISTOL8*), prostate (*DU145*) and lung (*L132*) cancer cell lines (Mukherjee et al., 2004c). The introduction of a methyl oxime or oxime group to betulinic acid **(1)** at C-3 resulted in the loss of cytotoxicity against the cul tured human melanoma (*MEL-2*) cell line. The 2-bromo-20, 29-dihydrobetulonic acid showed improved cytotoxicity against human lym-phoblastic leukemia (*MOLT-4* and *CEM.CM3*) and ovary (*PA-1*) cell lines. Betulin **(3)**, betulinic acid **(1)** and betulonic acid **(5)** have shown antiviral activity against herpes simplex type 1. Introduction of ureides or the C-28 amide group to betulonic acid **(5)** clearly increased their antiviral activiity against *HSV-1* virus. 3-Oxime of betulonic acid was more active against influenza A virus than betulinic acid **(1)**. When the C-28 carboxyl group was substituted by a primary amide group, the activity was further improved, the EC50 being 0.7. Ureido derivatives of betulonic acid caused clear inhibiting activity, but the effect was quite weak. The potential anti-HIV compound DSB 30 was inactive against influenza virus. Betulin (3), betulinic acid **(1)** and betulonic acid **(5)** showed antiviral activity against *ECHO-6* virus. Betulonic acid **(5)** caused the most significant reduction of the *ECHO-6* virus titer. Betulonic acid **(5)** and 28-oxoallobetulone have been shown to possess antiulcer (induced by indomethacin or acetylsalicylic acid) activity in rats. showed a comparable influence on cytotoxicity (*MEL-2*).

We have explored methods of synthesis of perspective derivative of series lupane - betulonic acid **(5)** from betulin **(3)** and developed a new synthetic route to obtain it according to the following scheme of reactions.



Betulonic acid synthesis was performed as follows: into three necked 50 ml flask equipped with a stirrer, a solution of 0.5 g load betulin in 20 ml of fractionated acetone was loaded. The reaction mixture was cooled with a mixture of ice and water and at stirring was added drop wise the calculated quantity of chromium (VI) oxide in acetone. At the end in the reaction flask was added 6 ml of methanol and stirring was continued for another 5 minutes. The reaction mixture was poured into 40 ml of ice water and added drop wise dilute hydrochloric acid to precipitate formation ending. The obtained precipitate of crude acid was filtered off, washed on the filter with water to neutral reaction and dried in air.

The precipitate of crude acid was dissolved in 25 ml diethyl ether, the organic layer was washed twice with dilute hydrochloric acid, then with water and separated. The obtained organic solution was shaken up with 7 ml of 2N sodium hydroxide solution. The ether layer was separated, the aqueous layer was treated with dilute hydrochloric acid until precipitate formation. Precipitate was filtered off and collected.

The precipitate of betulonic acid was dissolved in diethyl ether, washed with water, the organic layer was separated and the solvent distilled off, the resulting residue was dried at 60 $^{\circ}$ ^{C} for one hour. Thus were obtained analytically pure betulonic acid with the melting point of 252 - 253 ° C.

Therefore it is shown that for the oxidation time of 0.5 h at a molar ratio betulin/CrO_3 = 1: 0.7 and a temperature around 0º C it can be obtained analytically pure betulonic acid with a yield of 60%.

CONCLUSIONS

1). Conducted a survey of the pharmacological properties of betulinic and betulonic acids related compounds, derivatives of triterpenoids of lupane series.

2). Researched and developed optimal conditions for lupane series compounds extraction from birch *Betula Penula* and its chemical transformations to yield pharmacologically valuable betulonic acid by oxidation in liquid phase.

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Electrical spark and mechanical preparation of steel surfaces to enhance its corrosion resistance

Application of electric-machining and disc rotating brushing combined with the supply of patented cooler-lubricating fluid (MOP-NAU) containing surfactants and inhibiting components possessing positive synergistic action on the improvement of surface qualities of steel objects researched and developed.

Lower quality of metallic parts surfaces treatment cause serious disadvantages at metallic items production which include surface clots, remaining rust and scale, low cleanliness class, presence of dirt (sand, oils, and processing fluids), corrosion products and so on. These factors accelerate corrosion process, lower the mechanical properties of metals, weaken up the hydrodynamics of liquid and gas flow along the parts, deteriorate adhesion and protective properties of various coatings.

The existing methods of surface preparation do not always meet the desirable demands because of questionable productive qualities, complex and costly equipment, significant energy costs, non granting an effective corrosion protection (e.g. mechanical, laser, plasma electrochemical, etc.), [1-3].

The aim of this work is to create a combined electric and mechanical method of surface preparation using rotary brush sander while imposing a voltage between the brush tool and metal part, so, that the effect is achieved by thermal action both of the sparks of electric current and mechanical shock action of the brush wires ends upon the surface treated. To develop high-performance parameters of the processing method we have applied the usage of specially composition cooler-lubricating fluid (patented coolant *MOP-NAU*). It contains a mixture of cation-active and anion-active surface active compounds, which have had shown exhibited the phenomenon of positive additivity (synergism). Using the method of isomolaric series we have found that synergism is observed at a ratio of concentrations of cationic and anionic surfactants at 1:1. Under these conditions there is achieved an adsorption of surfactant on the metal surface leading to reducing the surface micro hardness and facilitating metal plastic deformation (Rebinder effect). We have found that increasing the surface activity of synergistic mixtures and reducing micro hardness of steel surfaces has simbatic nature and is achieved at equal relative concentrations of sulfanol and tetranil. As a result, the energy costs of processing were reduced by 30-40% and the finishing class of surfaces was augmented by 3 and more units.

Combining in the described process the electrical and mechanical components had been characterized by significant advantages. Thus, the surface treatment of steel only mechanically, without imposing a electrical potentials difference between the tool and the workpiece, and therefore in absence of electrical action but in presence of NAU-coolant, allows to upgrade the surface finish class only for 2 units, while the combined action of electric-and mechanical factors increase this parameter up to 3 or more units.

The presence in the fluid composition NAU-coolant the inhibitors demonstrating combined synergistic effect (inorganic passivation mixture of sodium nitrite and triethanolamine as an adsorption component) as a result of its treatment provided corrosion protection of steel transferring metal surface into passive state. Using the method of isomolar series, we have found that inhibitory effectiveness depends not only on the nature of the components and their mechanism of action, but also on the ratio of the components concentrations and its maximum value is achieved at a ratio of sodium nitrite to triethanolamine 1:1. The maximum inhibitory action is confirmed also by maximum displacement of electrode corrosion potential, by minimum passivation current and by passivation zone formation in a wide range of potentials, achieved at the same ratio of concentrations of sodium nitrite and triethanolamine [4-7].

The next stage of the study was a composition of synergistic mixtures of oxides passivation inhibitors (sodium nitrite) inhibitor passivation salt (sodium silicate), with which we had replaced the toxic triethanolamine to non-toxic silicate. Using mass-metrical method for determining of corrosion rate, we have found that the maximum efficiency of the corrosion synergistic mixture ratio action is achieved at concentrations of components of sodium nitrite and sodium silicate at 1:2. The study by method of scanning electron microscopy have shown that the higher efficiency of the corrosion synergistic mix action is achieved through the formation on the surface of steel the *hitit* $Fe_2O_3*nH_2O$, deposited simultaneously with insoluble iron silicate. It was found that the elemental composition of inhibiting components on the steel surface closely matches the elemental inhibitory composition in the mixture solution. Conducting the polarization potentiostatic studies of electrochemical and corrosion behavior of steel at high temperatures we have found a decrease in the degree of synergistic mixtures protection from 99.7% to 90%, which can be compensated by the increase in overall concentrations of inhibitors compounds. At the same time the developed process including electrical sparks and machining does not allow to provide a lasting protection of steel during its inter-operation storage. Even more, the effect becomes obvious at usage of industrial composition coolant, such as SWK and EM, which are normally used in the processing of metals by cutting.

Increased postoperative period of metallic equipment at storage can be achieved via depositing the widely used metals such as zinc, magnesium and aluminum in a role of protectors [8,9].

In purpose to apply thin layer zinc areas on the surface of steel at its electric and machined treatment we have used rotating disk brush, in which the wires were in advance deposited with a layer of zinc of average thickness 200 microns. In the processing area were also poured the coolant-NAU, containing mixtures of surfactants of synergistic inhibiting action [7,10].

To prove the fact of sacrificial protection layer deposited zinc occurrence on the steel parts during its machining and treatment with electric-galvanized rotating brush the details were subjected to alkaline digestion and presence of zinc was determined by method of atomic absorption spectroscopy.

Comparative study of postoperative stability of steel subjected to electric-galvanized machining with brushes in presence of lubricating fluid, were performed in accordance with GOST 20.57.406-81. At the beginning we have conducted accelerated testing of the effectiveness of the Zn-protection in the moisture chamber G-4 in the atmosphere of water vapor at 40 ° C and so evaluated the corrosion damage index Kn. The results have shown a significantly lower incidence of galvanized treated steel sample corrosion during the postoperative period, especially at using coolant *MOP-NAU* in comparison with the samples treated by simple sandblasting.

To assess the influence of different methods of preparation of steel surfaces for high quality paint coatings we have performed the relevant comparative studies: onto the samples of steel St-20 treated with conventional sandblasting method and galvanized brushed were applied four-layered coating of paint *Ticurilla Termacout RM-40* of 200 mkm thickness (GOST 9.032 -74) by method based in studies [11,12]), with controlled thickness measured by the device Konstanta K-5.

The depth of penetration of the underlayered corrosion was determined on samples which was undergone artificial coatings damage following their exposure to KTS-1 camera during 168 hours (GOST 9.308-85).

That research has shown that the electric-machining and galvanized brush steel treatment allows simultaneously to prepare the metal surface so, that to obtain on it some Zn-sacrificial protection coating thin areas. The obtained results give evidence of synergistic increase of corrosion resistance of steel in severely corrosive media of 3% NaCl solution at the transition from individual usage (as MOR-NAU and protector separately) so that at its combined usage is achieved full protection of the metal. In case of less agressive medium (in model water, the full steel protection is granted using Zn-protector only. Adhesion of coating was measured using adhesiometer before and after samples were exposed to salt fog by ISO 4219-2003.

The use of galvanized brush improves the adhesion of coatings, especially in terms of their exposure in aggressive mediums. So, after exposure of painted samples according DSTY (Ukr) into chamber FTC-1 for 720 hours for the adhesion of paint were measured 7.9 MPa at using sandblasting method on contrary were achieved 8,8-8,9 MPa when used elektrosparking method of surface treatment.

An improvement in the protective properties of coatings was observed at comparing it also with other protection methods. For example, we have obtained the results on measurement of the corrosion penetration depth under coating layer which was artificially mechanically damaged after undergone its aging for 168 hours in the FTC-1 chamber. This result for samples prepared by sandblasting method was 1.95 mm, with the conventional electric-brush method it was 1.45 mm, and with Zn-galvanized brush it had reached 1.25 mm.

Conventional coatings are permeable to water and molecular oxygen. Therefore, they are not able to prevent corrosion of steel by slowing down the process of cathodic oxygen reduction: $O_2 + 2H_2O + 4e^- = 4OH^-$

Inhibition of corrosion can be achieved therefore by slowing down the anodic reaction of metal ionization by shifting its electrode potential onto the negative side (sacrificial protection) or by transfer the metal into passive state (anode passivation). The observed effect of mutual strengthening of protective properties exhibited as a result of electrical-machining and galvanized brushing on paint coating qualities of zincated areas on steel surface can be explained by several factors. The most important from them are mutually reinforcing steel passivation effects attained during the preparation of its surface using components *MOP-NAU* and the protective influence of the zinc areas formed. Along with this we can assume that the effect of zinc film is not limited to its functioning as of a protector. A definite role in increasing the compactness of paint coating plays zinc hydroxide which is formed by binding the OH^- ions at the cathodic reactions on steel and of the Zn^{2+} ions resulting in anodic processes on the protector. Indeed, the formation of zinc hydroxide explains the increase in resistance properties of paint coating deposited on the galvanized surface in comparision with the resistance of coatings applied on the samples treated by other methods [11].

Conclusions

1. The electrical sparks processing and mechanical method of steel surfaces preparation using Zn-coated rotating rotating disk brush and combined MOP-NAU coolant of synergistic action allows to perform high-quality metal processing, reduces the energy costs and increases the surface finishing class.

2. Introduction into the coolant MOP-NAU composition the synergistic mixtures of cation and anion active surface active compounds at a certain ratio of its components leads to a growth of surface activity, increases adsorption of surfactant mixture components, reduces microhardness and enhances metal plastic properties.

3. The presence in synergistic mixtures compositions of coolant with the inhibitors of different mechanism of action leads to inhibition of corrosion anode reaction and provides effective protection achieved during electric sparking steel surface processing.

4. Using of zinc-coated brush during electrical sparking processing allows together with simultaneous formation of Zn-protecting areas to enlarge the corrosion resistance of steel at the between operational storages, improve adhesion, increase ohmic resistance and improves the protective properties of painting coatings.

5. The occurrence of synergetic effects between the metal sacrificial protection and the resistance properties of applied paint coating is explained as a result of the formation of zinc hydroxide inside the paint layers, which increases theirs density, adhesion and protective properties.

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Electrochemical processes in the technology of regeneration of used oils.

Abstract. *Review the course of electrochemical conversion processes oxygenate products hydrocarbon oxidation of petroleum oil. It has been shown that the electrochemical reduction of carbonyl compounds with formation of hydrocarbons flows at the aluminum cathode. Carrying out the anodic oxidation of the carboxyl compounds on graphite electrode is a perspective of its application for the preparation of hydrocarbons in the technology of regeneration of used oils.*

The annual world production of petroleum oils became widespread. Annual production reached 38.6 million tones in 2014 is predicted in 2019 will increase needs oil in 42.8 million tones, which will be an increase of 2.1%. Mineral oil make up 90% of total world production, while the synthetic - only 10%. At the same time the market of synthetic oils more actively developed.

Getting to the units of friction oil is exposed to various physical and mechanical influences one of which - the raised temperature. Under the action of high temperature hydrocarbon oil components undergo certain changes [1]. One of the main products of the conversion is the formation of condensed and polymeric substances and oxidation in the carboxyl compound. The most dangerous substances are carboxyl carboxylic acid, the presence of which increases the number of acid oils, which in turn increases its corrosivity negative affects the engine parts.

The oil after a certain period of use lose operational properties as a result of tripping additives, viscosity changes, the accumulation products of oxidation and wear of mechanical impurities, water etc.

However, the most aggressive products degradation of a hydrocarbon petroleum oil is carboxylic acid. Their presence directly affects the protective properties of petroleum oils, because it cause corrosion of equipment and engine parts, critically affects the duration of maintenance-free operation of the vehicle. Depending on the type of oil, the conditions and duration of its application, it can accumulate up to 10 kg of organic carboxylic acid per 1 m3 of petroleum oil. These oils are not suitable for further use as are used oils [2].

One of the most promising method for ecological disposal of used oils (waste from petroleum) is regeneration. Regeneration - the process of recovery the quality of the product for re-use. Today there are many methods for regeneration of used oils. They are divided into physical, chemical and physico-chemical as well as efficient regeneration technology, which include a combination thereof.

Physical methods of regenerating of used oils based only on the physical effects (heating for stripping light fractions removal of contaminants, water, etc.), resulting in a rough cleaning, which is the primary step in the further regeneration technology of used oils [3].

Chemical regeneration methods are based on the interaction of the hazardous components of used oils with chemicals. The most common chemical regeneration methods is sulfate cleaning, alkaline cleaning, hydrotreating. Their advantage consists in high quality of recovered oil. However, they have some negative drawbacks. For example, when sulfuric acid cleaning is formed large volumes of acid sludge, which is a significant part of sulfuric acid and organic sulfonic acid, which hinders its processing and recycling [3].

Physic-chemical regeneration methods are based on the physico-chemical interaction of hazardous components and subsequent removal. The most used method is coagulation and adsorption treatment [3]. However, use of adsorption treatment leads to the formation of highly toxic heavy recycled waste. Therefore, the development and improvement of technology of regeneration of used oils is an important scientific and technical challenge.

The purpose is to research and creation of electrochemical methods for regeneration of carbonyl and carboxyl compounds such as hydrocarbon degradation products of petroleum oils of back hydrocarbons to research the flow of electrochemical reactions.

The first part paper is devoted a comparative research on the different electrode materials processes of cathodic reduction of carbonyl compounds - aliphatic aldehydes and ketones. Typically, such processes using electrodes having a high hydrogen overvoltage, which relate to the II electrochemical group. Distribution received such metals: Pb, Cd, Hg, Zn, but they all belong to heavy metals, which are highly polluting.

Metals which are characterized by high hydrogen overpotential and low energy of hydrogen atoms adsorption (soft metals of d-elements) belong to the metals of II electrochemical group. They don’t almost adsorb hydrogen atoms and kinetics of electroreduction of H^+-ions at cathode electrode polarization is determined by the slow stage of charge transfer: $H^+ + e^- = H_{ads}$ and its removal stage is not restrictive. Concentration of atomic hydrogen is insignificant on such metals and therefore, reduction of organic compounds is unlikely. Reduction of unsaturated organic compounds of hydrogen adatoms cannot occur on such cathode metals because they are practically absent on the cathode surface. Compounds are reproduced on them as a result of electrochemical process under direct transition of an electron to their molecule with following protonisaion: $R + e^- = R^-$, $R^- + H^+ = RH$. Such conditions promote adsorption and electroreduction of polar groups, which include the carbonyl groups. Lack of hydrogen adatoms on the cathode surface allows them to adsorb and reproduce with predominant formation of corresponding alcohols, and in some cases also hydrocarbons [4].

We assume that environmentally safe aluminum can serve as cathode metal for electroreduction of carbonyl compounds of used petroleum oil when regenerating. Aluminum in aqueous solutions of acids is characterized by relatively high hydrogen overpotential, though it is inferior to typical metals of II electrochemical group in these indicators [5].

Experimental research electrochemical reduction of carbonyl compounds was performed on the aluminum cathode. As model substances having a carbonyl group using iso-valeraldehyde and 2-pentanone.

Polarization measurement was performed on the P-5827M potentiostat, used three electrode thermostated electrode (25 °C) cell with operating aluminum electrode mark UpA99 purity 99,99% Al, as an auxiliary served electrode a platinum wire separated from the working electrode porous glass partition potentials was measured against chlorine silver electrode and counted to the normal hydrogen scale. Background in sulfuric acid-aqueous-alcohol (isopropanol) solution composition was: 920 ml of isopropyl alcohol, 56 ml of distilled deionised aqua, 24 ml of concentrated (98%) sulfuric acid (pH = 2.98).

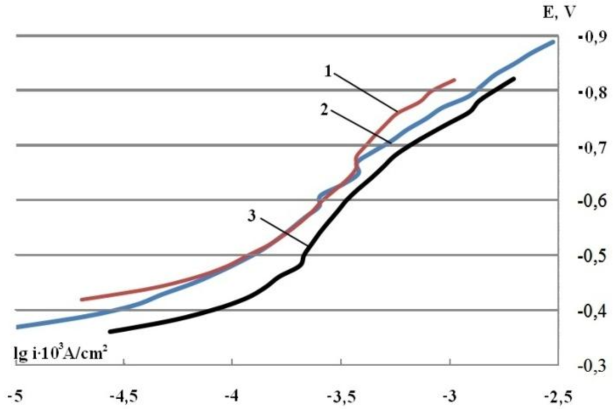

Fig. 1. potentsiostatichnomu polarization curves of aluminum: first the background aqueous alcohol, sulfuric acid solution; 2 - a solution of 0.5 mol / L isovaleric aldehyde; 3 - a solution of 0.5 mole of 2-pentanone.

Fig. 1 shows the potentiostatic polarization curves which show that the curve 1 in the background there is a solution of one wave of oxygen reduction: O2 + 4H + + 4e = 2H2O. The curves 2 and 3 can be seen already at two waves, one of which can be attributed to the process of reduction of the carbonyl compound.

Chromatographic analysis of the reaction mass after the electrolysis solution isovaleric aldehyde pentanone-2 and showed that the products of cathodic reduction there is a corresponding saturated and unsaturated hydrocarbons.

Implementation of electrochemical processes is always accompanied by progress as a cathode and the anode reaction. As appropriate to investigate the electrochemical process of anodic oxidation of carboxylic acids, the most aggressive oil degradation products. A typical anode for performing such processes is platinum, but due to its high cost applications in of used oils regeneration processes is not possible. The literature is not the numerous references to the use of graphite anodes for processes electrooxidation carboxylic acids, however, notes the low yield of the products [6 – 9]. Therefore, further research and the search for new electrode materials for electrochemical regeneration of used oils is an important scientific and technical assignment.

The second part paper is devoted the research of anodic oxidation of aliphatic carboxylic acids on graphite anode. As a model substance has a carboxyl group using hexane (caproic) acid. Fig. 2 presents potentiostatic polarization curves of graphite (1) in the background solution, and hexanoic acid in the solution (2) and for comparison with the typical metal with low hydrogen overvoltage platinum curve 3. From these curves it can be seen that the process of electrooxidation carboxylic acid concurrently flows through the potentials exceeding 2 V (HBE), in circumstances where the carboxylic acid anion adsorption at the anode.

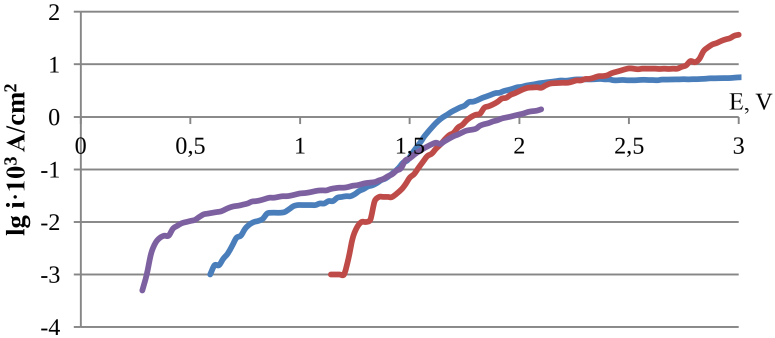

Fig. 2. potentsiostatichnomu polarization curves 1 - background of graphite in aqueous solution; 2 - graphite in a solution of 0.5 mol / l hexanoic acid 3 - platinum in the presence of 0.5 mol / l hexanoic acid.

The chromatographic analysis of extracts of aqueous solutions of caproic acid showed that, along with the main product of the Kolbe reaction, produced a series of hydrocarbons, it is the best option in the regeneration of used oils technology.

To implement the electrochemical processes of carboxylic acids in hydrocarbon media, was created the model hydrocarbon medium. The composition of the model developed according to the ideas of the class hydrocarbons content of the commodity petroleum oil. Used for this purpose the ratio of xylene as model of aromatic hydrocarbons and isooctane - isomeric alkane hydrocarbons. As a model of a carboxylic acid salt of hexanoic acid use small amount of water were added to increase solution conductivity. The created emulsion was homogenized by stirring and electrolysis was carried out. Chromatographic analysis of the products of electrooxidation of carboxylic acids showed similar results to those that were obtained for the aqueous solutions. The products of the transformation is a mixture of hydrocarbons of various structures.

Conclusions. We have also carried out preliminary research of electrochemical regeneration of waste oil. As a result of the process there was a substantial decrease in acid number and a small increase in kinematic viscosity. What can indicate a high speed electrooxidation carboxylic acid in the waste oil.

In this paper has been considered an electrochemical method for the regeneration of waste oils oxidized. The developed method consists in cathodic reduction of carbonyl compounds, as one of the petroleum oil oxidation products.

Also, in the anodic electrooxidation of carboxylic acids, such as more aggressive hydrocarbon degradation products. Experimental research has shown that products of the electrochemical regeneration of oxygenated compounds is a mixture of hydrocarbons, thereby increasing the yield of the regenerated oils and does not form harmful waste.

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Laws of hydrothermal modification of nickel-silica gels structure

Laws of hydrothermal modification of porous structure and phase composition of jointly precipitated nickel-silica gels with various proportion of NiO : SiO_2 were investigated. The results were explained by combined action of mass transport and phase transformations and mutual influence of components on these processes.

One of the main tasks of modern materials science is finding ways to create materials with given properties. This task is actual particularly for the production of adsorbents, catalysts and blank substrates for catalytic active substances because each specific process requires material with certain porosity, dispersity and surface chemistry. In the petroleum-refining industry, in the manufacture of aviation and automobile fuels the spectrum of catalytic processes is permanently extended. This is connected with increasing demands to the quality of fuel, attraction in the manufacture of petroleum with high content of heavy metals, sulfur compounds and other undesirable admixtures, and also with necessity of regeneration of the spent fuel and lubricants.

Among materials that are widely used as high performance and selective adsorbents and blank substrates for catalytic active substances one of the main place takes silica gel due to its economy, chemical inertness and great possibility of porous structure regulation. It has recently increased scientific interest in binary oxides-hydroxides systems on the silica gel base because in such systems due to mutual influence of components the possibility of not only regulation of porous structure, but also phase composition and acid-base properties of surface exists [1].

It is known considerable number of papers in the literature in that the binary porous materials are observed that composition include together with silicon oxide oxides of aluminum, iron, titanium, zirconium, tin, magnesium, chromium and other metals [2-4]. The main attention of these researches is spared to finding synthesis conditions of binary systems, dependence of porous structure on the composition and changing of the structure over influence of certain factors.

There are two principle difference ways of regulation of porous material structure. The first way – changing the synthesis conditions, the second – using various methods of processing the finished material. The second way opens greater opportunities in regulation of structure and the most effective method of modification is hydrothermal. Influence of hydrothermal modification on the structure transformations were better studied for silica gel [5-6]. Presence of metal oxide in the silica matrix cause to the specific character of porous structure changing because in the metal oxides is possibility of passing of crystallization processes at hydrothermal conditions that leads to not only change of porosity, but also phase composition, dispersity and surface chemistry of material and opens the ways to the directed synthesis of porous materials with given properties.

The purpose of the given work was the investigation of lows of hydrothermal modification of xerogels of binary system NiO : SiO_2 with various proportion of oxides to clarification of mechanism of processes of porous materials skeleton rebuilding and synthesis these systems with needed porosity, crystallinity and phase composition.

The initial samples of nickel-silica gels were obtained by jointly precipitation of solutions of Na_2SiO_3 and $Ni(NO_3)_2$ at pH=10. At this pH fullness metal precipitation as hydroxide and silica (SiO_2) as a dense precipitate was achieved. The obtained precipitates were washed by distilled water, squeezed on the filter and dried at the room temperature. Chemical composition of obtained xerogels was determined by the method of weight analysis of SiO_2. The samples of nickel-silica gels with content of NiO 11, 30, 51, 84 % mass was synthesized.

Hydrothermal modification (HTM) of the samples was carried out in steel autoclaves with teflon bushing during 6 hours at the temperatures 373, 473, 573 and 673 К and saturate vapour pressure 1 atm, 15 atm, 85 atm, ~200 atm correspondently.

The porous structure parameters of samples – a specific surface area (S), limiting sorption volume of pores (V_S) and diameters of pores (d) – were calculated on the base of isotherms of methanol adsorption by the equations of the BET theory, a total volume of pores (V_Σ) was determined by the method of percolation [7,8].

The results of influence of HTM on porosity of xerogels with different relation of NiO : SiO_2 are presented in table 1.

Table 1

Influence of HTM conditions on the nickel-silica gel porous structure

NiO, % mass	T, K	S, m^2/g	V_S, cm^3/g	V_Σ, cm^3/g	d, Å
11	Initial	457	0.72	0.87	76
	373	263	0.55	0.88	134
	473	173	0.68	0.93	215
	573	127	0.10	0.84	265
	673	34	0.36	0.67	788
30	Initial	528	0.76	0.93	70
	373	503	0.72	0.95	76
	473	363	0.64	0.88	97

	573	233	0.40	0.62	106
	673	50	0.50	0.55	440
51	Initial	458	0.28	0.44	38
	373	560	0.33	0.52	37
	473	511	0,45	0.57	45
	573	407	0.49	0.59	58
	673	94	0.50	0.52	221
84	Initial	191	0.11	0.11	23
	373	417	0.19	0.20	19
	473	420	0.25	0.32	30
	573	176	0.34	0.34	77
	673	155	0.31	0.31	80
100	Initial	99	0.21	0.22	89
	373	126	0.28	0.25	79
	473	117	0.31	0.32	109
	573	28	0.33	0.30	429
	673	21	0.20	-	-

The analysis of data of the table shows that for the initial samples dependence of specific surface area, limiting sorption volume of pores and total volume of pores on nickel content has an extreme character: the most value of S, V_S and V_Σ has initial nickel-silica gel with content of NiO 30%. With further increasing of nickel content all porous structure parameters decrease monotonically.

In result of HTM at increasing of temperature of processing there are not the same trends in changing of porous structure parameters of samples with different content of NiO. Thus for the xerogels with content of NiO 11 i 30 % value of specific surface area decreases and for the xerogels with content of NiO 51 i 84 % change of value of specific surface area has an extreme character with maximum at processing temperatures 373 i 473 K; values of limiting sorption volume of pores and total volume of pores decrease for the xerogels with content of NiO 11 і 30 % and increase for the xerogels with content of NiO 51 і 84 %. Diameter of pores for the all samples increases at increasing of temperature of processing.

To explain changes that take place at HTM of nickel-silica gels not enough to take into account only processes of solution-precipitation of colloid particles and surface diffusion, because at hydrothermal conditions can proceed phase transformations both of a pure components and a new compounds, that are formed at HTM. Therefore investigation of phase composition of nickel-silica gels with different relation of components by method of X-ray analyses was carried out. Diffractograms of samples were recorded with help of diffractometer ДРОН-3М using copper Kα radiation and Ni filter. The results are presented in the table 2.

Table 2

Influence of HTM conditions on the phase composition of nickel-silica gels

T, K	NiO, 11 % mass	NiO, 30 % mass	NiO, 51 % mass	NiO, 84 % mass	NiO, 100 % mass
Initial	amorphous	nickel montmoril-lonite	nickel montmoril-lonite	nickel hydroxide	nickel hydroxide
373	amorphous	nickel montmoril-lonite	nickel montmoril-lonite	nickel hydroxide	nickel hydroxide
473	α-cristobalite	nickel montmoril-lonite	nickel montmoril-lonite	nickel montmoril-lonite + pecoraite + nickel hydroxide	nickel hydroxide
573	α-quartz	nickel montmoril-lonite + nickel tail	nickel antigorite + nickel montmoril-lonite	pecoraite + nickel oxide + nickel hydroxide	nickel hydroxide
673	α-quartz + nickel тейл	α-quartz + nickel montmoril-lonite + nickel tail	nickel antigorite	pecoraite + nickel oxide	nickel oxide

The data of X-ray analyses show that for the boundary compositions of nickel-silica gels (11 i 84 % NiO) phase composition is determined by crystallization processes that are characteristic of the dominant phase. Thus the initial sample of nickel-silica gel with content of NiO 11% is amorphous SiO_2, at increasing of temperature of HTM crystallizes α-cristobalite (473 K), α-quartz (573 K) and chemical compound $Ni_3Si_4O_{10}(OH)_2$ (nickel tail), and the sample of nickel-silica gel with content of NiO 84 % is crystalline nickel oxides of different composition in which at increasing of temperature of HTM the processes of dehydroxilation and crystallization of the mixture of silicates of nickel montmorillonite ($NiSiO \cdot H_2O$) and pecoraite ($Ni_6Si_4O_{10}(OH)_8$) occur. In the samples of middle compositions (30 i 51 % NiO) the crystalline phase of nickel silicate (nickel montmorillonite) appears already at the stage of jointly precipitation of oxides. Beginning from a temperature of HTM 573 K in these systems also nickel tail, nickel antigorite ($Ni_3Si_2O_5(OH)_4$) and α- quartz crystallize.

The X-ray analyses data help to explain the results of adsorption-structure investigations and show that crystallization processes are one of the main factors that determine the ways of hydrothermal modification of nickel-silica gels.

On the base of conducted investigations in the given work the obtained results can be explained both by mass transfer processes that proceed in colloid systems at HTM and phase transformation processes. At jointly precipitation of silica colloid particles and nickel hydroxide mutual coagulation of particles and adsorption of silica gel on the surface of nickel hydroxide particles occurs that prevent crystallization and growth of crystals of nickel and also help formation of more developed porous structure of nickel-silica gels in comparison with pure nickel gel (table 1). At HTM the direction of porous structure change is determined by the dominant component. For nickel-silica gels in the compositions range till 51 % NiO processes of solution-precipitation and surface diffusion are predominant and in the compositions range with high content of nickel (84-100 % NiO) - processes of crystallization and dehydration of nickel hydroxide $Ni(OH)_2$. Peculiarity of nickel-silica gels in the middle compositions range is formation of chemical compounds that have crystalline structure already on the stage of jointly precipitation at that the composition of silicates depends on relation of components and change of crystallinity degree and recrystallization processes lead to the extreme changes of porous structure.

It was shown that hydrothermal modification allows to obtain nickel-silica gels with a wide range of values of specific surface area (20-560 m^2/g), sorption volume of pores (0.2-0.8 cm^3/g), total volume of pores (0.2-0.9 cm^3/g), diameter of pores (20-800 Å) and with various phase composition that opens great perspectives for their using.

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Volatile components of grape pomaces from cultivars of Ukraine *Vitis vinifera L.*

The volatile components of grape pomace coming from the processing of some of the most important varieties of grape. cultivated in Ukraine namely, Arcadia have been determined by gas-chromatography–mass spectrometry (GC–MS). On the whole, 38 components have been characterized in the samples of grape pomaces.

Agro-industrial by-products present two rather conflict-ing aspects: on one hand their disposal represents a great economical and ecological problem, further complicated by legal restrictions, while on the other, they may be con-sidered a promising and renewable source of useful com-pounds for their technological and nutritional properties. It is likely that the most immediate and economic use of this material is as feed and as fertilizer, even though some pre-treatments and composting procedures are necessary in most cases. It also is true that these wastes are rich in sev-eral micronutrients such as carotenoids, polyphenols, toc opherols, vitamins, oligo elements and others, whose beneficial effects on human health are frequently high-lighted, therefore this large amount of waste material could be a very cheap source of the aforesaid components. Of course, such potential exploitation would not avoid the dis-posal of a still substantial amount of waste, but the eco-nomic profit should make it more bearable.

Grape (Vitis vinifera L.) is one of the world's largest fruit crops, in excess of 60 million metric tons, and is mainly grown for wine production. Grape pomace, the main by-product of wine production, consists of skins, seeds and stalks, reaching an estimated amount of 13% by weight of processed grape. In line with different winemaking procedures, two kinds of grape pomaces are obtained after the removal of stalks before maceration and successive fermentation steps. The first consists of skins, pulp residues and seeds, the proper grape pomace, which is partially used for grappa and alcohol production; the second consists almost exclusively of stalks. The chemical composition of grape pomace is rather complex: alcohols, acids, aldehydes, esters, pectins, poly-phenols, mineral substances, sugars etc. are the most represented classes of compounds. The evaluation of the qualitative aspects of a grape pomace is carried out in view of the production of high quality grappa; otherwise the grape pomace is used for alcohol distillation, or thrown away. The best grape pomaces are highly rich in vinous liquid, namely not exhaustively pressed, with a moisture degree ranging from 55% to 70%, which allows to exploit the raw material better and to extract the organoleptic characteristics of the native vine. n our ongoing studies aimed at the possible exploitation of the main agro-industrial by-products obtained in Ukraine, we wish to report here the results of a study of the volatile components of grape pomaces.

Gas-chromatography–mass spectrometry (GC–MS) was carried out in the fast mode on a Shimadzu GC–MS mod. GCMS-QP5050A, ionization voltage 70 eV, electron multi-plier 900 V, transfer line temperature 280 C. Analytical conditions: SPB-5 capillary column (15 m ×0.10 mm×0.15 lm), helium as carrier gas. Injection in split mode (1:100), injected volume 1 ll, injector and detector temper-ature 250ºC. Constant linear velocity in column 50 cm/s. The oven temperature was held at 60ºC for 1 min, then programmed from 60 to 280ºC, 10 ºC/min. Table 1 lists the 38 volatile components characterized in all samples of grape pomaces, whereas Fig. 1 shows a typical GC–FID profile. The most represented class of components in all four cultivars was that of ethyl esters of aliphatic acids with a linear chain from 6 to 18 carbon atoms, both saturated and unsaturated, with the former predominating. The main components were ethyl octanoate, ethyl decanoate, ethyl dodecanoate and hexyl hexade-canoate. Other common compounds of the four cultivars were represented by some acetals, particularly 1,1-diethoxy ethane. Two monoterpenes: limonene and terpinolene – six sesquiterpenes: a-ylangene, 3,7-guaiadiene, aromadendrene, c-muurolene, c-amorph-ene, c-cadinene – and one diterpene: manoyl oxide have been characterised. However, it should be underlined that the total amount of these compounds is to be considered very low.

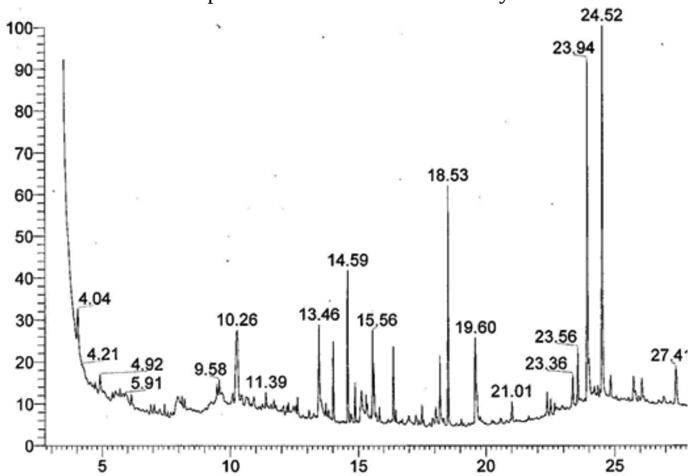

Fig. 1. GC–FID profile of volatile components of grape pomace

Concerning the aliphatic alcohols, showed the most complex composition with the 3-methyl-butan-1-ol and hexanol as the main compounds. Cabernet Sauvignon and Nerello Mascalese showed an identical qualitative profile due to 3-(E)-hexen-1-ol, hexanol and 3-ethyl-4-methyl-pentan-1-ol. Almost negligible was the amount of these components in the Frappato variety repre-sented exclusively by hexanol.

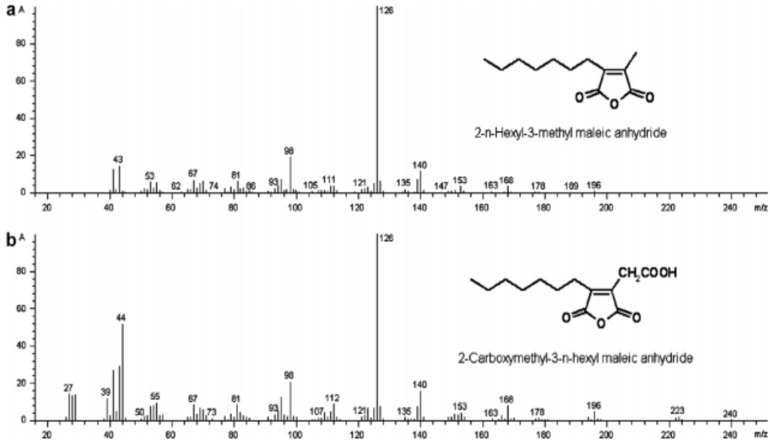

Fig. 2. MS spectra of 2-n-hexyl-3-methyl maleic anhydride (a) and 2-carboxymethyl-3-n-hexyl maleic anhydride (b)

Most of identified sesquiterpenes were hydrocarbons($C_{15}H_{24}$), the main components being a-ylangene, 3,7-guaiadiene, aromadendrene, germacrene D, epizonarene, d-cadinene, a-cadinene and germacrene B. Amongst the four oxygenated components, those present in highest amount were epi-a-cadinol, in all cultivars.

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Volatile inhibitorof mild steel corrosion

Rape cake extract was developed as novel volatile corrosion inhibitors (VCIs).Their vapour corrosion inhibition property was evaluated by volatile inhibiting sieve test (VIS) and potentiodynamic polarization. The volatiles of ethanol extract of cake oil rape were analysed by GC–MS. In total, 20 volatiles were identified with glycosides, ketone, alkaloid, aldehyde being the major components.

Temporary corrosion protection prevents the metal surfaces corrosion during transport and storage of equipment. Volatile corrosion inhibitors (VCIs) have been used for years to temporarily protect metals from corrosion in extreme conditions [1–3].

The VCIs are known to have extended corrosion-inhibiting properties to a metal surface due to their volatilization within an enclosed space.

Most of the reported VCIs are organic compounds containing P, N, O and S atoms. For example aliphatic amines, salicylic amines and their salts widely investigated as vapour phase corrosion inhibitors for various industrial metals and alloys. However, most of such compounds are toxic and hazardous to health. That's why application of natural products as anticorrosion agents is of interest to research [4 – 6].

Natural products are known to be incredibly rich sources of naturally synthesized chemicals for most applications. Besides, natural chemicals are environmentally acceptable and a readily available resource. Plant extracts are bio-degradable, non-toxic and of potentially low cost. Most of the naturally occurring substances are safe and can be extracted by simple procedures [7 – 12].

Recently, several researches concern the use of naturally occurring substances as corrosion inhibitors for several metals. The examples are numerous such as fenugreek, henna, black pepper, opuntia and eugenol [13 – 17]. Many of them showed their ability to act as corrosion inhibitors for the corrosion of different metals and alloys in different aggressive media. However, the extract of rapeseed cake has not been studied as volatile corrosion inhibitors. Hence, in the present work it has been aimed to investigate the corrosion inhibition efficiency of rapeseed cake as volatile corrosion inhibitors for mild steel. Two kinds of methods, volatile inhibiting sieve test and volatile inhibiting test that include impregnated craft paper, were applied to evaluate the inhibition effect of the VCIs. To obtain reproducible results three samples were used in each test simultaneously.

Plates of steel (50 mm $\times$25 mm $\times$1.5 mm) were used for gravimetric measurements. There was a hole in each plate drilled to suspend the sample by a nylon thread. The samples were grinded with SiC paper to 1000 mesh and were then cleaned in alcohol and rinsed before drying at room temperature. The final geometrical area was 25 cm^2. The gravimetric measurement was conducted by suspending the samples in a 250 cm^3 conical flask with a tight-fitting rubber cork containing a small dish. The VCIs were dispersed in the dish. The samples with freshly prepared surface were mounted on the flask with and without 1.0 g inhibitor, respectively. After inhibitor film-forming period of 3 days, 15 cm^3 deionized water was added. The test process included cyclic warming and cooling of the samples in a corrosion testing chamber of varying humidity. One cycle included an 8 h exposure in the thermostat (50 ± 1°C), and 16 h exposure at room temperature.

For volatile inhibiting tests that include impregnated craft paper the metal samples were covered on impregnated craft paper and mounted in a one liter bottle containing 100 ml of 1 N Na_2SO_4 solution. After corrosion test for 21 days, samples were removed for visual inspection and the loss of mass determinations. Lost segments of the film of the corroded sample were removed by hard rubber and rinsed in deionized water.

Corrosion rates and inhibitor effectiveness are calculated by means of the following equations:

$$CR = \frac{W_0 \ - W_1}{A \ \times T}$$

$$IE\% = \frac{CR_1 - CR_2}{CR_1} \times 100,$$

where CRs is in g m^{-2} h^{-1}; A is the sample area (in m^2); W_0 is initial weight of the sample, and W_1 is sample weight (in g) after the immersion period, T is the immersion period (in h), and CR_1 and CR_2 are the corrosion rates without and with inhibitor, respectively.

Electrochemical measurements were carried out in stimulated atmospheric corrosion solution in a three-electrode cell, consisting of a mild steel rod working electrode (WE), a platinum foil counter electrode (CE), and a saturated calomel electrode (SCE) as reference electrode. The WE was mechanically polished on wet silicon carbide (SiC) paper (grades 120, 600, and 1200), rinsed with double-distilled water, degreased with acetone and ethanol, and dried at room temperature. The WE was embedded into an epoxy resin holder exposing a 1 cm^2 surface to the solution.

The potential values are given versus SCE. The cell was open to the laboratory air and the measurement was conducted without stirring at room temperature (25°C). For the potentiodynamic measurements, the potential was changed from - 1100 mV to 500 mV around open circuit potential at a potential sweep rate of 1 mV/s. All the experiments were carried out in 1 N Na_2SO_4 solution. IE of potentiodynamic polarization measurement was defined as:

$$\text{IE }\% = \frac{I_{corr} - I_{corr(ing)}}{I_{corr}}$$

where I_{corr} and $I_{corr(inh)}$are the uninhibited and inhibited corrosion current density values, respectively, determined by extrapolation of Tafel lines to the corrosion potential.

Visual inspection was carried out following the criterion for the volatile corrosion inhibition test. Corrosion rate and inhibition effectiveness for the test samples are shown in Table 1. After the volatile corrosion inhibition test, almost all surfaces of the samples treated by extract of rapeseed cake were bright. The corrosion rate and inhibition effectiveness for the film formed on the surfaces of the samples by extract of rapeseed cake were 0,019 g × m-2× h-1 and 90.7%, respectively. This shows that rapeseed cake extract can volatilize and adsorb on the mild steel surface and protect the steel. Table 1 reveals the protection efficiency of impregnated paper (VPI paper) in 1 N Na2SO4 environment at 100 % RH for a period of 21 days for mild steel. It can be seen that these inhibitors proved up to 89 % inhibition effectiveness.

Table 1

Calculated corrosion rates (g m^{-2} h^{-1}) and inhibition efficiency (%) for volatile corrosion inhibition test

Samples	Corrosion rate / g m^{-2} h^{-1}	IE/%
Control	0,2481	-
Treated by vapour phase of rapeseed extract	0,0196	92,09
Treated byVPI paper	0,0165	93,34

The protection caused by the rapeseed cake extract was monitored on potentiodynamic polarization curves while varying the exposure time. The inhibition efficiency calculated from corrosion current density reaches a considerable value (%). The polarization behaviour of mild steel in 1 N Na2SO4 after 24, 48, 72 h of exposure of the rapeseeds cake extract film-forming is shown in Fig. 1. Both anodic and cathodic reactions are drastically inhibited after 48 h of exposure of the film-forming. One of such ways can involve the after effect of VCI (i.e., its ability to protect steel on by a protective film even after the inhibitor has been removed from the corrosive medium). The after effect can be provided by both relatively thick (“phase”) which often form when metal is kept in the vapour phase containing a VCI. This effect is based on the irreversible inhibitor adsorption, which depends on the chemical structure of the inhibitor. We studied the after effects of films obtained on still samples by immersing them in the vapour phase containing this inhibitor.

The resulting film have been sufficiently stable and completely protected the steel in the vapour phase of 3 % NaCl and 1 N Na_2SO_4 for 5-days and 10 days, respectively. The corrosion rate of the steel samples were 0,0356 g m^{-2} h^{-1} and 0,0188 for the 3 % NaCl and 1 N Na_2SO_4 respectively. The volatile chemical composition of the rapeseed cake extract involves glycosides, nucleosides, ketone, aldehyde, fatty acids, sterol and alkaloids. The most important compounds in rapeseed cake are shown in Table 4: Guanosine (about 10%), Sucrose (6%), Xanthosine (8%), 3',5'-Dimethoxyacetophenone (12 %) Benzaldehyde, 4-hydroxy-

3,5-dimethoxy (12%), Acetic, Oleic,Linoleic and Palmitic acid (about 32%),and Sterols (about 11%). The inhibition of mild steel corrosion by rapeseed cake extract is probably attributed to the presence of glycosides, keton, aldehyde, since these compounds contain such centres of adsorption as oxygen and nitrogen atoms. All individual chemical compounds are known as inhibitors for several metals. These compounds have extended π-electron systems and functional groups (such as –C=O, -CHO, -COOH, -OH, -C=C). However, it remains unknown, what molecules of vapour-phase of rapeseed cake extract are adsorbed on the steel surface and provides inhibition effectiveness.

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Airports geographic information system supports the safety and environment protection management

"GIS is an efficient way to manage time, effort, and budgets. It integrates seamlessly into our business and evolves with our needs."
Vicki Withnell, Manchester Airports Group

There is an increasing demand for accurate airport survey data for use in: developing runway approach procedures; determining maximum takeoff weights; ensuring the local in specific airport and overall safety of the National Airspace System; ensuring ecological safety, etc. Airport survey data meeting the specifications that have traditionally been collected by other national (or international) boards for the CAA.

The Airports Geographic Information System (Airports-GIS or AGIS) provides the airports' authority and Civil Aviation Administration (CAA) the conditions to collect airport and aeronautical data to meet the demands of the National Airspace System. Looking pragmatically AGIS is an instrument to issue grants under the Airport Improvement Program from the CAA and the State. Airports GIS helps to ensure that operational data is of the highest quality and meets airport regulatory requirements. The types of information typically collected include [1-3] the layout of an airport, features found at and near an airport of landmark value, reference data, and data relating to imaginary surfaces that define safe altitudes for approaches and landings (Obstruction Identification Surfaces or OIS as specified in the CAA Aviation Regulations).

The airport information used for airport mapping databases consists of airport features and associated information in the form of geometry, attribute, and attribute coding. This information is linked to data via a relational database schema or equivalent method. This information, when combined with other airport features such as the runways, taxiways, parking areas etc., forms a digital map of the airport for display in the aircraft flight deck. For example, traditionally pilots have relied on visual aids such as airfield markings, signs and lighting in conjunction with a paper chart (fig. 1) of the airport to navigate from point to point on the surface. Through radio communications, air traffic control (ATC) provides directions to pilots on the route to follow while on the surface. As a rule, the ground controller will issue route instructions to pilots using explicit instructions and strict protocol (phraseology) so that there is no misunderstanding. These instructions are sometimes very complex requiring the pilot to memorize it, write it down and repeat it to ATC to ensure comprehension. The pilot then needs to follow those instructions (typically without further assistance from ATC) following the surface markings and signs (fig. 1) to the destination while avoiding other surface traffic (airplanes or on-airport vehicles).

CAA is striving to maximize the level of data collected while trying to minimize the cost to airports. However, the appropriate collection and safety implications of the prescribed data against defined, repeatable and verifiable standards far outweigh the potential costs. The collection and maintenance of the data regarding airports is a shared responsibility of the CAA and the Airport authority (proponent). The uses of the information collected according to these standards and specifications are in part to complete the following tasks:

- Provide geodetic control for engineering projects;
- Assist in airport planning and land use studies, and for other miscellaneous activities;
- Certify airports for certain types of operations;
- Develop instrument approach and departure procedures;
- Determine maximum takeoff weights;
- Update aeronautical publications;
- Plan for and site navigational aids supporting the airport.

Figure 1. The development of highly accurate digital representations of the airport environment will enhance the operational safety systems at the airport

Compliance with these requirements and standards without deviation is mandatory for federally obligated airports, and recommended for all other airports. We have broken them down into eight primary survey types based on the intended use of the gathered data:

- Category II or III Operations;
- Navigational Aid Siting (Non-Precision, Visual, or Precision);
- Airport Layout Plan (ALP);
- Airport Obstruction Chart (AOC);
- Construction (Airside or Landside);
- Instrument Procedures Development;
- Pavement Design, Construction, Rehabilitation, or Roughness;
- Airport Mapping Database.

For example, the features included in the geospatial Airport Obstruction Chart (AOC, fig. 2) can be separated into four main categories:

1. Airport layout features:

a. Aircraft movement areas: Runway, Runway End, Stopway, Blast Pad, Taxiway, and Apron;

b. Designated areas: Restricted Access Boundary, Construction Area and Heliport touchdown and lift-off area;

2. Landmark objects on and near an airport, used for spatial reference by pilots:

a. Prominent buildings and the shoreline of bodies of water such as lakes and ponds collected as polygons;

b. Linear features of landmark value such as roads, railroads, fences, utility lines, shoreline when best collected as a linear feature, levees, quarries, etc,

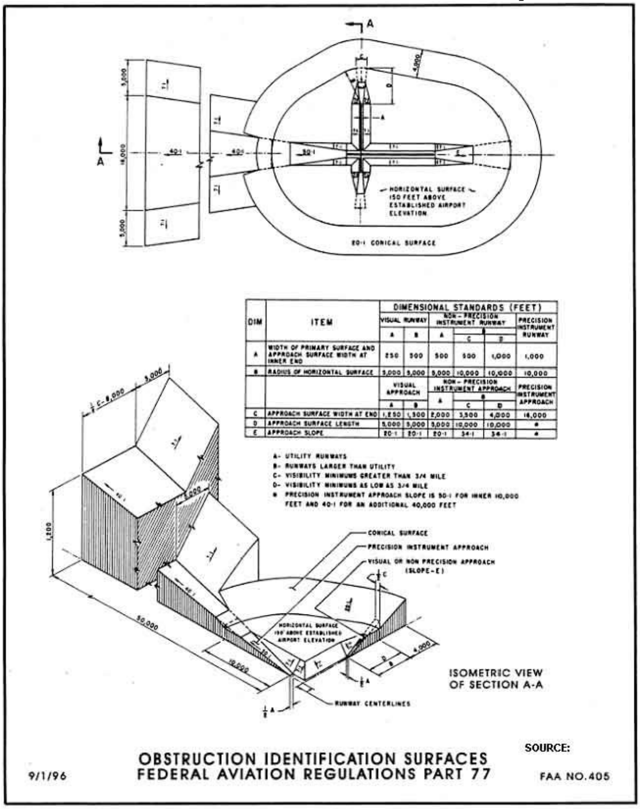

Figure 1. Example of Airport Obstruction Chart

3. Reference data:

a. Airport Control Point: a geodetic control point in the vicinity of the airport which is tied into the National Spatial Reference System;

b. Airport Reference Point (2D): the geometric center of the airport;

c. Runway threshold positions;

d. NavAid Equipment (there are 39 different types of equipment listed in the standard, including radar, beacons, guidance lights, and many others).

4. OIS related features and obstructions

a. Obstruction Identification Surface: the US FAR-77 surfaces;

b. Obstacle: an object that has a vertical element to it that may or may not penetrate (be taller than) an OIS such as individual trees, poles, masts, etc;

c. Obstruction Area: an area that has a higher elevation than the OIS such as a group of trees, buildings, mobile cranes, an urban area, agricultural area or ground (hills or mountains).

There are many advantages to moving the AOC to a geospatial format. The Data Content Standard required for defining a geospatial AOC serves to standardize a product, ensuring the same data will be collected at all public airports. This will facilitate the development of hardware and software necessary to fully utilize an airport layout and aeronautical obstruction data, contained in a geospatial AOC. The AOC may be viewed, queried, and printed using a wide variety of GIS software or freeware, enabling a broad audience to benefit from its GIS-ready data format. Data standardization also simplifies and streamlines the data collection process, enabling more private businesses to participate in airport surveying. This process will result in an increase in the volume of aeronautical survey data collected.

Some of safety specifications support the airport's planning and design activities for the development of vertically guided instrument approaches such as ILS, PAR, MLS, LPV, TLS, RNP and Baro VNAV. These surfaces assist in the identification of possible hazards to air navigation and critical approach/departure obstructions within the vicinity of the airport. All surfaces identified below must be completed for both ends of a runway. Evaluate each surface independently of other surfaces. Design all appropriate airport surfaces in reference to the runway ends and not displaced thresholds. Fig. 2 illustrates the areas, dimensions, and slopes of the Vertically Guided Approach Survey and Analysis Specification required to support instrument procedure development.

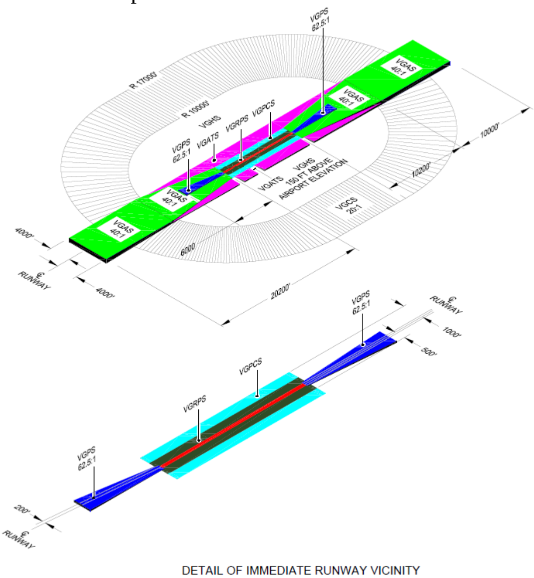

Figure 2. Vertically Guided Approach Survey and Analysis Specification required to support instrument procedure development

AGIS comes with a ready-to-use airport geo-database supporting both CAA and international data standards [1]. Efficiency of designed GIS may be shown how easily you may extend the geo-database to meet your current and future airport business requirements, for example it supports quick chart production and regulatory compliance. Its proven technology automates airspace analyses and improves operations. One system unifies your product, service, and workflow management. In that number – management for environment protection in vicinity of the airports and sustainable development of the airports in general. The general sustainable actions in airports are the following: reduce environmental impacts; maintain high, stable levels of economic growth; help to achieve social progress (a broad set of actions that ensure organizational goals are achieved in a way that's consistent with the needs and values of the local community).

To promote the development of a system of airports to meet the national needs, the CAA embarked on a grants-in-aid program to units of state and local governments and drew its funding from the general state budget, which is supported by user fees, fuel taxes, and other similar revenue sources. The tab. 1 below lists typical examples of eligible and ineligible projects; the list is not exhaustive.

Table 1

Examples of Eligible Versus Ineligible AIP Projects

Eligible Projects	Ineligible Projects
Runway construction/rehabilitation	Maintenance equipment and vehicles
Taxiway construction/rehabilitation	Office and office equipment
Apron construction/rehabilitation	Fuel farms (May be eligible)
Airfield lighting	Landscaping
Airfield signage	Artworks
Airfield drainage	Aircraft hangars (May be eligible)
Land acquisition	Industrial park development
Weather observation stations (AWOS)	Marketing plans
NAVAIDs such as REILs and PAPIs	Training
Planning studies	Improvements for commercial enterprises
Environmental studies	Maintenance or repairs of buildings
Safety area improvements	
Airport layout plans (ALPs)	
Access roads only located on airport property	
Removing, lowering, moving, marking, and lighting hazards	
Glycol Recovery Trucks/Glycol Vacuum Trucks** (11/29/2007)	To be eligible, the vehicles must be owned and operated by the Airport and meet specifications in the AIP grant

A particular Airport Environmental Program (AEP) helps airports implement the Law of Ukraine on Environmental Protection and other national environmental laws and regulations, including Aviation Code of Ukraine (Chapter X

Environmental Protection). This includes airport noise compatibility planning, airport noise and restrictions on flight operation, environmental impact assessments (review) for airport (particular runway) development, etc.

The following list defines the airport feature descriptions and specifications for each feature group and class. Utilize the specifications defined to ensure the data delivered is accurate and meets standards. Each feature is described by geometry type, feature group, information assurance level, requirements, positional accuracy, data capture rule, and the attributes required to provide the data to the airport and/or CAA. The following tab. 2 identifies how each feature description is setup and provides information on what is contained within the system. There are number of groups included in GIS today: AIRFIELD, AIRSPACE, CADASTRAL, ENVIRONMENTAL, GEOSPATIAL, MAN MADE STRUCTURES, NAVIGATIONAL AIDS, SEAPLANE, SECURITY, SURFACE TRANSPORTATION, etc. Among ENVIRONMENTAL groups the classes exist: Environmental Contamination Area, Fauna Hazard Area, Flood Zone, Flora Species Site, Forest Stand Area, Wetland, Hazardous Material Storage Site, Noise Contour, Noise Incident, Noise Monitoring Point, Sample Collection Point (Air samples, Boring locations, Biological samples, Ground water samples, Sediment samples, Soil samples, Solid material samples, Surface water samples, Waste samples, etc.).

Table 2

Paragraph Number and Feature Class Name

Definition: *Definition of feature.*				
Feature Group	*The Feature Group of the element.*			
Feature Class Name	*The proper name of the Feature Class.*			
Feature Type	*The compliant geometry of element.*			
CADD Standard Requirements				
Layer/Level	**Description**			
Compliant layer name.	*Compliant layer description. [Siting]*			
	Color	**Line Type**	**Line Weight**	**Symbol**
AutoDesk Standards	*Color code AutoCAD*	*Line Type required*	*Line weight AutoCAD*	*Symbol type is user defined*
MicroStation Standards	*Color code MicroStation*		*Line weight MicroStation*	
Information Assurance Level	*Security level credential*			
Equivalent Standards	**AIXM**	*AIXM equivalent of feature.*		
	FGDC	*FGDC equivalent of feature.*		
	SDSFIE	*SDSFIE equivalent of feature.*		
Documentation and Submission Requirements	The required documentation for feature class elements. Minimum requirements are defined in paragraphs 1.5.2 and 1.5.3. Additional or expanded documentation requirements are located here.			
Related Features				
Data Capture Rules: *Description of proper collection limits and requirements for feature class element.*				
Monumentation	*Monumentation requirements.*			
Survey Point Location	**Horizontal**		**Vertical**	
	Description of specific HSP location.		*Description of specific VSP location.*	

For example **Noise Contour** (Feature Class Name = NoiseContour, Feature Type = Polygon) is defined as an area that describes the noise attributed to operations. For aircraft operations, the day/night average sound level descriptor L_{dn} is typically used to categorize noise levels. It is used for description of the noise zone in airport vicinity. The tab. 3 identifies its other feature descriptions and provides information on what should be contained within the system (GIS).

Table 3

Feature Class Name = NoiseContour

Documentation and Submission Requirements	Noise contour map		
Related Features			
Data Capture Rules: *Acquire from the Integrated Noise Model (INM).*			
Monumentation	No monumentation required.		
Survey Point Location	**Horizontal**	**Vertical**	
	N/A	N/A	
Accuracy Requirements (in feet)	**Horizontal**	**Vertical**	
		Orthometric	**Ellipsoidal**
	N/A	N/A	N/A
Resolution	**Geographic Coordinates**	**Distances and Elevations**	
	N/A	N/A	
Feature Attributes			

Attribute (Datatype)	Description
name (VARCHAR2 (50))	Name of the feature.
description (VARCHAR2 (255))	A description for the noise zone.
status (Enumeration: codeStatus)	A temporal description of the operational status of the feature. This attribute is used to describe real-time status.
contourValue (Real)	The decibel level of the contour line
userFlag (String 254)	An operator-defined work area. This attribute can be used by the operator for user-defined system processes. It does not affect the subject item's data integrity and should not be used to store the subject item's data.
Alternative (Number(2))	Discriminator used to tie features of a plan or proposal together into a version.

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Energy saving programs at airports for environmental impacts reduction

The study is aimed to define the potential of energy conservation at Ukrainian airports in order to improve environment quality at the adjoined area. The major reasons of energy losses at airports are defined. The environmental effects and economic efficiency of energy conservation projects and prospects of their implementation are considered for the International Airport "Kyiv".

Energy efficiency is currently one of the main trends of both domestic and global economy. Therefore for Ukraine, which was not properly engaged into the process of energy saving during long period, the trend is now a major motion vector of economic development. An important participant of the energy saving technologies implementation is transport of all kinds, and especially air. This is because the aviation industry combines two components: intensive impacts on the environment and big volumes of energy consumption, including fuel. Thereby, the purpose of the research is to define the potential for energy conservation at airports of Ukraine and for the improvement of environment quality at the adjoined area.

The issues of energy consumption optimization at airports were considered by Rozen V.P., Sokolova N.P., Zakharchenko V.P., Leschynsky O.L., Konovalyuk V.N., Velychko Yu.K., Kozlov V.S. and others [1-4]. They have highlighted the major problems and opportunities for the improvement of energy efficiency at airports. Thus, according to their experience, the analysis of power management at the world airports, especially those within the same climatic zone with Ukraine, cannot be provided with adequate assessment due to closed access to the information on power consumption. Based on the statistical data on power consumption collected by Zakharchenko V.P. and Sokolova N.P. at Ukrainian airports during 2002-2013 there exist stable trend to growing volume of electricity consumption and considerable variations of power consumption characteristics in time and regions are present [1]. One reason is the lack of clear system of energy economy management.

Practically, the major energy consumers in airports are illumination, steam and heating systems, climate control systems and comfort provision systems. The specific trait of airport energy economy is the need to support constantly the activity of certain systems, decisive for airport functioning. This is first of all related to the illumination of runways, aprons and terminals, climate control systems provision, power supply of navigation and routing systems, as well as safety control systems, heating of terminals and fuel supply systems. It is impossible just switch off these systems, as it will ruin all the work at an airport. In much the same way it is not possible to reduce the intensity of illumination without increasing accidents risks or to change production capacities of an airport without reduction of its ecomonic characteristics. Nevertheless, accurate planning, control and management of technological processes, their thorough distribution creates opportunities for the reduction of energy consumption. To address the problem of energy losses at airports efficiently it is necessary to use complex automated systems of power management based on the latest developments from the leading equipment manufacturers such as Danfoss, ABB, Carrier, Siteco.

Thus, energy efficient solutions for illumination include installation of daylight reflection systems, allowing redirection of the most of light into the premises during the daytime. Besides the obvious energy savings, it helps create a soft even illumination in the rooms, comfortable for visitors. Although the intensity of this daylight illumination depends on the level of natural light and must be adjusted automatically or supplemented with electric illumination.

Centralized illumination control system also allows the operator manage apron illumination, lighting at adjacent areas when the platform is occupied with aircraft, boarding on or off is carried out and other operations are performed. In the airport waiting areas and terminals lighting is automatically scheduled and adjusted to the timetable of arrivals and departures.

Equally interesting solutions can be used to optimize the management of microclimate. The airport interior is excessively heated by the direct sunlight, illumination, various technological equipment and people within. So, to neutralize the excess heat effectively the special circuits with variable cooling media flow are used. It is supplied only to those areas where and when sensors record the air temperature rise above the level comfortable for visitors or staff, for example - in the terminal area under daylight. The extracted heat is also a valuable resource and must be reused, which is performed with the systems of heat recuperation. Thus, 85% heat energy, present in the exhaust air, is returned through the energy recovery equipment to the heating system - at present the most efficient energy-saving technology [5].

Efficient heating system is essential for complete climate control of airport in temperate latitudes. Its stable operation should be provided by two or more independent sources of heat, as this allows running them separately if required level of heat is insignificant, and thus reducing energy consumption for the functioning of heating system. Climate control systems also involve management of ambient parameters in terminal buildings by means of electronics, computer network related to the airport. This allows implementing the principle of preventive climate control, when ventilation and air conditioning system are adjusted automatically to increase or decrease the intensity of work based on the analysis of information coming from the CO_2 sensors and data about passenger traffic in a particular area of the terminal.

Electricity must be also supplied to terminals from several independent energy centers, which airport is connected through several transformer substations. It is necessary for the organization of uninterrupted electricity supply of security, telecommunication and navigation systems and should not turn off for a second, even in cases of accidents. However, it is possible to find the way to saving costs and resources by using energy-saving equipment in electrical system – the result may achieve 20% reduction in energy losses. This result is provided by the implementation of reactive power compensation, which reduces the total load on transformers and power lines. The use of lighting equipment with electronic adjustment reduces power losses by 10% [5].

Dispatching and control over the operation of all engineering and information systems in terminals using automated system of supervisory control also contributes to reducing energy losses. Automation control equipment opens the way to reducing the number of necessary operations and terminal personnel, minimize errors caused by human factor, increase the reliability and safety of all engineering information infrastructure at the airport. In addition to these management functions, centralized controlling system software is able to collect and process data on power consumption, allowing operators to monitor energy use, identify trends, make appropriate decisions and implement corrective measures to improve energy efficiency, especially in terms of electricity.

The pioneering representatives of the branch in energy saving solutions are the Heathrow Airport, Great Britain, Munich Airport, Germany, and Vnukovo Airport, Russian Federation [5].

Thus, Heathrow Airport has developed complex program on energy conservation, approved by the state government and airport managers. The certain points of the program to improve energy efficiency in Heathrow Airport include regulation of illumination to cover only the areas being used, heat and cold recovery, power disabling for the equipment not used.

HVAC systems and operations at Munich Airport include the classic management functions for energy saving in combination with a number of specially developed intelligent functions. CPS implements energy optimization program for remote buildings, as well as areas of outputs, including lighting and temperature control. Individual controllers in premises regulate temperature and ventilation in approximately 1,700 rooms throughout the airport, allowing operators to accurately manage energy use and support comfort levels of ambient parameters.

At the Terminal A at Vnukovo airport, all large premises are equiped with the system of daylight reflection, allowing the best use of it in the daytime. Besides the split system of heat generation, the systems of heat recovery provide regulation of microclimate parameters and formation of energy reserve for heating. The intensity of power supply for ventilation and lighting depends on the level of terminals traffic load and number of passengers and services provided [5].

The main air gate of Ukraine, the Boryspil airport, has begun to implement the energy saving technology trying to reduce power and natural resources consumption. Thus, easy to operate systems for the daylight reflection are installed in all major halls, allowing minimal use of artificial illumination during the most of daytime. The expected reduction of energy consumption will be 12-15% [5]. Application of such systems has also decent payback period which is said to be 4-5 years at the most.

Kyiv International Airport (Zhuliany) is one of the two passenger airports of the Ukrainian capital Kiev. It is owned by the municipality of Kiev and located in the southern Zhuliany neighborhood of the city. Aside from facilitating regular passenger flights, Kyiv International Airport is also the main business aviation airport in Ukraine, and one of the busiest business aviation hubs in Europe.

After Ukraine gained independence in 1991, "Kyiv" airport began receiving international flights from nearby countries, but in 2011, when Wizz Air, the locally-pioneering low cost airline, had moved all its operations to "Zhuliany" from the Boryspil Airport, the new era of around-the-clock flights at the airport started and the passenger traffic increased by 1520% [6]. The new "A" terminal opened in 2012, now receives all international and some domestic flights. Projects for expanding Zhuliany's taxiways and aircraft parking lots considered as well, unfortunately, the issues of energy conservation are not sufficiently covered in these plans.

However, our investigations have showed that the following measures will be highly efficient:

- installing energy efficient lighting with motion sensors throughout the airport;
- natural illumination indoors for passengers in terminals;
- double glass windows and solar shading devices, providing natural light penetration into the building, but minimizing heat received from the sun;
- turn off escalators and baggage lines at night;
- turn off peripheral illumination in daytime.

The overall effect of this complex of activities will lead to reduction of energy consumption by 19-27%, depending on the intensity of energy conservation opportunities implementation. Even under the minimal scenario, the manetary value of the project will be equal to 627 kW of energy capacity, which a dramatic improvement. In applied presentation this volume of energy can provide heating for two 16-storey residential buildings. The payback period for the corresponding capital investments will range from 7 to 11 years, but considering the instability on energy resources provision typical for current economicand political situation in Ukraine, the need to invest in energy efficiency improvement turns to be the need of survival importance.

Energy saving makes it possible to reduce the pressure both on the energy economy and environment. Environmental effect is not limited merely to the decreased consumption of natural resources. Each saved calorie of heat or kilowatt-hour of electricity also provide significant environmental benefits at all previous stages of energy generation, associated with fuel extraction, enrichment, processing and transport; production, transportation of electrical and thermal energy to the consumer and its distribution [7].

For example, every saved thousand of kilowatt-hours on average prevents emission of 4.2 kg of solid particles, 5.65 kg of sulfur oxides, 1.76 kg of nitrogen oxides and saved Gcal of heat - 2,2 kg of solid particles and 3 kg of sulfur oxides and about 1 kg of nitrogen oxides emissions [7]. Given this, the perspective reduction of energy consumption at Kyiv International Airport, based on our calculations, will be equivalent to the emissions of solid particles decreased by 9.48 t, sulfur oxides emissions decreased by 12.75 t and nitrogen oxides emissions decreased by 3.97 t every year. The resulted effect will include lower contribution of airports activity to greenhouse effect enhancement, atmosphere dimming and intensity of acid rains formation.

Conclusions. Among the barriers to the development of energy saving and energy efficiency in our country is mostly the lack of motivation, including among government authorities, insufficient information support, lack of experience in financing energy efficiency projects, lack of organization and coordination of implementation. Such a barrier as technology drawback is, to date, substantially removed, including through the investments from the developed countries. Currently the market has a very wide range of energy efficient equipment, energy-saving materials and a range of consulting services on energy conservation and efficiency, creating a strong infrastructure base. This is also valid for airports as they are the facilities with extremely high and expensive energy consumption, conditioned in many cases by safety and functionability. Nevertheless, leading airports of Europe have discovered strong potential of energy conservation, which could be applied in Ukraine for major airports. The investigations show that implementation of the basic set of energy saving recommendation releases energy capacity enough to provide the needs of residential blocks and leads to reduction of emissions related to greenhouse effect enhancement, atmosphere dimming and intensity of acid rains formation.

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Development of environmental express remote sensing for detection the state of ecosystems

Actuality of problem consist in solutions of particularly applied problem – identification, assessment and minimization of influences on environment from transport activity, determination of ways for minimizations of such influences on society, and support of environmentally compatible development of transport network, in connection with formation of environmental network under the context of ecosafety and ecological footprint.

Remote sensing researching in our country has been going nearly half a century. During this time has performs enrichment of theoretical, methodological and technical arsenal of researches. If in firs works was prevail aerial photography of the earth's surface, in our time widely used also spectral, heat, and radiolocations surveying, complex researches with applying of different methods in optical, infrared and low-frequency component of the vibration. Given methods is effectively used predominantly in solution tasks which connected with mapping of vegetation cover (in botanic, forest and agriculture), for detection of pests centers (in plant pathology, forestry), optimization of land using, in geological surveying, meteorology. For learning of vegetation cover predominantly using remote sensing and spectrometry in visible, near IR and heat diapasons, TV survey.

At given stage, in area of remote researches has emerged successes in such directions:

1) Assessment of spectral characteristics of vegetation in visible and near infrared area of specter (dependence of reflection specters from physiological state of vegetation and environmental conditions);

2) Research of vegetation in infrared heat (receiving of information about hydrological and hydrotermal parameters of environment and activity of plants);

3) Analysis of fluorescence ranges the plants, violate light by laser and receive information about change of metabolism in plants and environmental conditions.

Based on the general principle about unity of all live organisms and environment, their living, can be considered that exist correlative connections between factors (characteristics of parameters) of environment, and reactions of live organisms on it. Especially evidently this should be manifested in plants organisms that closely “related” to specific territory, and consequently to the environment of habitation.

Growth and development of plants (that based on metabolic processes) directly depends from the conditions of lighting, temperature, humidity, fertility of soil on given territory. That’s why we can say that indicated links are very stable for the plants.

One from manifestation of biosystem stability – is stability of ecosystems and phytocenosis (plant communities). A necessary conditions for definition of over organism system are indication of placement of its elements, and sufficient condition for such determination are designation on the connex (following [1]) – law of organization the elements interaction, because during this also indicated content (set) and structure of system (location of elements).

Method of induction of chlorophyll fluorescence (CF) is perspective method in environmental monitoring, because studying of fluorescence kinetics can provide important information about character of environmental activity concerning influence on photosynthesis parameters. Such information can be used for monitoring and for assessment of stability of photosynthetic organisms [2-4].

Efficiency of photosynthesis is one from main parameters by which cut be determined state of plants. Determining of photosynthesis efficiency in research object can be caring out by the method of CF induction. Exist three principles of CF induction method [3].

Exist three ways for realization of energy from light quanta that absorbed by chlorophyll molecules – photochemical reactions, heat dissipation and fluorescence.

CF is indicator, which is very sensitive to the different types of stresses, when outside on plants and in its specters of absorption and reflection of light has not revealed changes. During measuring of variable component of CF, we can receive reliable information about relatively static ’’passport’’ characteristics of photosynthetic apparatus (PHA) of plants, such as optimal intensity of light for PHA, which caused by (and are factor) indicator of average daily illumination area. Research of CF takes additional possibility for assessment of chlorophyll content in phytoelements, ratio of photosystem 2 (CF2) and photosystem 1 (CF1), and size of light collection antenna CF2, that correlates with ration of chlorophylls *a* and *b*.

Except this, research of CH take possibility for determination of relatively dynamical processes, such as quantum yield of electron transport in PHA. Photochemical quenching of fluorescence, that reflect oxidation of new pool through availability of terminal acceptor electrons, and petrochemical quenching of fluorescence.

Device for measuring of main parameters of method – modulating fluorymetr XE-PAM. Difference in fluorescence signal, which occurs in result of flash of measuring light, enhanced by selective amplifier (Lock-in amplifier).

Fluorymetr XE-PAM has three source of light, which provides three types of object illumination:

- ML (*measuring light*) – measuring light. Weak impulse light, that not cause photochemical reactions (Integrated density of photon flux during the pulse – 0,2-1 mmol photons $m^{-2}s^{-1}$, duration of pulse – 1-3 ms, frequency – from 1,6 to 600 kHz in dependency from recording mode and device type).
- AL (*actinic light*) – active (actinic) light, which support photosynthesis.
- SP (*saturation pulses*) – short outbreaks of saturated light, intensity of which is sufficient for fast restoration of pool Q_A (> 2000 mmol photons m^2 s^{-1}, duration of flash 0,8-2 s).

During launching of induction curves comply following order in on-off of light sources that listed above. Turn on light of measuring light in result of which fluorescence is reach value of F_o (fig. 1).

Intensity of ML is so slow that reaction centers CH2 (RC CH2) remain "open". Then used short flash of light, which restore Q_A of all complexes of CH2. Fluorescence is reach maximal value F_m. By the difference between fluorescence levels F_o and F_m asses potential effectiveness of PHA photochemistry in state that adapted to the darkness.

After that, as CF is relaxes to F_o level (through outflow of electrons from Q_A to plastoquinone pool), turn on active light, which cause changes of fluorescence exit. Intensity of fluorescence in certain moment of time during photosynthesis induction is denote as F. Reduction of signal level (quenching of fluorescence) that caused by oxidation of Q_A, in result of activation of reactions of dark phases of photosynthesis (photochemical quenching of fluorescence) and increasing of heat dissipation in light collection antenna PHA (non-photochemical quenching of fluorescence).

For accessing contribution of photochemical and non photochemical processes it is necessary to exclude the influence from one of them. As a rule is caring out to the relation to photochemical component through fast restoration of initial acceptors, Q_A – through using of short flashing of high intensity light. In result saturated light flashing (SP) also happens restoration of all Q_A in example, which accompanied by increasing of fluorescence intensity to the level of F_m, significantly lower than F_m through non photochemical quenching of fluorescence. Presence of photochemical quenching cause difference between F_m and F (Figure).

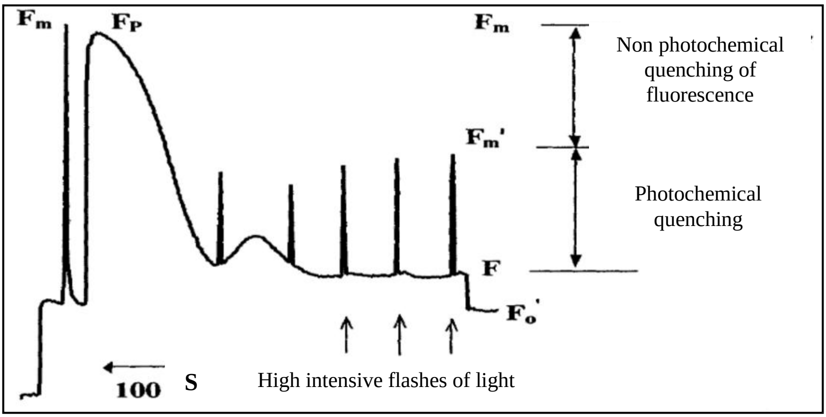

Figure 1 – Example of curve for determination of levels of photochemical and non photochemical quenching of chlorophyll fluorescence

After flash of SP turn on active light (AL). Together with oxidizes pool of electors carriers. Level of fluorescence reach value of F_o. Knowing values of F_o i F_m, can determine real quantum yield of photochemistry PHA (in state adapted to the light).

In result receive curves, general form of which was presented on fig. 1. Parameters are calculated by following formulas [6, 7]:

Maximal potential quantum yield of variable CH (F_v/F_m), formula 1:

$$\frac{F_v}{F_m} = \frac{(F_m - F_o)}{F_m}, \tag{1}$$

Where, F_m – maximal fluorescence; F_o – minimal (dark) level of fluorescence.

Photochemical quenching of CH (qP), formula 2:

$$qP = \frac{(F_m' - F_t)}{(F_m' - F_o')}, \tag{2}$$

Where, F_m – maximal fluorescence in state adaptive to light; F_t – current state of fluorescence;

F_o – minimal fluorescence is state adaptive to light.

Effective quantum yield of PHA (Φ_{PSII}), formula 3:

$$\Phi_{PSII} = \frac{(F_m' - F_t)}{F'_m}, \tag{3}$$

Non photochemical quenching of CF (NPQ), formula 4:

$$NPQ = \frac{(F_m - F_m')}{F'_m} \tag{4}$$

Conclusions

The development of civilization is accompanied by a negative impact on the natural environment. One of the essential factors of such influence is the transport. Taking into account that the main source of information about the environmental monitoring is actually developing monitoring methodology seems promising as to assess the role of these factors on the environment (particularly through EIA/SEA) and practice usage for the branch.

Based on research results showed the effectiveness of the method of photo induced chlorophyll fluorescence, which allows testing the object without disturbing the photosynthetic apparatus activity and mechanism of its adaptation to stress environmental factors.

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Measures for electromagnetic safety of radiotechnical objects of civil aviation

In the work the level of electromagnetic radiation of radiotechnical objects of civil aviation is analyzed and proposals to minimize the influence of the aerodrome radio equipment on the airport staff are provided.

Introduction. Constant growth of the electromagnetic load on the environment caused by the development of energy infrastructure, networks of wireless communications, radiotechnical equipment of civil aviation, etc., requires determining the levels of electromagnetic fields and radiation of individual objects, evaluating of their impact on the public, staff and different buildings, and determining the areas of restrictions of people stay. It is provided with Sanitary Control measures for sources of electromagnetic fields. Such supervision is based on current sanitary norms and rules based on the results of research in this area. Ones of the main factors of negative impact on workers are electromagnetic fields and radiation of almost the whole frequency spectrum that require a careful investigation of their numerical values and determine the conditions to minimize them.

Actuality of the problem. Sanitary norms and rules are obligatory for all ministries and other central executive bodies, enterprises, institutions and organizations regardless of subordination and ownership, citizens, that design, produce, operate and service equipment, facilities, appliances, equipment, etc.,that are sources of electromagnetic fields (EMF); that develop and implement measures to reduce the harmful effects of EMF on workers. The maximum permissible levels (MPL)of EMF are based on the principle of presence of the limit of harmful effects of EMF. For MPL EMF usually use such values, that in condition of daily irradiation (with standard for the source of radiation regime) doesn't cause diseases or deviations in health of the population without limitation of gender and age.

The state sanitary norms and rules at work with sources of EMF [1] establish the requirements for workers engaged in the manufacture, operation, maintenance and repair of equipment, that is a source of constant electromagnetic fields and electromagnetic radiation in the frequency range of 50.0 Hz to 300.0 GHz.

Aim of the work is to identify whether there is excess of maximum permissible levels of radiotechnical means of the aerodrome and providing proposals to minimize their impact..

Basic material. Sources of electromagnetic radiation at the Antonov aerodrome (Kyiv), according to the AIP and the Instruction on execution of flights [2] (Table. 1) are such radiotechnical support means of flight:

- drive distant radio beacon DDRB-15;
- drive distant radio beacon DDRB -33;

– near the drive radio beacon NDRB-15;
– near the drive radio beacon NDRB-33;
– landing system LS-80 GRM-15;
– landing system LS-GRM-33;
– landing system LS-80 KPM-15;
– landing system LS-80 KPM-33;
– direction-finder ARP-75;
– overview radiolocator 1RL139-2 (P-37);
– airport radiolocator DRL-6M2;
– accurate landing radiolocator RP-4G.

Table 1

Radio navigation equipment and facilities of landing

Type of facility, category ILS/MLS the magnetic declination for VOR/ILS/MLS	Denotation	Frequency	Work hours	The coordinates of the transmitting antenna
1	2	3	4	5
LMM 15	C	257.00 KHZ	HS	503733N 0301029E
LMM 33	O	286.00 KHZ	HS	503452N 0301230E
LMM 15	LC	534.00 KHZ	HS	503902N 0300921E
LMM 33	GO	590.00 KHZ	HS	503329N 0301330E
LLZ ILS 33 CAT 1	IGO	108.70 MHZ	HS	503714N 0301043E
GP		330.50 MHZ	HS	503532N 0301207E
MM		75.00 MHZ	HS	503452N 0301230E
OM		75.00 MHZ	HS	503329N 0301330E
LLZ ILS 15 CAT 1	ILC	111.90 MHZ	HS	503508N 0301218E
GP		331.10 MHZ	HS	503657N 0301104E
MM		75.00 MHZ	HS	503733N 0301029E
OM		75.00 MHZ	HS	503902N 0300921E

There has been a sanitary certification of electromagnetic radiation sources at the aerodrome Antonov (Kyiv). The results of calculation and measuring are given in sanitary passports of electromagnetic radiation sources of radiotechnical support means of flights to the surrounding areas at the height of 2 meters from the ground at a distance L meters from the center of ffundamentals of transmitting antennas. It was received the following levels of tension of magnetic field H for the following sources of electromagnetic radiation (Table 2).

Table 2

Levels of tension of magnetic field for sources of radiation

Source of radiation	***H*, V/m**	***L*, m**	**MPL**
DDRB -149 (drive distant radio beacon)	5780-0,62	0-100	15 V/m
DDRB -329 (drive distant radio beacon)	5780-0,62	0-100	15 V/m
NDRB--149 (near the drive radio beacon)	4470-0,15	0-100	25 V/m
NDRB--329 (near the drive radio beacon)	9020-0,5	0-100	25 V/m
R-140 (radio communication station «Polosa»)	146-1,12	0-200	3 V/m
SP-80M (KRM)	1,77-0,2	0-400	3 V/m

At the airfield was received the surface flux density of energy of airfield radiotechnical support means (Table 3).

Table 3

Levels of surface flux density for sources of radiation

Source of radiation	**W, mW / cm^2**	**L, m**	**MPL**
Airfield radiotechnical support means	46360-0,01 mW / cm^2	0-5000	ORL-15mW / cm^2 other-2,5 mW / cm^2
SP-80M (GRM)	9,0-0,16	0-400	2,5 kW/ cm^2

So on the certain distance these levels exceed maximum permissible level for existing radiation sources.

Conclusions and prospects for research.

Must be set due to the excess of the MPL radiotechnical support means at the airport Antonov (Kyiv):

– for DDRB-15 sanitary protection zone (SPZ) in the form of an ellipse with axis 33 m and 45 m (counting from the canvas antenna);

– for DDRB -33 sanitary protection zone (SPZ) in the form of an ellipse with axis 34 m and 47 m (counting from the canvas antenna);

– for NDRB-15 sanitary protection zone (SPZ) in the form of an ellipse with axis 47 m and 50 m (counting from the canvas antenna):

– for NDRB-33 sanitary protection zone (SPZ) in the form of an ellipse with axis 42 m and 48 m (counting from the canvas antenna);

– for SP-80 [10] sanitary protection zone with a radius 18 m;

– for radio communication station R-140 („Polosa”) sanitary protection zone (SPZ) in the form of an ellipse with axis 40 m and 80 m (counting from the canvas antenna);

– for ORL P-37 sanitary protection zone with a radius 130 m;

– for RSBN-4N sanitary protection zone with a radius 64 m;

– for RSP -6M2 sanitary protection zone with a radius 190 m;

– for RP-4G sanitary protection zone with a radius 2065 m in azimuth 149 and 329 degrees in the sector of ± 16 degrees from the direction of the main azimuth;

– for SP-80M [11] KRM sanitary protection zone with a radius 25 m, for GRM SPZ is absent.

For near-field radiation intensity the levels of EMF is generated by radiating T-shaped antenna which does not depend on the height above the ground, so the need to establish building limitation zones (BLZ) around is absent.

For near-field radiation intensity the levels of EMF is generated by radiating antenna of the radio communication station R-140 «Polosa»),is maximum directly on the ground, so the need to establish BLZ around the station R-140 is absent..

BLZ also absent for RSBN-4N, RSP -6M2 and RP-4G.

BLZ is set for: ORL P-37 for buildings height 5 m and radius of 770 m, height 7m and radius of 900m, height 15m and radius of 1250m, height 25m and radius of 1575 m.

BLZ is set for: SP-80M KRM for house with height higher than 15m and radius of 26 m, and house with height lower than of 15m BLZ is absent.

Existing living buildings are not subjects for sanitary protection zones and zones of building limitation.

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Efficiency of small unmanned aerial vehicle detection based on acoustic signal analysis

New method for estimation of unmanned aerial vehicle (UAV) noticeability is proposed. This method is based on measurement of UAV sound power level in reverberation room. Research of acoustic background in vicinity of UAV deployment was conducted. The range of UAV acoustic noticeability is determined as a function of its flight parameters and meteorological conditions.

Small UAV is widely used for the decision of tasks of environment monitoring, mapping, patrolling, as well as for military purposes. In the future UAV will be an instrument for the decision of important tasks, which pertain to national economy. One of major UAV characteristics is a level of its acoustic radiation. Therefore, investigations of UAV acoustic characteristics with the aim of sound level reduction of already existent aircrafts and development of noise reduction methods of perspective UAV is topical. The power-plant of small size airplane includes: reciprocating engine and airscrew, that are the basic sources of noise. Two-stroke engines (in comparison with four-stroke) are characterized by the higher values of power. Therefore, two-stroke engines are more widely used for small size UAV. Spectral and total characteristics of noise of small size UAV were determined in the acoustic laboratory of National Aviation University (NAU). Sound power level (SPL) of small size UAV were determined in the reverberation room of NAU by comparison method [1]. Figure 1 illustrates small size airplane PRESTO 5 in reverberation room.

Figure 1. Small size airplane PRESTO 5 in reverberation room of NAU

On fig. 2 the 1/3 octave SPL spectrum of small size airplane PRESTO 5 is shown on the cruise engine operational mode.

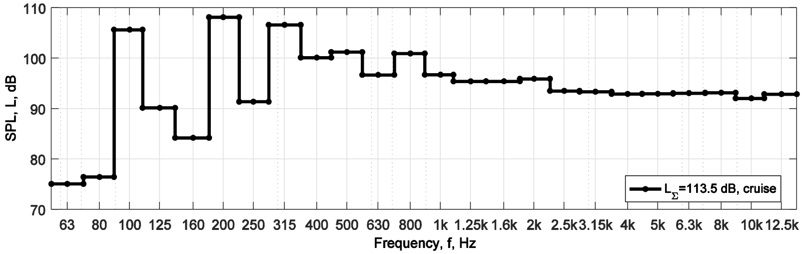

Figure 2. 1/3 octave SPL spectrum of airplane PRESTO 5 on the cruise engine operational mode

The spectrum of noise of small size airplane is broadband with discrete harmonics on frequencies, which are multiples of screw rotation speed. The total level of engine sound power prevails in area of low frequencies and is determined by the first 8 harmonics of screw. The narrow-band noise spectrum of small size airplane (fig. 3) confirms data of noise measurement in the 1/3 octave frequency bands.

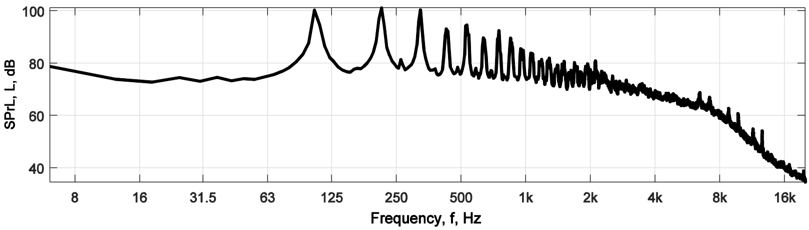

Figure 3. Narrow-band sound pressure level (SPrL) spectrum of airplane PRESTO 5 on the cruise engine operation mode

The basic sources of noise of reciprocating engine are aerodynamic and mechanical processes, that accompany intake of fuel-air mixture in a combustion chamber, burning and production of working gases, and also processes of friction and impacts at the mechanical motion of engine parts in relation to each other. It becomes clear from fig. 3 that there are broad-band and discrete constituents on separate frequencies in the noise spectrums of small size airplanes with a reciprocating engine and airscrew. These constituents are multiples of the number of rotations per second n and depend on the number of blades of z. Frequency of discrete constituents obey to the following equation $f_m = mnz$, where f_m is frequency of m-th harmonic. As it can be seen on fig. 3, discrete harmonics in the noise spectrum prevail in area of low frequencies, and broad-band is observed for frequencies of acoustic vibrations more than 2000 Hz.

Obtained small size airplane SPL values allow defining its acoustic parameters on the different stages of flight by taking into account the factors of noise distribution in an atmosphere. It is necessary to take into account influence of turbulence, gradients of temperature and wind in the boundary layer, viscosity and molecular sound absorption, reflection from an earth surface and diffraction from landscape nonuniformities on sound propagation at distribution of sound-waves in an atmosphere. When receiver of acoustic information is close to earth, there is interaction of acoustic waves with earth, building, relief and vegetation. Attenuation of acoustic waves in an atmosphere depends on the degree of air mixing in an atmosphere. We will suppose that power of sound source is set by SPL - L_{p}. Then the SPrL in the reception point is defined in a form:

$$L = L_p + I_e - 20\lg R - \Delta L - 10\lg 4\pi, \quad (1)$$

where I_{e} is an index of sound source directivity; R is distance from a source to the sound receiver; ΔL is a factor of sound attenuation that takes into account the environmental conditions.

The most substantial absorption of sound-waves in air is observed at high-frequencies of vibrations. For the flat wave the pressure value p on the distance x from position, in which pressure equals p_0 is given in form :

$$p = p_0 \exp[-\frac{\alpha(f)}{2} x], \quad (2)$$

where attenuation coefficient $\alpha(f)$ takes into account absorption of acoustic oscillations in air depending on its frequency f, humidity and air temperature of [3]. SPrL reduction on the distance R for f -th of frequency band due to atmospheric absorption in accordance to equation (2) equals:

$$\Delta L(f) = \alpha(f)\, R.$$

A relationship between sound attenuation, frequency, temperature and air humidity is expressed by next empiric equation [3]:

$$\alpha(f) = 10^{[2,05\lg(f_0/1000)+1,1394\cdot 10^{-3}t-1,916984]} + \eta(\delta)\cdot 10^{[\lg f_0+8,42994\cdot 10^{-3}t-2,755624]},$$

where $\alpha(f)$ is the attenuation coefficient (dB/100 m) , t is the air temperature of (^{0}C)

$$\delta = \sqrt{\frac{1010}{f_0}}10^{(\lg H-1,328924+3,179768\cdot 10^{-2}t)}10^{(-2,173716\cdot 10^{-4}t^2+1,7496\cdot 10^{-6}t^3)},$$

where H is relative humidity, a function $\eta(\delta)$ and $f(f_0)$ is determined from data in [3].

The results of the conducted researches give an opportunity to set the task of determination of UAV acoustic noticeability distance. Acoustic noticeability distance is maximum distance of UAV flight, for which the spectral SPrL from UAV in the audible frequency range is equal (or above) SPrL of natural background. Experimental researches of spectral and integral characteristics of natural acoustic background are conducted on the airdrome of small aviation deployment. The results of experimental researches of natural acoustic background allowed to set dependence of sound-levels on the speed of wind, character of underlying surface, difference of daily and minimum night temperature of air [2]. An acoustic radiation of natural acoustic background is broad-band in the frequency range of 20-10000 Hz.

It is possible to distinguish four frequency ranges in the spectrum of natural noise background. There is a characteristic change in frequency of noise constituents' spectral levels in these ranges [2]:

- range of frequencies of 20-500 Hz, where the monotonous decrease of spectral SPrL is noticed;
- range of frequencies of 500-2000 Hz, where with the frequency increase the spectral SPrL decreases slowly or even saves a permanent value;
- range of frequencies of 2000-4000 Hz, where the increase the spectral SPrL of natural acoustic background takes place;
- range of frequencies of 4000-8000 Hz, where the small decrease of spectral SPrL of natural acoustic background takes place.

A general formula for the SPrL of natural noise background is defined with next correlation:

$$L_{\Phi}(f) = L_{\Sigma} + \Delta L_{\Phi}(f), \tag{3}$$

where L_{Σ} is measured total SPrL for the concrete supervision conditions, $\Delta L_{\Phi}(f)$ is spectral correction of background SPrL in the 1/3 octave frequency bands (shown in Table 1).

Table 1

Spectral correction of natural background noise in the 1/3 octave frequency bands (wind speed of less than 0.5 m/s)

Frequency, Hz	Spectral correction, dB	Frequency, Hz	Spectral correction, dB	Frequency, Hz	Spectral correction, dB
20	-6.3	160	-25.2	1250	-52.0
25	-6.9	200	-29.4	1600	-52.9
31.5	-7.7	250	-34.6	2000	-53.2
40	-9.3	315	-39.9	2500	-52.6
50	-10.9	400	-43.3	3150	-51.5
63	-13.0	500	-46.3	4000	-50.5
80	-15.5	630	-48.4	5000	-51.6
100	-18.0	800	-50.4	6300	-51.8
125	-21.3	1000	-51.1	8000	-49.8

For determination of spectral characteristics of natural background noise measured total SPrL values for the concrete observation condition are necessary. Total SPrL can be determined in the field conditions by means of, for example, modern mobile telephones. The use of correlation (2) and data of table gives an opportunity to calculate spectral characteristics of natural background noise in 1/3 octave frequency bands. On a fig. 3 the 1/3 octave noise spectrums of small size airplane of PRESTO 5 are shown at flight on the cruise engine operational mode on distances of 100 m, 200 m, 500 m, 1000 m.

Results of conducted investigations have shown, that spectral characteristics of noise of small size airplane PRESTO 5 at flight on cruise engine operational modes at distances less than 1000 m exceeds corresponding background acoustic noise levels.

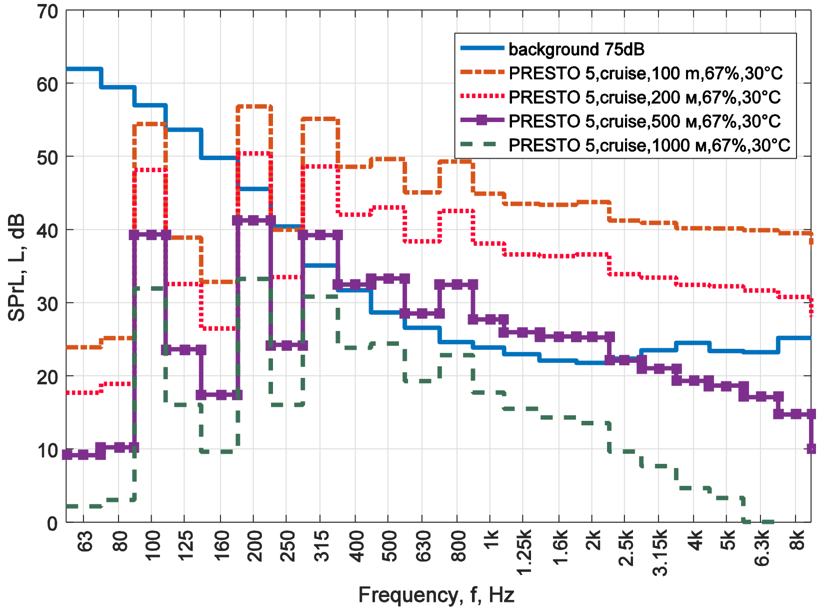

Figure 4. 1/3 octave spectrums of noise of small size airplane PRESTO 5 at flight on engine cruise operational mode on distances of 10 m, 100 m, 200 m, 500 . and natural background noise (with total SPrL of 75 dB, relative humidity of 67%, air temperature 30°C)

Conclusions

Results of investigation allowed to elaborate the method of UAV noticeability range determination as a function of engine, screw characteristics and environmental acoustic conditions.

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Future of More Electric Aircraft

More Electric Aircraft Concept seem to be a key player in achieving better environment and sustainability. This work discusses the future and possible applications of more electric aircraft, taking into considerations of technological limits, reliability and integration issues.

History

Although before 1900s, first automobiles had all electric powertrain, following the Ford Industrial revolution, automobiles became using internal combustion engines (ICE), which made the engines cheaper and widely available. This also effected the aeronautical history which started at those times where ICE engines are available but electric energy storage was heavy.

Pilots of early aircraft flew by hand, using rudder pedals and a stick which were connected to the rudders, ailerons, elevators and flaps by wire rope or rigid links (fly-by-cable). In the 1940s, some aircraft became so heavy or so fast that hydraulic power was required to move the aerodynamic surfaces. In the late 1950s, hydraulic motors were introduces as the sole means of moving those surfaces. Later in 1970s fly-by-wire introduces and used first in F-16 (1975), Mirage (1980) and later on Grippen (1988). In the full fly-by-wire system, the controls send electrical signals to a computer system which operates the control surfaces. This system has no mechanical means of backup. [1]

Since 1995, avionics have been undergoing a rapid growth because of the digital revolution of the 70s. Avionics require a source of electric power. Many avionic devices are safety critical, for example flight-control computers, navigation systems, which require own level of reliability. Following the introduction of fly-by-wire concept, electronic avionic systems made integration easy and both concepts feed each other’s development.

Beginning 1990s, passenger services and infotainment systems which are fully electronic, created a demand for electric.

Enabler Technologies

In order to achieve no emission, no noise aircraft with cheaper and easier to maintain features, more electric aircraft (MEA) concept is taken into consideration. MEA concept had been researched in the following areas;

- Propulsion technology
- Energy production, storage and delivery
- Structural Weight Reduction and
- Advanced Aerodynamics

Propulsion technology leads the aviation industry starting from the first flight [2]. Development of electric motors are promising low weight and high power ratios. This leads to higher performance per battery energy stored on board. But, as power density of the electric motors is not sufficient, for time being, it is not able to power the large aircrafts with electric motors and build all electric aircrafts [3]. Only light aircrafts are capable to be flown by automobile like power trains.

Electric energy on board the aircraft is essential as it is being used by avionics, actuators, computers and even by passengers. As this is the main energy, during the flight, it shall be produced and/stored for different energy demands on different flight phases. Electric energy storage itself shall not reimburse additional weight and cost. Developments on Li-ion batteries starting from 1990s, made it possible to think on future flights with stored energy. For now, the energy density is promising but not enough. Also fuel cells using hydrogen as fuel is still promising after years of research.

For now, starting from large aircrafts, the replacement of conventional hydraulic actuators by the electric ones already made dramatic improvements in reliability, maintainability, supportability and lighter aircraft with the potential of saving fuel.

Power electronics is another enabler technology [4], as smaller and cheaper power electronics components provide more control over energy.

In 1970s it was a huge effort to design, develop and install the harness, because of the heavy loads of wires. Multiplexing or new means of communication helped in reducing harness amount and increasing reliability.

Using High Voltage DC, aircraft components like actuators, convertors and harness became smaller and lighter [4].

Future of MEA

Aviation is solely responsible for the 3% of all the emissions of today's industrial life. More Electric Aircraft (MEA) Concept seem to be a key player in achieving better environment and sustainability. New powering concepts for more electric aircrafts are being developed, subjecting to developing better battery technologies, fuel cells and other types of engines and systems. Although technology is evolving fast, there are still some hurdles for the concept to be widely used.

For future aircraft designs, the continuation of increasing avionics will still occur but in addition to this concept. The trend is to replace existing secondary power systems, such as hydraulics, pneumatics with electrical equivalents [5].

Reliability also is a common concern, caused by an accident which shed hesitations on this new concept. This is seen as an opportunity to look MEA in a new manner, including all chains of the concept.

As electronic components get smaller and smarter, avionic equipment gets smaller in size, weight and energy usage [6].

Besides higher energy efficiency, electric propulsion gives advantage of using renewable energy sources and more transportable generators like solar cells, fuel cells, ultra-capacitors and batteries.

Some applications show that in cruise phase, only solar cell is enough for powering the electric motor [7]

Conclusion

For decades, only electric equipment on board was the engine's magnetos that feed spark plugs. Following demand for more complex aircraft systems, new subsystems and new technologies for them created a new path for aviation.

Avionics evolved from simple instruments to complex systems that permitted to fly virtually in all weather conditions. The aircraft which had only spark ignition became user of megawatts of electric power.

In the MEA, the replacement of conventional hydraulic actuators by the electric ones lead to dramatic improvements in reliability, maintainability, supportability and lighter aircraft with the potential of saving fuel.

Besides higher energy efficiency, electric propulsion gives advantage of using renewable energy sources and more transportable generators like solar cells, fuel cells, ultra-capacitors and batteries.

Electric propulsion by nature, makes it easy for the integration with other electronic systems.

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Advantages and Future of Electric Propulsion in UAVs

This work discusses technological aspects and market wise applications of electric powered UAVs and their future trends. It is seen that more autonomous and lighter the UAV is, more electric power is preferred.

Historical Background

An Unmanned Aerial Vehicle (UAV) can be defined as “remotely piloted or autonomous aircraft, that can carry camera, communication equipment and other payloads” [1]. UAVs have emerged as a viable platform for operations under extreme conditions where human pilot is too risky or unnecessary, in a diverse range of applications, from military uses to civil tasks [2]. As the operation costs are low compared to satellites and aircrafts, interest in UAVs are getting higher for both military and civilian uses.

UAVs come in all shapes and sizes for these broad range of applications. Although the types and size of UAVs differ, autonomous and remote operation are common properties.

These “flying robots” emerged from towed banners that were used for target practice during and just after World War II. The banners were replaced by towed gliders and then by remote-piloted drones during the 1960s. In the 1970s, chip-scale circuits and servomotors became available that allowed model airplane enthusiasts to pilot their aircraft remotely. Late in that decade, remotely piloted model helicopters became available commercially. They could carry virtually no payload and so no military or commercial applications were found. During the Vietnam War, F-4 pilots were asked to fly on to antiaircraft batteries to launch missiles. They experienced high losses. As a result, unmanned aircraft were developed to release missiles on the antiaircraft sites.

Reconnaissance versions of these unmanned air vehicles or remotely piloted vehicles were developed that carried video cameras and wideband communication links for real-time transmission. Unmanned reconnaissance vehicles were widely used during the Gulf War.

Applications and Requirements

Payload and endurance is always a problem in design of UAVs. Like the bigger aircrafts, UAVs also suffer the weight and size limitations for the onboard systems. This limitation creates a bigger problem for smaller UAVS.

As electronic components get smaller and smarter, avionic equipment gets smaller in size, weight and energy usage [3].

Traditionally, small UAVs used ICE engines for propulsion which have a thermal efficiency of around 30% [4]. Although the higher energy density of hydrocarbon fuels, more efficient power plant solutions are sought.

For small UAVs, electric propulsion is more desirable because of weight, simplicity and reliability considerations. Also, quiet operation is a plus for electric propulsion which makes surveillance operations easier where UAVs are preferred widely. Electric motors are capable to operate nearly 100% efficiency [5].

Market research reports that the electric power is optimal for most future UAV needs. Autonomous applications are easier and cost effective in case of using electric power. Besides, payloads are demanding electric power which is a requirement for UAV to generate and/or store electric energy.

US DoD defines the criteria for future UAVs as systems that easily accept technological improvement capabilities, which means electronic navigation systems [6]

Besides higher energy efficiency, electric propulsion gives advantage of using renewable energy sources and more transportable generators like solar cells, fuel cells, ultra capacitors and batteries.

Some applications show that in cruise phase, only solar cell is enough for powering the electric motor [7]

Civilian based UAV design and development efforts are mainly rooted in academic research and hobby activities. As small UAVs are easy to develop and low cost, the development of small UAVS are globally outreached. This also opens window for search for commercial use of UAVs. It is estimated that by 2020, military market will be around 11.4 billion USD, where commercial market and hobby market will be around 6.4 and 4.4. billion USD respectively [8].

As a good example, glacier research studies were conducted by satellite images up till now, but in UAV usage the cost involved in data acquisition is minimal and researchers can acquire imagery according to their schedule and convenience [9].

Further in the future, swarms of unmanned air vehicles (UAVs) may cooperate wide areas of use.

Production and Technology

The subsystems of unmanned vehicles are the same as those of manned aircraft.

Propulsion technology leads the aviation industry starting from the first flight. Development of electric motors are promising low weight and high power ratios. This leads to higher performance per battery energy stored on board. Recent production technologies provided the market with integrated gearing in the same case of the electric motor.

The electric propulsion system of a typical UAV includes these components; propeller, electric motor, energy source, driver, wirings, plugs and connectors. Design of an electric propulsion system for an unmanned aerial vehicle incorporates various disciplines such as the propeller’s aerodynamic and structural properties, characteristics of the electrical system, and characteristics of the vehicle itself.

On the structural part, 3D printers are also providing support for civilian research and thus promoting more and more academicians enter into this field. New production technologies not only offer light weight product manufacturing but faster prototyping capabilities, which lead to more efficient designs to be tested in short time.

Power electronics is another enabler technology [10], as smaller and cheaper power electronics components provide more control over energy.

As civilian market develops, more products enter into market making it more competitive and forcing companies to innovate new functions and capabilities. One of the companies offer over 110 minutes of endurance with 21.5 kg MTOW using all electric propulsion [11].

Research shows that the non-electric powered UAVs are tend to be military only, leaving civilian market to electric versions [12].

Electrical energy storage shows a great leap, following the use of Lithium in the batteries. The energy storage capacity became over 200 Wh/kg, which is the most essential element in electric UAVs.

Following the advances in technologies used in aviation which are also critical for the UAVs providing great advantages for the future of UAVs.

Conclusion

UAVs provide lower operation costs compared to aircrafts and satellites. This leads to wide use of UAVs especially for sensing applications.

Market research reports that the electric power is optimal for most future UAV needs. Autonomous applications are easier and cost effective in case of using electric power. Besides, payloads are demanding electric power which is a requirement for UAV to generate and/or store electric energy.

Besides higher energy efficiency, electric propulsion gives advantage of using renewable energy sources and more transportable generators like solar cells, fuel cells, ultra-capacitors and batteries.

Electric motors with integrated gearing also provide more compact and low weight power pack solutions.

Electric propulsion is also makes it easy for the integration of electronic control systems.

In the near future, full electric, small UAVs will be used widely for military and civilian purposes.

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Considerations to assess the environmental noise level inside the building

The effect for adequate indoor noise assessment is reached by introducing into calculation of specific spectrum adaptation term $C_{spec,100\text{-}3150}$ for the noise emitted façade in-situ instead of the standard spectrum adaptation term $C_{tr,100\text{-}3150}$, applicable for account the road traffic noise only as recommended by ISO 16283-3. The four step measurement/calculation procedure for dwelling indoor noise assessment is presented. The specific spectrum adaptation term is based on the average spectrum of specific noise events that appear in outdoor environment at the site under consideration. The practical experiments at the site with various environmental noise sources demonstrate that the account of the specific spectrum properties for environmental noise events allows to assess indoor noise level more adequately.

Residential facilities potentially eligible for sound insulation generally include single-family and multifamily residences located inside the areas, where $L_{\mathrm{Aeq,night}}$, L_{dn}, L_{den}, or other used noise indicator values are generally considered compatible, but potential for additional soundproofing of the dwellings elsewhere inside these areas. The limit value for indoor noise and especially at night time in latest WHO and EU documents is recommended to keep on 30 dBA or even lower level. In article it is shown that very often the indoor noise levels are below 30 dBA, they are produced by penetrated outdoor noise events and cannot be measured in practice directly because indoor background noise inside dwelling usually masks such low outdoor levels. Such a procedure is influencing not only on subject of sleep disturbance by noise at night, but also sufficiently mitigating human annoyance as a more general noise impact result. Insulating buildings against outdoor noise is not a new problem. Mitigating the impact of environmental noise on communities is known by a variety of terms, including noise insulation, noise attenuation, soundproofing, sound insulation, acoustical treatment and sound mitigation. A widely accepted design procedure with improved sound insulation from transportation noise has been in use since the 1970s, which is now largely obsolete, because based on the spectra of older transportation means (older and noisy aircraft, trains and road vehicles types) and does not include sound insulation data for commonly used modern exterior façade construction types.

Acoustic quality inside the buildings is dependent of sound insulation of building façade from airborne sound. Acoustic performances of building façade should be related to the outdoor noise levels and its spectrum, for example, how standardized sound level difference $D_{\mathrm{2m,n}T\mathrm{,w}}$ is dependent from L_{DEN} as it is shown in [1]. The possibility to reduce common measurement time for assessment the annual composite rating level L_{DEN} based on the partially deterministic model for choosing the number of successive measurement days. In this approach only results from selected representative days (or days with normal weather as defined in standard and cars operation conditions) should be used for L_{DEN} assessment. Estimated accuracy of L_{DEN} value assessment was based on uncertainty intervals within a 95% confidence level. The best results for window microphone case were obtained for a representative one-week continuous measurements giving an uncertainty interval for annual L_{DEN} of (-1.7 dB(A);+1.9 dB(A)). When the estimation of annual L_{DEN} was done using only one representative working whole-day, the appropriate uncertainty interval for window microphone was (-2.7 dB(A);+2.4 dB(A)). For comparison an estimation of annual L_{DEN} value from one arbitrarily chosen day during the year (worst scenario) results an interval of (-4.6 dB(A);+3.7 dB(A)).

As stated in standard EN 12354-3 [2] the $D_{2\mathrm{m,n}T}$ values practically are the same in both cases: when outdoor noise and/or the artificial sound source (loudspeaker) is applied. In other words if $D_{2\mathrm{m,n}T}$ is determined applying the loudspeaker, it may be used in formula (3) instead of $D_{\mathrm{tr,2m,n}T\mathrm{,w}}$ when transport noise is applied for façade sound insulation measurements. This substitution is important because quite often façade sound insulation measurements are very complicated due to low deference between the spectral sound pressure levels of environmental noise and background noise inside the sound receiving room. Important to emphasize, that in formula (3) the included component $C_{\mathrm{tr,100\text{-}3150}}$ is derived by standardized transport noise spectrum, presented in related standards. In our task it should be practical in the façade insulation for investigated specific building to consider the spectral properties of sounds events (from outdoor noise sources) that are dominating at the environmental site where the building is erected.

The façade sound insulation properties commonly depend from an environmental noise spectrum and the angle of sound wave incidence on the façade. So practically usage of C_{tr}, obtained with typical spectra from the standard, cannot be justified for all in-situ cases. But 45° angle of noise incidence into the façade (façade location against the noise sources) is uniquefor the artificial sound source (loudspeaker) and included in standard [3], while façade insulation properties must be designed especially taking into account the spectral properties of noise sources character for the site under consideration. So by our suggestion the spectrum adaptation term must correspond to the real spectrum of incident noise and for determination of indoor noise level with formula (3) the noise specific spectrum adaptation term C_{spec}, derived in the frequency range between 100 and 3150 Hz, should be considered instead of standardized spectrum adaptation term $C_{\mathrm{tr,100\text{-}3150}}$.

Long-term outdoor environment noise measurement are provided with noise monitoring technique to register statistically enough number of all significant noise events dominated in outdoor environment under consideration. Synchronized audio recording for further proper noise events recognition and analysis may be used also. Microphone is located on distance 2 m from façade or to be flush-mounted on window surface (correction C_{env} should be used).

Specific spectrum analysis $L_{\mathrm{spec},i}$ (i denotes one-third octave spectrum component) is carrying out for further appropriate spectrum adaptation term C_{spec} calculation to define the spectra of specific noise events (averaged for the setof events), which are determined in accordance with standard A-weighting procedure.

- All the values should be recalculated for distance 2 m from façade surface.

In general case, instead of spectra for specific noise events, an equivalent sound level spectrum for observation time interval may be used if necessary.

Façade sound insulation $D_{2m,nT,w}$ ($D_{2m,nT,i}$) is determined by standardized measurement procedure [3] using artificial (point) or environmental (transport) sound source spectrum.

Reverberation times are measured in octave frequency bands and T^* is assessed as an average value of reverberation times at frequencies 500 Hz, 1000 Hz and 2000 Hz. Specific noise event spectrum adaptation term C_{spec} is determined in frequency range between 100 and 3150 Hz using the formula for spectrum adaptation term calculations:

$$C_{\mathrm{spec},100-3150} = -10\,\lg \sum_{i=1}^{16} 10^{\left(L_{\mathrm{spec},i} - D_{2\mathrm{m,n}T,i}\right)/10} - D_{2\mathrm{m,n}T,\mathrm{w}} \quad . \qquad (1)$$

Note that actually taking into account (1) the indoor equivalent sound level is determined by formula:

$$L_{\mathrm{Aeq,in}} = L_{\mathrm{Aeq,out}} + C_{\mathrm{env}} + 10\,\lg\left[\frac{T^*}{T_0} \sum_{i=1}^{16} 10^{\left(L_{\mathrm{spec},i} - D_{2\mathrm{m,n}T,i}\right)/10}\right] \quad . \qquad (2)$$

It means that indoor noise level for furnished rooms (where reverberation time is about 0.5 s) is practically equal to the outdoor level reduced on the energy averaged value of the difference between spectral components of measured outdoor noise and façade insulation. Note that real indoor noise level comprise of transmitted through façade partition noise, which is produced by outdoor noise events plus noise increment due to reverberant sound field inside dwelling and background noise existing in absence of the noise events. In calculation procedure the influence of the reverberation time is taken into account only, because by excluding the measurements of background noise inside dwelling we avoid a number of problems be treated in main practical situations. But in experimental investigations for comparison with the direct measurements the background noise inside dwelling was taken into account.

The installed on distance 2 m from the façade and flush-mounted on window surface microphones were used for environment noise measurements near façade. Outdoor microphones with preamplifiers were connected to the level meter placed indoors via the slim cable. Window outdoor microphone was flush-mounted in the same manner as it is described in [4]. The rotating table was used to collect the indoor noise data with 100 ms step sampling.

The analysis of outdoor noise spectra show that at site of consideration there were two specific groups of noise events observed with the same significant sound immission on the façade, but with some spectral differences in low frequency range. Obtained appropriate resultant spectra $L_{spec,i}$ for two groups of events and for overall night time interval in comparison with standard transport noise spectrumapplied for spectrum adaptation term $C_{tr,100-3150}$ calculation are presented in Fig. 1.

The values of specific spectrum adaptation term and appropriate indoor equivalent levels may be calculated for considered specific group of noise events. For comparison the calculations were done for both cases, when insulation of façade is measured applying loudspeaker, as well as for noise from outdoor transportation events. The resultant data are presented in Tab. 1.

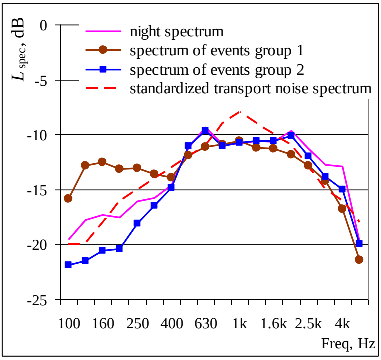

Fig. 1. Specific spectra for calculationof spectrum adaptation term $C_{spec,100\text{-}3150}$vs. standard A-weighted transport noise spectrum

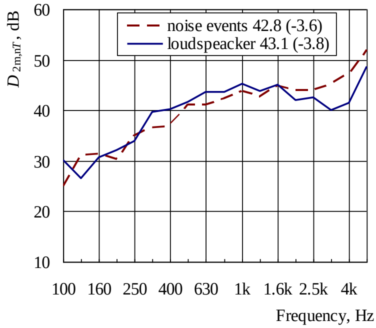

Fig. 2. Spectra with appropriate single number quantities $D_{2m,nT,w}(C_{tr,100\text{-}3150})$ for the sound insulation measurement of the façade by ISO 16826-3 using loudspeaker and real noise events

Table 1. Measured and assessed indoor levels for different group of events

Events group	Measured equivalent level, dBA		$C_{spec,100\text{-}3150}$	Assessed indoor level, dBA	
	Outdoor	Indoor		Using $C_{spec,100\text{-}3150}$	Using $C_{tr,100\text{-}3150}$
1	66.8	33.3	-7.5 (-7.1*)	31.9 (31.9*)	28.4 (28.5*)
2	66.4	27.1	-2.3 (-2.6*)	26.7 (27.2*)	28.0 (28.1*)
Night interval	60.0	23.3	-4.2 (-4.2*)	23.1 (23.3*)	22.8 (22.9*)
* In brackets the results are shown when façade insulation was measured applying outdoor noise					

Results presented in Tab. 1 correspond to outdoor noise levels on distance 2 m from the façade and measured indoor levels without correction for background noise, which was equal to 17.7 dBA during night period. In calculations this background noise was added for comparison with direct measurement results. As follows from Tab. 1 indoor levels calculated by suggested formula (4), when the specific spectrum adaptation term $C_{spec,100\text{-}3150}$was used, show a good conformity with measured indoor values. Usage of the standardized spectrum adaptation term $C_{tr,100\text{-}3150}$, that is equal to -3.8 dB in all the cases (Fig. 2), leads to sufficient scattering in results from measured ones for events comprising low frequency components (group 1 events).

It is shown how indoor noise level may be assessed from the measurements of outdoor noise near building façade together and simultaneouslywith sound insulation of the façade. These measurements proposed to be grounded on standardized procedures from ISO 16283-3, as well as from ISO 1996, and accomplished by using microphone placed on distance 2 m from the building façade, as well as the microphone flush-mounted on the building façade surface (window surface). In the latter case the environmental correction of -3 dB must be introduced in comparison with the noise level data for microphone located at distance 2 m from the façade.

The four step measurement/calculation procedure for dwelling indoor noise assessment is presented. In accordance with it the equivalent level for indoor noise is calculated from the equivalent level of outdoor noise events by its reduction on value equal to energy average of the spectral components difference between outdoor noise and façade insulation. Main effect is reached by introducing the specific spectrum adaptation term instead of standard one, recommended by the standard, defined in frequency range between 100 and 3150 Hz.

Measurement experiments, provided at the site with various environmental noise sources, such as railway transportation, industrial activity and overall town background noise with different spectral components, especially in low frequency range, demonstrated that conception of specific spectrum adaptation term based on appropriate specific environmental noise events spectral properties, allows to assess indoor noise level more adequately to the various environmental noise sources.In result the calculated values for indoor noise in all cases show a good agreement with directly measured ones, while usage of the standard transport noise spectrum, as recommended by current standard, provides the misleading of the result for dominant low frequency noise events.

Current Lithuanian or Ukrainian norms for this façade is fulfilled in all cases for all environmental noise sources in consideration. But for the group 1 noise events the equivalent sound level (produced by all these events) exceeds the recommended by WHO indoor night level of 30 dBA. Note that usage of the standardized transport noise spectrum (last row in the Tab. 1) provides the misleading results, lower than 30 dBA.

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Monitoring as an instrument for aircraft noise nuisance reduction

This is the reason for a number of current concepts, approaches and efforts to reduce aviation noise annoyance, keeping the produced noise levels the same. Permanent or/and temporary noise monitoring to be undertaken usually in their local community on the assumption that aircraft noise will exceed what is considered 'acceptable' or legally permissible.

The aircraft noise is the single or somewhere one of the most important local impact factor arising from airport operations which, unless managed effectively, has the potential to constrain the ability of airports to grow in response to demand and hence limit the social and economic benefits that future growth could bring. Current ICAO and ACARE targets and goals are not only to reduce the noise levels, the novel and more real approach is based on the idea that noise level reduction at receiver point is not a final result for society, but it is just a tool to achieve the real final goal, which is the reduction of the noise effects. By ICAO this effect is defined currently as a reduction of number of people affected by aircraft noise – or simply a number of exposed people by noise over the protection guide value, or predefined number of highly annoyed people.

This is the reason for a number of current concepts, approaches and efforts to reduce aviation noise annoyance, keeping the produced noise levels the same (fig. 1). Despite the implementation of noise-abating measures, first of all by implementing quite aircraft in operation, the number of people in EU exposed to noise levels above 55 dB (from aircraft traffic, which was increased) has increased little bit or even stable, but number of annoyed by this noise people living in vicinity of huge airports has increased unexpectedly dramatically (the more recent studies in airports of Manchester, Paris, Amsterdam, Frankfurt). People are driven to complain when some nuisance factor (or stressor) in the environment gives rise to annoyance and when this stressor reaches a threshold of tolerance. This phenomenon is primarily due to increased traffic, partially due to increased settlement close to traffic routes, but more important – by poor involvement of the population to noise impact management. Crucial evidence that annoyance measured last decade in European airports is much higher dependent from the noise indices, the clear difference equivalent to around 5-6 dBA between the average trend of all of these more recent studies and the much older data, it means that high number of annoyed people observed in acoustic conditions which were considered not so serious decades before.

There is important to differentiate between noise exposure and the resulting noise nuisance in different communities, and manage each appropriately. The protection of the residents is understood as a dynamic process, meaning that the evaluation criteria must be repeatedly tested and - if necessary - adapted to new scientific findings. The only significant determinant of perceived disturbance is the level of noise exposure. Comparing with traditional ICAO balanced approach elements, which are defined by physical effects of sound generation and propagation, an annoyance is a psychological phenomenon (in nature of effect on humans the noise is a psychological phenomenon too!).

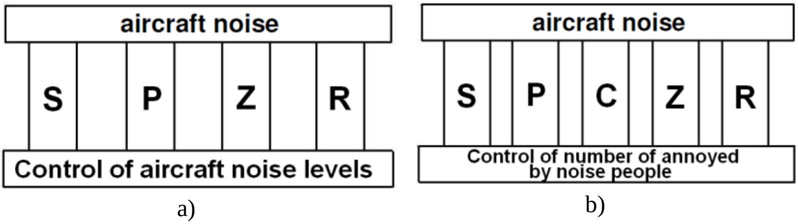

Figure 1. Two approaches for aircraft noise impact management in airports: a) 4-pillar Balanced Approach by ICAO (**S** – in source; **P** – noise abatement procedures; **Z** – noise zoning and land use; **R** – flight restrictions); b) new approach including communication (**C**) with population to control its reaction to noise

To evaluate the effect of the protection measures implemented, a comprehensive set of surveys to evaluate the short- and long-term effects should be undertaken. A number of the previous studies indicate that when changes in noise exposure are achieved by source-related measures (quieter aircraft and/or low noise flight procedures implemented, air traffic reduced, etc.), the responses could be higher than those predicted from the exposure-response relationships established from a more stable condition. In studies where the changes include noise screens or insulation efforts, the change may be smaller than predicted. For example, inside dwellings of the "experimental" group that received the noise reduction intervention, an average equivalent noise reduction of 7 dBA was calculated inside the dwellings. But some of intervention studies show that people are often satisfied with an intervention regardless of the result of the intervention (Hawthorne effect). For example, one study show the positive effect equal to average equivalent noise reduction of 5 dBA from informing a population about simply a noise monitoring program realised carefully around the airport. A review of different theoretical approaches explaining such differences can be found elsewhere.

In best known solutions the process is continuing with public notification and consultation procedures and even being a mechanism for dispute resolution. The type of information collected and the way in which it is analyzed and reported will differ according to the objective of the program of noise control. This objective is expected to be achieved by bringing information closer to the people living in airport surroundings – customizing it to target meaningful and friendliness, in order to optimize the aircraft noise mitigation strategies. For example, there is some previous assumption that shared unattended noise monitoring results can improve airport noise acceptance, as general public can check the compliance with noise limits in their proximity, raising people awareness. The generalized use of the Internet in recent years has allowed improving data accessibility by the general public, but: a) information reported is overly technical, and should be customized for different users' profiles, so that they can understand the information provided; b) commonly used noise prediction indices do not satisfy the general public's expectations, as, on some occasions, they seem to mask the real pollution under mathematical operations. New studies should be implemented to test traditional and novel reporting templates aimed at improving awareness, comprehensibility, and properly matching noise scenarios to people's perception.

The measurements of aircraft noise and the analysis of the results are necessary in order to protect correctly the local community living in the airport surrounding areas. Permanent or/and temporary noise monitoring to be undertaken usually in their local community on the assumption that aircraft noise will exceed what is considered 'acceptable' or legally permissible, and in this connection it is necessary to refer to the legislative controls on aircraft noise. The results show that for airports with low intensity of flights the long term equivalent sound level is heavily changing in relation with the long term maximum sound level, but for high intensity flight traffic this interrelation is quite stable. In the vicinity of airports with low flight intensity the maximum sound level as a noise impact metric is more sensitive than the equivalent level. In general case the purposes of monitoring are described elsewhere as: 1) to assess the current status of the resource to be managed or to help determine the priorities for management, 2) to determine if the desired management strategies were followed and produced the desired consequences, 3) to provide a greater understanding of the system being managed, and 4) to show that population involvement in noise management helps to reach the goals of the noise management program, etc. Although today in most cases the main concern is the negative impact of aircraft noise, the highest goal is to show that measuring and monitoring the aircraft noise can be used for positive purposes. For example to show in routine mode what an aircraft exceeded the permissible level at a point of noise control, to show even why it was exceeded (flight procedure mistake happened or an aircraft type is quite noisy to be operated in particular conditions), any flight safety issues may be raised with monitoring system usage and at the same moment providing confidence to aviation as a whole. A very new challenge should be expected: how to deliver respite from aircraft noise at the airport that is valued by the community, which is consistent with efficient operations?

The number and location of the monitors is important depending upon the specific role they are to play. Quite usual elements of current aircraft noise monitoring systems are the air traffic data connection for flight events detection (correlation with noise events) and the latest point – gathering the complaints from residents living around. A number of technologies is available currently to provide all these necessary functions independently from airports and air traffic providers and in cost-efficient manner, in such way being available for any airport (or community), which is interesting in efficient noise management.

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Considerations to assess accurately the aircraft noise level in rearward arc

The practical experiments are used to improve the accuracy of aircraft noise directivity function, which is of special significance for observer locations behind the start of roll for take-off, or start of landing on runway, or for the taxiway noise.

The maximum noise level from one flight path segment $L_{max,seg}$ can be expressed in general as [1,2]:

$$L_{max,seg} = L_{max}(P,d) + \Delta_I(\varphi) - \Lambda(\beta,\ell) \qquad (1)$$

the correction terms in (1) account for the following effects: $\Delta_I(\varphi)$ - *installation effect,* describes a variation in *lateral directivity* due to shielding, refraction and reflection caused by the airframe, engines and surrounding flow fields; $\Lambda(\beta,\ell)$ - *lateral attenuation,* significant for sound propagating at low angles to the ground, this accounts for the interaction between direct and reflected sound waves (ground effect) and for the effects of atmospheric non-uniformities (primarily caused by the ground) that refract sound waves as they travel towards the observer to the side of the flight path. For jet aircraft on a ground a lobed radiation pattern in the rearward arc (aircraft directivity function) Δ_{SOR} should be used for calculation instead of both specific corrections $\Delta_I(\varphi)$ and $\Lambda(\beta,\ell)$. This pattern is the more pronounced the higher engine thrust (higher the jet velocity) and the lower the aircraft speed. This is of special significance for observer locations behind the start of roll for take-off, or start of landing on runway, where both conditions are fulfilled (Fig. 1). This effect is taken into account by taxiway noise, never mind this noise is less contributing to total noise inside and around airport. Taxiing is an aircraft's movement on the ground before take-off from the parking position to the runway or after landing from the runway to the parking position.

As one can see from Fig. 2, the directivity patterns of noise generation are specific to each engine type. Differences between these specific directivity patterns and the generalized relationship proposed by ICAO or ECAC [1,2] may be as large as 10 dBA in certain directions. The graphic illustration of the directivity shown in Fig.2, is not applied as sound pressure level in a related distance. In general form of the directivity index ***DI***, which is standard in acoustics is a following:

$$DI = L_i - L, \qquad (2)$$

L_i - level in observed direction, L - energetic mean of the level in all directions.

The DI is really aircraft type specific – it is evident from the Fig.3, where the DI are presented from ground noise measurements for maximum thrust and idle modes of the engines in operation. It is also evident for turboprop engines (Fig. 4), never mind the noise radiation from propeller are not so dependent from engine operational mode like it is for turbofans (Fig. 3). Once again turbojets (see the Fig. 5 for combat aircraft) noise directivity patterns are very dependent from aircraft type.

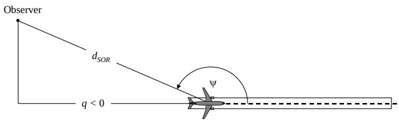


Figure 1. Aircraft-observer geometry at for estimation of directivity correction

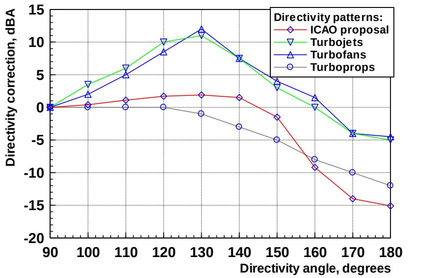
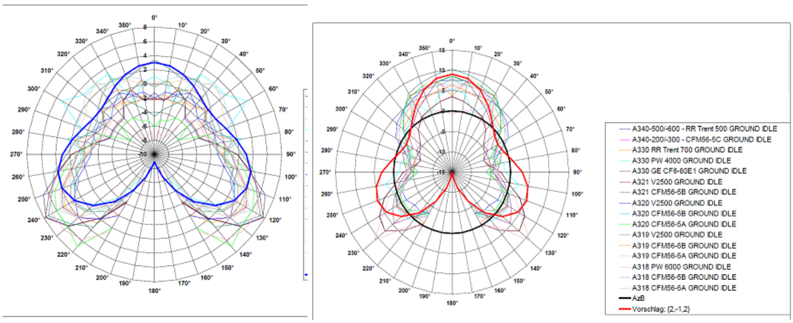


Figure 2. Generalized directivity corrections for characteristic engine types



a) b)

Figure 3. Directivity index of the Airbus family: a) at maximum power on the ground; b) during ground idle

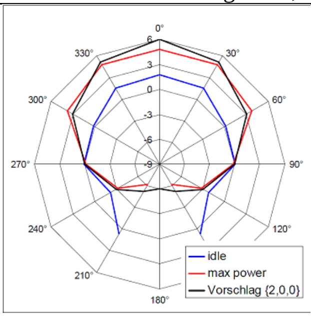


Figure 4. Directivity index for the turboprop aircraft C-130 illustrated for various loads

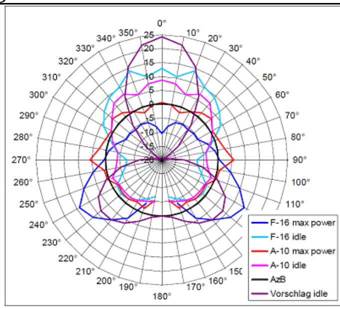


Figure 5. Directivity indices for the combats - specific for jet noise radiation

To improve the accuracy of airport noise calculations it is proposed to provide in model data base few type specific directivity patterns to calculate the aircraft noise, when aircraft is maneuvering on the ground:

depending from engine type in power plant of the aircraft (Jet, Turbofan, Turboprop);

depending from aircraft group – CIVILIAN (General Aviation and/or Commercial) and/or MILITARY;

depending from aircraft weight class: Jumbo Air Carrier, Heavy Air Carrier, Large Air Carrier, Regional Jet, Propeller Aircraft;

depending from the spectral class of the aircraft, which is character for aircraft departure and arrival.

It might be expected that as noise levels from flight operations decrease over time, noise exposure from ground operations will decrease proportionally. It may concern the noise during aircraft taxiing, rolling up along runways, etc. Of course, during take-off the noise from the aircraft is much higher than from any operation on stands, apron and taxiways, but the importance of accuracy to assess the noise levels from any ground operation of the aircraft is of highest priority today. Taxiway noise is remaining a relatively small contributor to airport noise, but two circumstances may provide new vision on its importance.

First, the reductions in flight noise resulting from the introduction of new engine technology are, however, not necessarily reflected in the noise at the low engine thrust settings that are typical of taxiing operations. Furthermore, as traffic grows, and airports approach capacity, the resulting ground congestion will mean that aircraft will be spending more time on the ground in hold short positions and waiting queues. Fuel heavy departing aircraft will be producing more noise as they accelerate to taxiing speed from hold short positions. The overall result is that ground operations may, in fact, become a larger contributor to airport noise, hence, the need to include them in future airport noise estimates required in airport planning studies, master plans, Environmental Assessments (EA) and Environmental Impact Statements (EIS).

Second, the airport (aerodrome) scheme may prioritize the taxiway noise in comparison with aircraft flight, including the noise from the aircraft on runway – during take off and landing, fig. 6.

The calculation methods applied to aircraft noise such as the noises emitted during taxiing, the APU noises or the calculation methods usually applied to systems, and traffic noises in emission protection are not easily adapted. On the other hand, in many cases due to the level of generated noise emissions and the number and duration of engine test runs, it is unacceptable to disregard these in the evaluation of the impact noise has on areas surrounding airports. Therefore, separate investigations are required for a unified determination of noise emissions caused by engine test runs.

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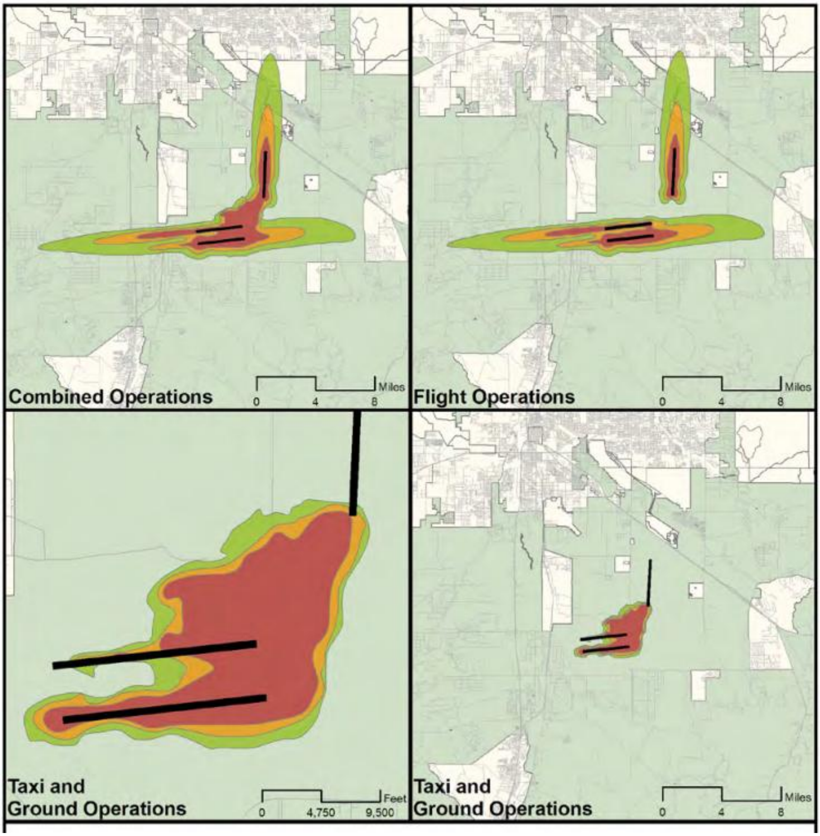

Figure 6. Comparison of noise footprints from ground and flight operations (green – 55 L_{DN}, orange – 60 L_{DN}, red – 65 L_{DN}) [3]

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Wireless communication safety analysis

The features of electromagnetic pollution generated by means of wireless communication have been studied. It has been established that under the conditions of partial screening at premises, poor passing radio waves causes significant increase in radiation intensity. For the purpose of electromagnetic fields attenuation the use of composite metal and polymeric electromagnetic screens with minimal reflectance properties has been proved to be efficient.

Radio signals are part of everyday life that are created by both natural and artificial sources, such as base stations of mobile communication, radar installations, remote controls, medical, electrical and electronic equipment. The level of electromagnetic radiation from the source grows exponentially, popularity of wireless technology and Wi-Fi are also increasing. In Ukraine the impact on public health associated with the effect of electromagnetic radiation (EMR) of ultra high and higher frequency is growing as well.

Despite the considerable attention paid to applied research and development of protecting means from the effects of high radiation for people under the production and living conditions, problems related to this issue are far from the final solution. Ukraine has risen the maximum permissible levels of radiation frequency for base stations by four times (10 $\mu W/cm^2$, corresponding to general European standards) , which will partially reduce the severity of the problem, but will also put forward new tasks associated with redistribution of radiation in space. Most studies on protection of people from the exposure to electromagnetic fields of ultra high and higher frequency (mobile, wireless computer networks, microwave technology for various purposes, radio facilities of civil aviation, etc.) are limited to testing certain areas, buildings, premises and ascertain the specific fact of exceeded or acceptable levels of radiation [1, 2]. Considerable number of work is devoted to the experimental study of the levels of radiation, development of actual distribution diagrams and definition of sanitary protecting zones, zones of building restrictions, etc. [3, 4]. In recent years, a series of experimental and theoretical researches on reducing radiation exposure of workers to ultra high and extremely ultra high frequency by the means of shielding with protective materials of various compositions and configurations has been made [5].

The most common and widely applied methods of protecting workers are reduction of equipment radiating capacity, increase of the distance between the source and employees and reduction of working time in the area of radiation. In modern terms, these methods are of limited use or not efficient at all. Approaches to protect workers from exposure to certain radiation sources (sources group) are significantly different.

Capacity of some power sources can be reduced. This includes UHF equipment that is used in the production and spurious emissions of many electronic devices. This method is used to reduce the impact on personnel operating radio equipment in civil aviation. But virtually all wireless devices (both indoor and mobile base stations) must operate at nominal capacity. This capacity reduction and increase equally result in unstable operation. The limitation of time of exposure to radiation is problematic given that person is exposed during the working day at the workplace, and in many cases further under domestic environment, making recovery time insufficient.

The most acceptable method of reducing the impact of high radiation on workers is their shielding. But there is a problem of losing connection used for industrial purposes or its insufficient quality.

It was established that under the conditions of partial screening areas poor passing radio waves causes significant increase in radiation intensity due to reflection of waves from the internal sources (Table. 1).

Table 1

The levels of energy flux density in different rooms with the same generation of ultra-high frequency radiation

Number	Energy flux density W, $\mu W/cm^2$	
	Background radiation level of external radiation source	Radiation level at switched source
1	0,20	2,3
2	0,19	2,5
3	0,20	4,3
4	0,25	2,8
5	0,22	3,6
6	0,20	7,8
7	0,24	12,5
8	0,20	16,7

Thus, the cell phone radiation significantly increases the lower the level of base station signal.

Our experimental studies have shown that the intensity of radiation of mobile communication devices increases dramatically when the signal from the base stations to reduces to 0,2-0,1 $\mu W/cm^2$. But the real radiators of ultrahigh and superhigh frequencies are very sensitive to mechanical and other influences (even humidity and pollution of surface antenna affect them) that leads to origination of side radiation (spurious emissions).

The importance of taking into account the spurious radiation is conditioned by the fact that current regulations allow the installation of antennas of base stations on the roofs of buildings. In general, it is safe because the building itself is in radiation shadow ("dead zone") relative to the main lobe. But side emission can significantly exceed the electromagnetic fields in the building. The most effective means of reducing their impact is shielding. But there is a problem with the focusing of the reflected radiation in unwanted directions. This imposes certain requirements for protective surfaces: they must ensure overall screening rates, leaving the level of radiation sufficient for industrial needs and have minimal reflection indices. Metal and polymer composite electromagnetic screens with adjustable protective properties are proved to meet the mentioned requirements. Thus, the most efficient method of reducing electromagnetic fields of ultrahigh and superhigh frequencies is shielding external radiation with simultaneous reducing emissions of internal sources. Reduced levels of external radiation of mobile communication cannot exceed 0.2 $\mu W/cm^2$, that will ensure reliable mobile communications without excess radiation levels from cell phones themselves. The metal and polymer composite electromagnetic screens with minimal reflectance properties are efficient for the reduction of electromagnetic background.

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Usage of biotesting methods for rating treatment efficiency of aviation enterprises wastewater polluted with oil products

Necessity of usage of biosorption and aeration to improve efficiency of polluted with oil products wastewater treatment was experimentally proved. Experiment has defined that testing plant organisms were more sensitive in conditions of this experiment. Usage of biotesting techniques has determined that application of biosorptional technology treatment is not connected with environmental risk for hydroecosystems.

One of the most acute problems of our time is problem of environmental pollution by wastes, emissions and wastewater of all kinds of industrial production.

Today scientists pay attention to environmental pollution by oil products [1], because they occupy one of the top places among the most dangerous pollutants in natural waters.

It was found that aviation enterprises are one of the largest sources of pollution of natural water by oil products [2-3].

Usually wastewater at aviation enterprises is treated before discharging into water bodies. Optimal technology for treatment of wastewater contaminated by petroleum products is comprehensive technology, which involves use of biosorption [4-5].

According to investigations the effectiveness of biosorptional technologies for wastewater treatment depends on temperature, pH, and sufficient amount of oxygen in medium [6].

Everything is found in previous studies, while there is no so much works which analyze impact of oil products or treated wastewater by biosorbents on living organisms [7].

Thus, purpose of this work is to study impact of treated wastewater (which was contaminated by petroleum products) on test organisms of different trophic levels using biosorptional technologies.

Experimental method. Investigated objects have included solutions of oil products (mixture of mineral and synthetic motor oils in ratio 1:1) with concentration 113,5 mg/dm^3 (it corresponds to average concentration of oil in waste water of aviation enterprises) with added biosorbents “Ekolan-M” or “Ekonadin” – 100 cm^3 of model solution contains 1 g biosorbent.

Retorts with model solutions were placed in thermostat at a temperature t=25 °C (such temperature is the most favorable for maximum biosorption effect) [8].

Varied parameters of this investigation have included: biosorbent type, aeration medium and duration of treatment.

Biotesting of investigated water samples was carried out on animals – aquatic invertebrates *Daphnia magna* [9], fish *Poecillia reticulata* [10-11] and plant test organisms – duckweed *Lemna minor L*., [9] onion *Allium cepa L*., [12], and lettuce *Lactuca sativa L*. [13].

Results of the experiment. We have found that model samples had highly toxic impact on all investigated plant and animal test organisms. During day of treatment by biosorbents fish mortality rate was at level 33,3-50,0%, mortality of *Daphnia magna* – 100%. Inhibition of growth of lettuce roots *Lactuca sativa L*. was within 49,2-63,6%, inhibition of onion roots *Allium cepa L*. was 49,3-62,4%. Highly toxic effect of model samples was also observed for duckweed *Lemna minor L* after processing by biosorbents only during 1 day. Impact on growth of duckweed was more significant; inhibition of plant growth was observed at level of 50-70,5%.

Treatment by biosorbents "Ekolan-M" and "Ekonadin" during 7 days has decreased toxic impact on fish to 16,7-33,3%, on lettuce *Lactuca sativa L.* – to 33,2-56,4%, onion *Allium cepa L*. to 34,0-54,8%, duckweed *Lemna minor L*. – to 18,2-61,4%.

Fifteen days of treatment led to insufficient toxic influence: on fish within 10,0-16,7%, lettuce *Lactuca sativa L*. – 12,8-33,2%, onion *Allium cepa L*. 10,7-31,8%, duckweed *Lemna minor L*. – 6,8-31,8%. Model samples were toxic only for *Daphnia magna*. It caused by presence of oil film on water surface, which prevented passage of oxygen.

Biotesting methods proved that biosorbents "Ekolan-M" and "Ekonadin" possess better biosorptional properties in conditions of aeration, if to compare with conventional cleaning on 21% and 22,1% respectively. So, reduction of model solution toxicity for lettuce *Lactuca sativa L*. after 15 days of treatment was by 66,4-74% for onion *Allium cepa L*. – by 66,2-78,3%, for duckweed *Lemna minor L*. by 85, 3-86,4%.

Samples of oil-contained water treated by biosorbents were undergone to additional aeration. These water samples have become better environment for fish habitation, growth and development of plant test organisms.

Conclusions

Biotesting methods have demonstrated on plant and animal biotests efficiency of water treatment (polluted by oil products), using biosorbents "Ekolan-M" and "Ekonadin". Performed biosorptional treatment within 15 days has led to significant reduction of highly toxic effect in all investigated test organisms to 47,8-86,4%.

Aeration treatment efficiency of polluted water by oil products was shown. Organisms have shifted to active phase of growth on 15-th day of treatment. In that period toxicity of investigated solutions was reduced for lettuce *Lactuca sativa L*. by 66,4-74%, for duckweed *Lemna minor L*. – by 85,3-86,4%, onion *Allium cepa L.* – by 66,2-78,3%. It can be explained by additional supply of oxygen to microorganisms due to increasing of its solubility, removal of gaseous products of metabolism, and dispersing of oil emulsion in water (it could improve a positive result).

The most sensitive test objects during these studies were plant biotests – duckweed *Lemna minor L*., onion *Allium cepa L*. and lettuce *Lactuca sativa L*. It allowed qualitatively evaluating impact of negative factors on ecosystem components.

Obtained results indicate feasibility of further research to improve the biosorptional purification technology for oil-containing waste water of aviation enterprises.

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Review of European Union road safety policy for monitoring on vehicle collisions and adaptation it for Ukraine

The review of scientific research to be carried out to adapt of European Union strategy on road safety for Ukraine. The strategy of safety on the roads of Netherlands, Sweden, Switzerland, Australia, which are advanced developers conservation strategies on the road and a minimal number of accidents. The experience of these countries was formed in the European Union Strategy «Policy orientations on road safety 2011-2020».

The European Commission initiated an analysis of national road safety strategies in the EU, in follow-up to the Policy orientations on road safety 2011-2020 that has the good planning practices and interesting road safety actions . Based on the progressive and successful approach to road safety developed in the Netherlands (Vision Zero) and Sweden (Towards Zero) - the Safe System approach to road safety adopted in many countries that seeks to achieve harm minimization by structuring the processes involved in the analysis of road safety problems, and by considering a broader and more integrated range of solutions and treatments under four key areas, or pillars, of road safety. Supporting principles of them: a.) preventing death and serious injury to road users; b.) recognizing that road users will make mistakes and that these mistakes should not cost people their lives or to suffer serious injury; c.) that the road and traffic environment should be forgiving of road user error.

Method

The manuscript is a review of scientific research to be carried out to adapt the EU strategy on road safety for Ukraine. We reviewed of the articles that concern the strategy of safety on the roads in Netherlands, Sweden, Switzerland, Australia that are advanced developers principal of safety on the road and has a minimal number of road accidents. The experience of these countries was used in the European Union Strategy «Policy orientations on road safety 2011-2020». The analysis of some subparagraphs of strategy that concerning of monitoring and information systems for safety measures on the roads to prepare appropriate strategies in Ukraine.

Results

The Strategy of the European Union «Policy orientations on road safety 2011-2020» and the Global Plan Decade of Action for Road Safety 2011-2020 of World Health Organization (WHO) were investigated three following sub-strategies and their compliance with road safety Ukraine "Strategies for improving of road safety in Ukraine (2015).

1. “Promote the use of modern technology to increase road safety” that has the following content:

• A number of studies and research activities on Intelligent Transport Systems (ITS) were carried out during the period covered by the 3rd European action programme for road safety (RSAP). ITS have the potential to play a considerable role for the improvement of traffic safety, for example through the adoption of systems to detect incidents and supervise traffic that are able to provide information to road users in real time.

• Within the framework of the implementation of the ITS Action Plan and of the proposed ITS Directive14, the Commission will notably propose technical specifications necessary to exchange data and information between vehicles, between vehicles and infrastructure and between infrastructures .

• The possibility of extending the implementation of Advanced Driver Assistance Systems (ADAS) such as Lane Departure Warning, Anti Collision Warning or Pedestrian Recognition systems by retrofitting them to existing commercial and/or private vehicles should also be further assessed.

To implement these subparagraphs is need to realisation the next steps:

a.) Within the context of the implementation of the ITS Action Plan and of the proposed ITS Directive, the Commission will cooperate with the Member States with a view to: 1. Evaluate the feasibility of retrofitting commercial vehicles and private cars with Advanced Driver Assistance Systems.

b.). Accelerate the deployment of e-Call and examine its extension to other vehicles.

2. Common tools for monitoring and evaluating the efficiency of road safety policies

Improve monitoring through data collection and analysis Under a Council Decision of 1993,, Member States have the obligation to communicate to the Commission data on road accidents resulting in death or injury that occur within their territories with a view to setting up a Community data bank, the CARE database. The quality and comparability of CARE data are overall satisfactory, except for the comparability of data on the injured. The available European road safety data and knowledge have been integrated and made publicly available on the Internet through the European Road Safety Observatory (ERSO). Such an integrated tool is essential for monitoring the application of road safety policies, evaluating their impact and devising new initiatives.

3. Establish and support data systems for on-going monitoring and evaluation to include a number of process and outcome measures, including:

establishing and supporting national and local systems to measure and monitor road traffic deaths, injuries and crashes;

establishing and supporting national and local systems to measure and monitor exposure to road traffic injuries.

Conclusion

Strategy improvement of road safety in Ukraine, which has some points that are required to implement the Council of Europe for its members. The result shows a number of levels of compliance strategies enhance road safety in Ukraine, which is performed partially and belatedly, to road safety standards of the European Union. It should be noted that the implementation of security strategies in the form of activities in Ukraine does not happen as a result in 2014 was 25,820 accidents killed 4420 and injured 31,966 people.

Sections are investigated in this article can be used as new research areas. It should explore more progressive and successful approach to road safety developed in the Netherlands (Vision Zero) and Sweden (Towards Zero) - the Safe System approach to road safety adopted in many countries.

Is need to implementation of necessary measures:

1. Promoting twinnings and other modes of cooperation to increase the safety level Ukraine.

2. Improving data collection and analysis as regards accidents and developing the role of the European Road Safety Observatory.

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Influence of electric field on a soil moisture during biodegradation of hexadecane

There was analyzed a method of biological remediation of n-hexadecane polluted soil by Rhodococcus erythropolis bacteria under the influence of direct electric current. Presence of electric field has ability to affect biodegradation rate both negatively and positively by enhancing bacterial metabolism from one side and by changing dramatically moisture and pH of the soil from the other side.

The important environmental characteristics of soils is their pollution by hydrocarbons, because their presence cause a wide range of adverse effects for soil organisms and ecosystem in general [1]. There are techniques available to treat oil pollution in soils and one of the most promising among them in biological remediation by bacterial species that have necessary enzymatic sets to digest hydrocarbons. In recent times coupled application of electrokinetic remediation, when direct electric current is applied to polluted system, together with biological remediation are becoming more and more popular [2-4]. Such process is named electrokinetic bioremediation. On the other hand, electric current causes changes of other factors like soil moisture and pH, what is not less important for soil ecosystem and could reason some negative effects for soil ecosystems as well and for bioremediation in particular [5].

To solve this challenge it was decided to investigate influence of direct electric current on biodegradation of n-hexadecane polluted soil and to see what differences will occur in soil pH and moisture and to observe how this will influence bioremediation in general. N-hexadecane was chosen as a model hydrocarbon due to its easiness in further quantification and comparability with other scientific results. *Rhodococcus erythropolis B-7012* bacterial strain was used as biological object, because being the compound of Ecolan-M biosorbent [6] that is used to treat oil pollution this species has proven ability to digest a wide range of hydrocarbons, including n-hexadecane.

The experimental setup is illustrated at fig. 1. Firstly, inoculum was prepared from lyophilized culture of *R. erythropolis B-7012.* Sells were cultivated at Petri dishes with meat-peptone agar medium and after 72 hours were washed out by isotonic NaCl solution. Obtained suspension was used as inoculate for Munz [7] medium with 0,2% of n-hexadecane by volume as single carbon source. Flasks with 100 ml of media each were cultivated during 72 hours at room temperature with constant mixing. The liquid Munz medium with grown culture was introduced to the soil after cultivation by thorough mixing.

For further study the peat soil mixed with sand in a ratio of 3:1 was used. The soil was sieved through a sieve of 5 mm and sterilized in oven for 18 hours at 175^{o}C to kill other bacteria and fungi that can consume organic matter and prevent the growth of desired microbial flora.

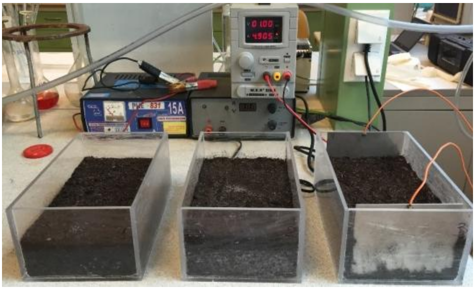

Fig. 1. Experimental setup (from left to right: control box with soil without bacteria; box with bacteria; box with bacteria under influence of electric current)

The soil moisture after sterilization and addition of microbial suspension was brought [8] to 30% (mass by dry soil mass). Initial concentration of cells in soils was $4,8*10^7$ CFU per gram of dry soil. For control box (fig. 1) instead of microbial suspension, sterile water was added. N-hexadecane was added to initial concentration 2% (mass by dry soil mass). Mixture of soil, suspension and hexadecane was thoroughly agitated to receive uniform soil sample. Initial soil pH was adjusted [9] at level 6,7. Soil with microorganisms and hexadecane was layered uniformly into perspex boxes of 24*14*10 cm inner size until 6 cm height (fig. 1.) without pores and capacities inside. Plate rectangular electrodes from stainless steel were immersed directly into the soil and supplied 1 V/cm direct current. Experiment were conducted at room temperature and relative air humidity 34,7.

Samples for investigation were taken by sterile glass tubes from 3 parallel lines along the box at distance 0, 12, 24 cm from anode. For each sampling round samples taken at the same distance from anode from 3 points were thoroughly mixed forming uniform sample for further investigation of such parameters: pH changes, soil moisture changes, CFU concentration and n-hexadecane concentration. Here results received for changes in soil pH and moisture and their influence on viability of *R. erythropolis* cells are further discussed.

As it is generally known, bacterial cells are extremely dependent on pH and soil moisture parameters. Bioremediation can't proceed without active biological agent, thus general hydrocarbon biodegradation rate will be highly influenced by changes in soil pH and moisture induced by electric field.

In the table 1 pH change data are shown. As it seen from the table, after 2 weeks of cultivation pH decreased dramatically in all samples, but the lowest value was received near anode, where pH decreased faster. In the table 2 changes in soil moisture are presented. The content of water in the soil decreased significantly during the experiment in all boxes, including control. At the same time, it is clear that the lowest content of water is observed near anode and cathode, so we can suppose that electric current here promoted faster desiccation. If to compare this results with data on dynamics of bacterial growth, we can see that decrease in concentration of microbial cells was more notable in those samples, where soil moisture and pH decreased faster. Thus, all microbial cells have died near cathode on the 4th day of experiment at pH 6,25 and soil moisture 13,72%, while their growth was still observed in the box that was not exposed to the action of electric field.

Table 1.

Changes in soil pH during biodegradation

	No electric current		Under electric current		
Day	Control (without microorganisms)	With microorganisms	0 cm from anode	12 cm from anode	24 cm from anode
0	6,7	6,7	6,7	6,7	6,7
4	6,7	6,6	6,46	6,51	6,25
8	6,1	5,92	5,9	5,87	5,96
13	6,2	5,9	5,9	5,91	6,01

Table 2.

Changes in soil moisture during biodegradation

	No electric current		Under electric current		
Day	Control (without microorganisms)	With microorganisms	0 cm from anode	12 cm from anode	24 cm from anode
0	30	30	30	30	30
4	15,13	16,63	18,27	17,30	13,72
8	10,49	11,41	10,56	11,16	10,30
13	6,76	8,68	7,57	7,98	7,26

In addition to this, in all samples there was no more bacterial growth on the 8th day of experiment, when pH dropped lower than 6 in all samples, because soil moisture dropped due to evaporation.

Conclusions

As a result of conducted research, it is shown that during electrokinetic bioremediation it is crucial to control pH and soil moisture parameters, because rapid decrease of pH and drying near electrodes lead to death of microorganisms. To prevent such negative effect it is possible to apply buffers to control soil pH, add water in process of bioremediation or to change regularly polarity [10] of electrodes. The latest technology is more suitable, because it does not require use of additional reagents and could be easily automotized.

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Soil environmental control of Rozdil state mining and chemical enterprise "Sirka"

This work has established qualitative and quantitative composition of chemical elements in the soils near to dumpsites of phosphogypsum, tailing pond and place with tars of Rozdil state mining and chemical enterprise "Sirka" territory, using the X-ray fluorescent method. The enterprise is included in a list of the top 100 companies for causing environmental pollution.

Mining has caused a number of negative environmental consequences:
– air pollution with hydrogen sulfide, sulfur, sulfur dust;
– removal from the traditional use of thousands of hectares of lands;
– discharge into rivers mineral waters;
– depletion of drinking water;
– activation of karst processes;
– landslides near settlements;
– flooding, accumulation of wastes and others.

All this led to the formation of negative public opinion about the mining companies. Even more exacerbated this attitude, when the enterprises stopped producing products with reasons of unprofitableness that only deepened environmental problems.

The purpose of this work is environmental control of soil near the dumpsites of phosphogypsum and tailing pond of Rozdil state mining and chemical enterprise "Sirka" territory.

The open development of Rozdil sulfur deposits, storage of overburden, construction of repositories for wastes – all this fundamentally changed the natural conditions of the territory. Were accumulated technological formations: about 60 million tons of sulfur ore tailings; 3,045,400 tons of phosphogypsum; 1.5 million m^3 acid water; 17.195 thousand tons modifier such as "MG", made from neutralized tar residues and residues boiler anhydrite maleic acid; thousands of tons of sulfur sub-standard residues and other chemicals; thousands of hectares of land disturbed by mining works which are not used; ruins of buildings that will never be used for new productions and others.

There is satellite image of zoning Rozdil state mining and chemical enterprise "Sirka" on the fig. 1, where:

1. The factory of the production of ammonia.

2. Place dump hundreds of tons of tars in the building of chemical water treatment in 2002.

3. The factory of the complex fertilizer. Departments of sulfuric, nitric, phosphoric acids. Department of NPK fertilizer.

4. The factory of the complex fertilizers. Current department (former department high-modulus cryolite).

5. The territories of sulphate departments.

6. Industrial Park (is projected).

7. The territory of direct sulfur production.

8. The liquid sulfur composition.

9. The lumpy sulphur composition.

10. The territory, which was washed away dispersed ground sulfur.

11. “Energia – Novyi Rozdil” Ltd, CHP, wastewater treatment of the plant and the city.

12. The territories of auxiliary stations and storage premises for service of Rozdil state mining and chemical enterprise “Sirka”.

13. The territory of the plant of building materials and the old auto base.

14. The territory of mine equipment repair stations, motor transport department, the former small construction companies.

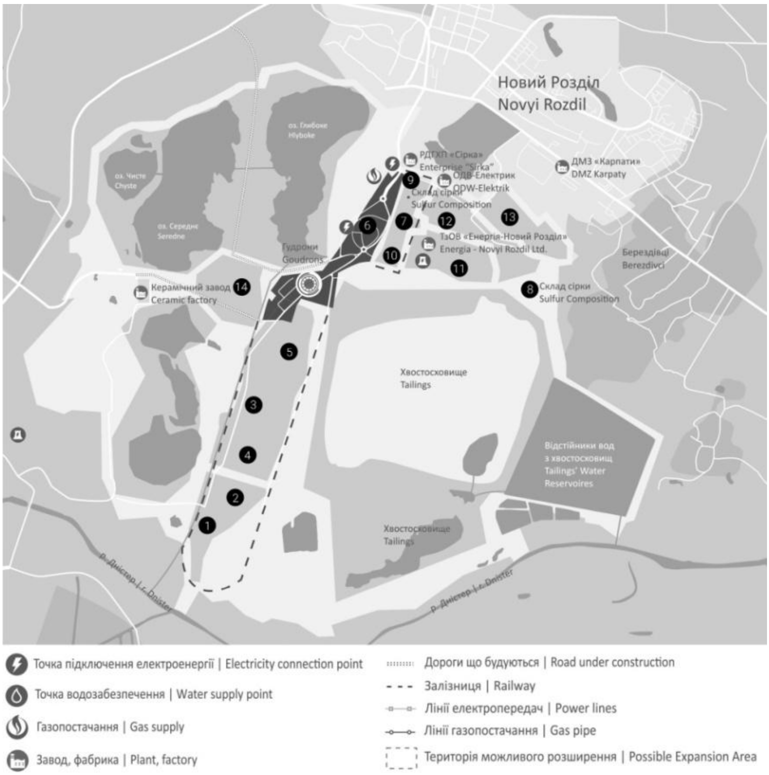

Fig. 1. Satellite image of Rozdil state mining and chemical enterprise “Sirka”

Mining wastes (dumps, the storage ponds, tailings) are often the sources of hydro-chemical changes in the impact zone. Exploitation of these facilities puts practical important tasks such as the term of the areal pollution formation, radius distribution of pollution and concentration distribution in space.

With laboratory methods were established qualitative and quantitative compositions of chemical elements in the soils near of dumpsites of phosphogypsum, tailing pond and place with tars of Rozdil state mining and chemical enterprise “Sirka” territory, using the X-ray fluorescent analyzer.

Large-tonnage wastes of enterprises have a dangerous effect on neighboring soils. In soils are present:

Zink (0.138% – in soil, 0.03% – MPC), Lead, Arsen (0.0006% – in soil, 0.0002% – MPC) – very dangerous heavy metals, which are included in Class 1of dangerous heavy metals (high risk). There are excess of MPC of Zinc near phosphogypsum dump and the excess of Arsene MPC near the tailings.

– Nickel, Copper, Chromium, Manganese (0.477% – in soil near phosphogypsum dump, 0.15% – MPC) – Class 2, moderate risk.

– Iron, Strontium (1.587% – in soil near phosphogypsum dump, 0.1% – MPC) – Class 3, low risk.

– in addition to Silicon, Sulfur, Calcium, Titanium, Yttrium, Cerium, Rubidium, Niobium, Rhodium, Stannum, Vanadium, Aluminium, Potassium and mutagenic element – Magnesium (3.513% in soil).

Fig. 2-3 shows the contents of heavy metals on various lengths and depths. The decrease of heavy metals depends on the distance and depth.

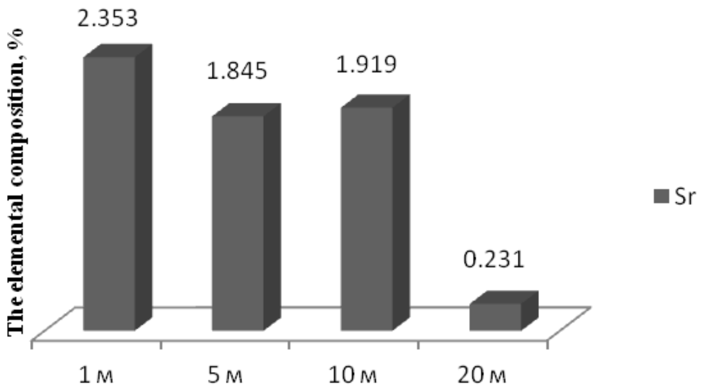

Fig. 2. Distribution Strontium in soil near dump of phosphogypsum depending on the distance

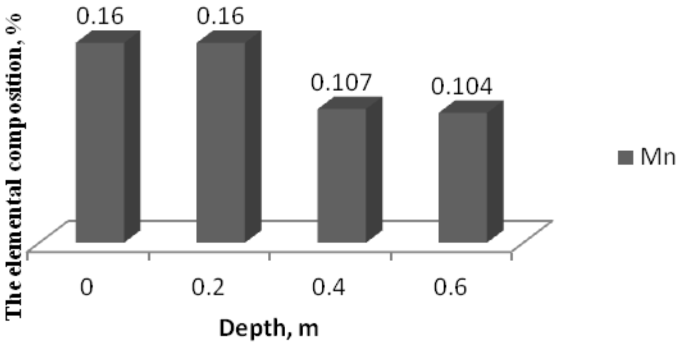

Fig. 3. Distribution of Manganese in depth in the soil near tailing

Phosphogypsum wastes related to the 4 classes of danger. The problem of utilization of phosphogypsum and sulfur needs to be resolved. Phosphogypsum is used to produce sulfuric acid and cement for processing of saline soils, for construction materials. Processing of phosphogypsum to the specified products require considerable expenses for the establishment and operation of relevant industries, but in this case costs are less than the cost for the same products from traditional raw materials, storage and transport of of phosphogypsum. Given the scale of phosphogypsum wastes what are produced, rational use of it is of great economic importance.

Limestone is widely used in many industries. In the steel industry (as a flux), binding materials in industry - for the manufacture of portland cement. Used in the production of soda ash, calcium carbide, fertilizers and more. It is indispensable in sugar refining: limestone clears sugar from beet juice. In the glass industry, it is used to make the glass thermal stability, mechanical strength and resistance against the action of chemicals and weathering. In addition, the limestone is used in the printing industry, as well as the residential, road and industrial construction. By limestone are produced building materials such as bottles, gravel, stone masonry walls, facing and decorative stone, etc.

The main problem of mining enterprises in liquidation, to date, is funding in complete volume recovery of remediation work. So, the correct project of liquidation is not a full guarantee of environmental safety territory of the affected mining activities without the designed sequence of stages, timely response to the unintended change of elements of the environment and emergency situations.

Mining complex area is often of high risk zone and a list of the risk (probability of harm to the national economy, property, human health) information about them, which it carries must be available to the public. To optimize the information exchange system could create a informational and reference system of mining complex.

Conclusions

So, was investigated the harmful ecological effects of large-tonnage industrial wastes on soil of Rozdil state mining and chemical enterprise “Sirka”. Was established that the content of heavy metals in soils decreases with increasing distance from the source and depth of contamination.

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Air pollution at the airports by pm produced by aircraft under the operations

Currently the primary object of airport air quality are the nitrogen oxides and particle matter (PM_{10}, $PM_{2.5}$ and ultrafine PM) emissions from aircraft engine exhausts as initiators of photochemical smog and regional haze, which may further impact on human health. Paper describes the basic methods for calculation of emission and dispersion of PM, produced by aircrafts under the LTO operations.

Today the local air quality (LAQ) deterioration in airports at ground level due to aircraft engine emissions of non-volatile particulate matter (nvPM) is of particular interest to the scientific community and policymakers. There are multiple health effects associated with exposure to PM, including impacts to the respiratory, cardiovascular, and neurological systems [1]. NvPM are the small particles of soot (a.k.a. black carbon) that form as a result of incomplete combustion and aerosols from condensed gases, which really small enough to be inhaled, are referred to as particulate matter [2]. Local communities are less affected by PM emissions from cruise operations. In USA it was estimated about 160 (with a 90 percent confidence interval of 64 to 270 incidences) yearly incidences of PM-related premature mortality due to ambient PM exposure attributable to the aircraft emissions (from 325 airports nationwide, non-aircraft airport sources were also not included) [3]. The resulting PM in the plume can be solid or liquid and include carbon in the form of soot, inorganic salts, and heavy hydrocarbons that condense into aerosol particles. NvPM of various sizes are grouped usually as following: PM_{10} (size diameter <10 μm), $PM_{2.5}$ (<2.5 μm) and ultrafine particles – UFP (size diameter <100 nm). Smaller particles less than 2.5 μm in diameter, which are typical of aviation emission, tend to pose higher risk since they migrate deeper into the lungs and bloodstream causing cardiovascular effects and even affecting the nervous system [1]. Most of the aviation-related PM, that reaches airport communities, are released during ground operations and landing and takeoff of the aircraft (from 50 to 85 % of the total PM inventory in airports). But other emission sources also responsible for PM influence of LAQ of the airports: auxiliary power units; ground service equipment; vehicles; stationary power plants; construction equipment [2,3]. The CAEP/9-WG3 was working to generation data to be used by MDG to calculate the inventory of nvPM emissions from aircraft engines and auxiliary power unit (APU).

The $PM_{2.5}$ regulations are for a 24-hour period and annual mean time periods. The regulations allow only one exceedance of the 24-hour standard (EU Air Quality Framework Directive requires for 50 μg/m^3, USA NAAQS - for 150 μg/m^3) in a calendar year and no exceedance of the annual standard [4].

In Ukraine the air pollution prediction methods are based on solutions of turbulent diffusion equation. In general, the problem of air pollution forecast can be defined mathematically as a solution under certain initial and boundary conditions of the following equation [4]:

$$\frac{\partial q}{\partial t}+\sum_{i=1}^{3}u_i\frac{\partial q}{\partial x_i}=\sum_{i=1}^{3}\frac{\partial}{\partial x_i}k_i\frac{\partial q}{\partial x_i}-\alpha\times q \qquad (1)$$

where t — time; x_i — coordinates; u_i – velocity vector components; k_i — the turbulent diffusion coefficients (i=1, 2, 3); α — coefficient, which takes into account the air pollutant transformation. Wind velocities u_w and coefficients of atmosphere turbulence k_x, k_y, k_z describe the state of the atmosphere (depending on stratification or stability class). The significant material was assembled according to parameters of wind velocities and turbulent diffusion factors depending on atmospheric stability class (meteorological parameters), time of the day, season, and geographical arrangement of the location under the research. It means that the coefficients of atmospheric diffusion (k_x, k_y, k_z) are predefined as initial data for the dispersion calculation in dependence to these meteorological parameters.

Particularly the main calculation expressions of the OND-86 [5] method are based on the analytical solution of the semi-empirical equation for turbulent diffusion in the atmosphere with a vertical wind profile of the form $u_{w0}(z/z_0)^c$. Berlyand [4] found analytical solution of the equation (1) to calculate the maximum PM concentration from point emission source for the case, that the wind speed varies with power law and the coefficient of turbulent diffusion linearly increases:

$$u=u_1\times z^n, \qquad k_z=k_1\times z \qquad (2)$$

So, maximum concentration is calculated in following way for volatile (3) and non-volatile (4) PM [4]:

$$q_m=\frac{0.116\times(1+n)^2\times M}{u_1\times H^{1.5\times(1+n)}}\sqrt{\frac{k_1}{k_o u_1}} \qquad (3)$$

$$q_{\omega m}=\frac{0.063\times(1+n)^2\times M}{u_1\times H^{1.5\times(1+n)}}\sqrt{\frac{k_1}{k_0 u_1}}\frac{(1.5+\omega)^{1.5+\omega}}{\Gamma(1+\omega)e^{\omega}} \qquad (4)$$

where u_1 – wind velocity and k_1 – coefficient of turbulent diffusion at height z_1 both; n – temperature stratification of the atmosphere; M – emission rate; ω – deposition rate; H – height of the emission source.

The maximum value of surface concentration (mg/m^3) produced by emission of point source (round nozzle) under unfavorable meteorological conditions at distance x_M (m) from the source is determined by OND-86 method [5] in following way:

$$q_{mu}=\frac{A\cdot M\cdot F\cdot m\cdot n\cdot\eta}{H^2\sqrt[3]{V_1\cdot\Delta T}} \qquad (5)$$

where: A - coefficient depending on the temperature stratification of the atmosphere; M – emission rate, g/s; F – dimensionless coefficient that takes into account the rate of PM sedimentation in the ambient air; m, n – coefficients depending on output conditions of the exhaust mixture from the emission source; H – the height of the emission source above ground level, m; $\boldsymbol{\eta}$ – dimensionless coefficient that takes into account the effect of the terrain, in the case of flat terrain η

= 1; ΔT – temperature difference between exhaust mixture and ambient air, °C; V_1 – exhaust mixture rate, m^3/s.

Dimensionless coefficient F is determined by deposition rate of the particles. The diameter d_g and appropriate deposition rate ω_g will be determined in a way that the mass of PM with a diameter greater d_g is 5% of the total PM mass [5]:

– F=1, if $\omega_g/U_m \leq 0.015$;

– F=1.5, if $0.015 \leq \omega_g/U_m \leq 0.030$;

– F=2.0 – 3.0, if $\omega_g/U_m > 0.03$,

where U_m–unfavorable wind velocity with taking into the emission purification factor (EPF): if EPF is at least 90%, F = 2; if EPF is in the range 75-90%, F=2.5; F = 2; if EPF is less than 75%, F=3. The deposition rate of particles is calculated according to Stocks law [5]:

$$\omega_g = \frac{10^{-8} \cdot d_g^2 \cdot \rho \cdot g}{18 \cdot \mu} \qquad (6)$$

where: μ-dynamic viscosity of the air, g/cm·s. So in dependence on deposition rate and wind velocity the coefficient F may be determined in wider range of their values (fig.1).

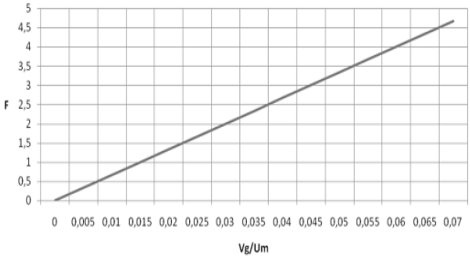

Figure 1. Dependence of dimensionless coefficient F coefficient on v_g/u_m

Analysis of the expressions (6, 7) indicates that the concentration varies inversely proportional to the wind velocity u_1 and directly proportional to the vertical component of the turbulent exchange coefficient k_1/u_1. The impact of the horizontal component of the turbulent exchange coefficient is determined by $k_0=k_v/u$. The distance x_m from emission point source, at which PM concentration will obtain the maximum value, is calculated according to formulas (3, 4) correspondingly for volatile and non-volatile PM [5]:

$$x_m = \frac{2}{3} \frac{u_1 H^{1+n}}{k_1(1+n)^2} \qquad (7)$$

$$x_m = \frac{u_1 H^{1+n}}{k_1(1+n)^2(1.5+\omega)} \qquad (8)$$

It was found, that the maximum concentration of nvPM ($q_{\omega m}$) is higher than volatile one (q_m), while the distance x_m is less. The difference in q_m and x_m values increases for volatile and non-volatile PM with increasing of particle deposition rate.

Concentration of non-volatile PM (q_w, q_{wm}) is related with concentration of volatile PM (q, q_m) by following way at the distance x from emission source with height H [4]:

$$q_\omega = q\chi\left(\frac{\omega}{k_1}, \frac{k_1 x}{u_1}, H\right) \tag{9}$$

$$q_{\omega m} = q_m \chi_m\left(\frac{\omega}{k_1}, H\right) \tag{10}$$

Differences in concentrations of volatile and non-volatile PM are caused mainly by the dimensionless parameter w/k_1. At same value of ω the sedimentation rate of PM will be different depending on the atmospheric turbulence intensity. In strong turbulence, for example, in the case of well-developed convection, the differences in the sedimentation velocity ω are manifested mainly for large x.

The complex model PolEmiCa was used to calculate the distributions of PM fractions for aircraft APU exhausts (height of installation was given H=4,5m like for Tupolev-154), the results are shown in comparison to gas emission (fig. 2, 3) and between themselves (fig. 4, 5).

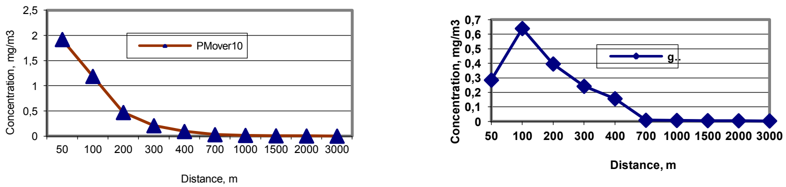

Figure 2. Longitudinal distribution of PM_{10} (a) and gas (b) emitted by APU of Tupolev-154 along wind axis

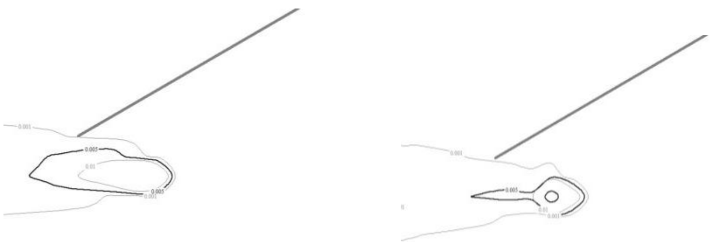

Figure 3. Area distribution of PM_{10} (a) and gas (b) emitted by APU of Tupolev-154 at stand close to runway (shown as direct line) in wind direction

From fig. 2 and 3 there is evident higher concentration for PM close to the source of emission than for gas. Also, it may be concluded that PM polydispersity leads to the separation of maximums concentration in space for individual fractions on the wind direction and therefore it contributes to the reduction of maximum total concentration (fig. 4, 5 in comparison with fig. 2a, 3a correspondingly). The coefficient χ_m for the maximum of surface concentration is substantially *less dependent* on the source height *H* than in the case of monodisperse PM, but it is still somewhat increases with *H*, especially when *h*> 300m [4].

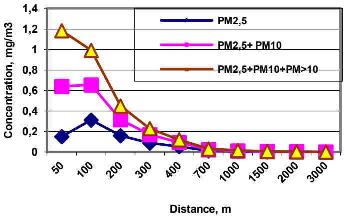

Figure 4. Longitudinal distribution of polydispersed PM ($PM_{2,5}$, PM_{10} and $PM_{>10}$) emitted by APU of Tupolev-154 along wind axis

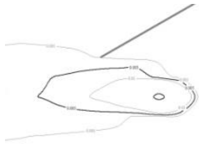

Figure 5. Area distribution of polydispersed PM ($PM_{2,5}$, PM_{10} and $PM_{>10}$) emitted by APU of Tupolev-154 at stand close to runway (shown as direct line) in wind direction

Conclusion.

Analysis of PM emission inventory results at major European and Ukrainian airports highlighted on sufficiently high contribution of aircraft engines and APU. Analysis of numerous studies and experimental investigations allowed to evaluate mass, number and size of PM in exhausts from aircraft engines and APUs during the aircraft LTO operations. The PolEmiCa model is under the improvement, including the modeling of PM dispersion in the atmosphere with taking in mind the investigated production mechanisms and properties of the PM, which are quite different in comparison with gaseous emissions.

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Estimation of efficiency and reliability in the systems of management for industrial safety and health

The article substantiates the conditions of formation the requirements of efficiency and reliability the management of staff in the complex dynamic systems. The study system of industrial health and safety (SISH) in complex dynamic structures of Ukraine includes in itself the two interrelated subsystems - technical and human-machine.

Employees who work in healthy conditions is essential for the company, which operates continuously and efficiently. The economic objectives of the enterprise should not be in conflict with the problems of working conditions, on the contrary, they are complementary. Unfortunately, a recent study of working conditions in the European Union showed that workers' health is not recognized as a factor in productivity. Of course, now there are "classic" threats to health - heavy jobs, work under the influence of weather conditions, etc., but also encountered new problems - the intensification of work, lack of time, increase accountability and improve concentration, and on the other hand, monotony and social isolation. This pressure causes difficulties with health, stress and the syndrome of "burning" which reduces motivation and encourages indifference.

Improving working conditions, including safety and health at work, play a critical role in increasing productivity. European Association of National Centres of performance with its members seek, through information meetings and consultations, to prove the economic importance of both the macro- and micro - conditions for as many government agencies and enterprises. This is necessary not only to employees, but plays a role in an open competition between enterprises and economies.

In Western countries, since the 90s of the last century, dramatically changing approaches to safety. On the one hand organizational factors in security policy are becoming more and more important. On the other hand represent organizations with regard to security has changed dramatically. There tendencies, when evaluating the security emphasis is not on the design features of the hardware, which in itself is very important, and such less tangible and measurable factors such as organizational culture, change in behavior, increased responsibility or commitment of certain goals and objectives. Eventually this led to the development of the West national quality standards that have emerged in a series of international quality standards ISO 9000-1994 and recently - ISO 9000-2000. Due to the fact that in the fight for the reduction of losses and quality included all structural units of the companies, as a result of the quality management system elements have been used in the creation of environmental management (ISO 14000-1996) and further such a system is created and safety management and health. In this regard, the British Standards Institute has developed in collaboration with leading certification bodies in different countries specifications OHSAS 18001: 1999, according to the requirements which it became possible to assess and certification of safety management systems of any organization. Currently OHSAS is one of the regulations on management of industrial safety and health protection for companies around the world. Its advantage is that OHSAS designed to be compatible with ISO 14001 and ISO 9001 [1,2].

The study system of industrial safety and health (SISH) in complex dynamic structures of Ukraine incorporates two interrelated subsystems: the technical synthesized based on a two-tier information-measuring systems and human-machine that performs gathering information about factors forming conditions in the workplace; analysis of data on the level of security; and making decisions on changing conditions in work areas. In addition, the introduction of SISH encourages managers and all units to intensify actions to meet the requirements of hygiene and safety.

The effectiveness of management depends on many factors, their combined allowable or worst characteristic of the type of production, works or professions [3,4]. As for the upper level system should be made that the operation of the SISH reduced to four stages of implementation:

- Information on working conditions;
- Evaluation of information and selection of characteristic features;
- Formation of the control action;
- Making decisions and issuing commands for their implementation.

The criterion of the efficiency of a top-level objective is evaluated and output of information received on the basis of its decisions. The information coming in the system and made a decision must satisfy the requirements:

- Reflect working conditions in controlled facilities;
- To be timely and accurate;
- Form presentation will compare operational data with normative values underlying factors;
- Action taken only on the basis of existing guidance documents;
- The time between taking the initial data and decision-making should be minimal (rate and processing).

The first stage is carried out assessment of information that characterizes the employment rate in the working area. This information is taken from the output device information display systems (detectors, indicators, video terminals). The estimation of aggregate values for each of the defined parameters $(i = 1,2, \dots, n)$ by checking the feasibility of dependencies (1):

$$A\left(t_{np}\right) = A_1\left(t_{np}\right) \Lambda A_2\left(t_{np}\right) \Lambda \dots \Lambda A_n\left(t_{np}\right);$$

$$A_i\left(t_{np}\right) = \begin{cases} 1, W_i \leq W_{i,\partial on} \\ 0, W_i > W_{i,\partial on} \end{cases}; \qquad (1)$$

where, A - technical device status information display systems; W_i - human condition - operator at the time moment; $W_{i,\partial on}$ – acceptable human condition - operator.

The system is recognized as fulfilling its function at time checking if t_{np}, $A_i\left(t_{np}\right) = 1$ and fails - if $A_i\left(t_{np}\right) = 0$.

The second stage is implemented with the appearance of the values of informational factors that go beyond the tolerances established regulatory framework, when $A_i\left(t_{np}\right) = 0$. In this situation, a link of analysis, additional analyzes a data that coming from the lower level, with the possibility of establishing the causes of an abnormal situation on controlled objects (or place bursts of hazardous and harmful factors of the production process or the environment that go beyond tolerance), or exercises check to determine the most probable causes of problems and places SISH. This stage is implemented optimally in the presence of part of the system of automated controls and diagnostic equipment. Depending on the importance of the cause and depth control is tested path of signals, and other functional blocks.

The task of the second stage is performed in sequence: the stage of the flow of information by its collection, presented analytically dependence (2):

$$Q_{q_1,\dots,q_{n-1}}{}^{(n)} = \frac{1}{t_n}\sum_{q_n} P_{q_1,\dots,q_{n-1}(q_n)} \left[\sum_{l} \{P_{q_1,\dots,q_n(l)}\} \log_2\{P_{q_1,\dots,q_n(l)}\} - \sum_{l} \{P_{q_1,\dots,q_{n-1}(l)}\} \log_2\{P_{q_1,\dots,q_{n-1}(l)}\}\right] \quad (2)$$

information is collected and placed according to the expression (3):

$$\{P_{q_1,\dots,q_n(l)}\} = \frac{\{P_{q_1,\dots,q_{n-1}(l)}\} P_{l,q_1,\dots,q_{n-1}(q_n)}}{\sum_l \{P_{q_1,\dots,q_{n-1}(l)}\} P_{l,q_1,\dots,q_{n-1}(q_n)}} \quad (3)$$

based on the information presented formed a conclusion about a place or causes problems (4):

$$\{P_{q_1,\dots,q_n}{}^{(l=l^*)}\} \geq 1 - \Delta\,; \quad (4)$$

where, l - symbol of space and cause of problems;

$n - n\text{-}th$ channel - carrier of diagnostic information, such as an electrical signal;

q_n- index n -th channel information on a standard ($q_n = 0$ - coincidence with the standard, $q_n = 1$opposite result）;

t_n- time of receiving information n-th channel (carrier);

$Q_{q_1,\dots,q_{n-1}}{}^{(n)}$ - the volume of incoming information and comes up with n-th channels (carriers);

$P_{q_1,\dots,q_n(l)}$- the probability of possible prognoses of n-th information;

$P_{l,q_1,\dots,q_{n-1}(q_n)}$- the probability of error-free information on the n-th carrier of the place and the reasons for their occurrence;

Δ - measure the risk of choosing the diagnosis efficiency (e*) with incomplete information.

In the third phase formed the task for the resumption of normal conditions in the facilities. Developed strategy restorative process. This problem is a lot of parametric optimization comes down to choosing j - prevention strategies transactions in which a run relation (5):

$$f_j = f\left(T_{пр}, T_{в}, t_{проф}, t_{расп}, K_{в}, m_v\right) \rightarrow \underset{j}{extr}\,; \quad (5)$$

where, $T_{пр}$ - time the start of maintenance work; $T_{в}$ - time the restoration of normal conditions; $t_{проф}$ - the time of maintenance (predictive); $t_{расп}$ - an acceptable time of restoration work; m_v - the total number of manufacturing procedures for the facility hygiene and safety, requiring better working conditions; $K_в$ - the number of transactions for the remedial work (required) $f_j \rightleftarrows \mathrm{A}(t_{np}) = 1$.

This confirms the fact that SISH progressive with efficiency when it tends to unity $(0 < e^* \leq 1)$ [4]. As shown in the analytical calculations based on the assessment criteria laid efficiency SISH concept. From the above shows that efficiency index(e*) will receive a set of values within acceptable tolerances.

The effectiveness of the system on the basis of the criteria characterizing its reliability. Reliability SISH determined reliability components, the ability to perform parts and devices functionality in the diversity and multiplicity of production of different factors that affect the most complex and dynamic nature of the management, territorial divisions objects hygiene and safety, imperfection of individual devices control, transmission, conversion and display information and so on.

Conclusions

The effectiveness of the system on the basis of the criteria characterizing its reliability. SISH reliability define the reliability components to perform parts and devices functionality in the diversity and multiplicity of factors of production, complicated structure and dynamic process the management, territorial divisions objects hygiene and safety, imperfection of individual control devices, transmission, transformation and information display and etc.

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Assessment of biotic potential of aquatic ecosystems in the influence area of aviation enterprises

Investigation results of water of upper and bottom layers, and bottom sediments of river zone of intense influence of civil aviation enterprises are given. Loss of self-purification ability of aquatic ecosystems was identified. Necessity of means development for biotic regulation of hydro ecosystems under the influence of technogenic influence of aviation industry was determined.

Content of pollutants in bottom sediments (BS) is one of the most objective and reliable indicators of water pollution and general level of anthropogenic impact on it. They accumulate salts of pollutants washed out by surface water, products of wind erosion, heavy compounds formed in the surface atmosphere and solid phase of industrial and domestic waste water [1].

Any changes of anthropogenic load lead to transformation of hydro ecosystem bonds, causing irreversible changes in structure and composition of BS.

On the one hand, it promotes self-cleaning of hydro ecosystems since different ecotoxicants are accumulated, including the set of microelements. On the other hand it is a secondary source of water pollution and is an indicator of the dynamics of anthropogenesis, since BS reflect changes in admission of many micronutrients to aquatic ecosystems. Results of numerous experimental observations indicate possibility of pollutants transition from BS to water during influence of different factors [2].

BS is a kind of "underwater soil" which defines features of water bodies ecology. They play a role of "depots", where accumulation of the most widespread substances takes place (oil, polycyclic aromatic hydrocarbons, pesticides, heavy metals) and specific contaminants (polychlorophenol, polyaromatic compounds, sulfur compounds) [1].

Fine-dispersed alluvial fractions of BS are formed at the bottom of hydro ecosystem. These fractions are especially sensitive environment for accumulation of chemical elements.

According to literature sources distribution and accumulation of contaminants in BS primarily affect their physical and chemical characteristics [1]. Numerous investigations have proved that coefficients of accumulation of some heavy metals and organic compounds in high-BS are much higher than in the water column.

Investigations of upper and bottom water layers and BS of river Nyvka were conducted in the area of influence of civil aviation enterprises. These investigations have indicated MPC household exceeding of Copper content in discharge place and after discharge in upper water layers - in 1,7-24 times, in bottom water layers - in 2, 6-30 times and in all water samples of BS in 7,9-27 times. Lead content in investigated samples exceeds the economical and living standards in discharge place and after discharge in upper water layers in 1,6-1,9 times, in the bottom water layers - in 1.7-1.9 times. It also exceeds fisheries regulations in discharge place and after discharge in upper water layers in 4,8-5,8 times, in the bottom water layers in 5,2-5,8 times. Manganese content exceeds norms in upper water layers in 110-315 times, in bottom water layers in 120-332 times. Manganese content exceeds fishery MPC in upper water layers in 1100-1750 times, in bottom water layers in 1210-3320 times. The largest river pollution by Manganese was detected in place of wastewater discharges. Nickel concentration exceeds fishery MPC in water in 3-9 times. In all investigated water samples Fe content exceeds household and fishery MPCs in upper water layers in 7,6-48 times, in bottom water layers in 12,3-38 times [3].

It was proved that transition of pollutants from BS to the bottom water layers can be conducted by mudding of BS, and by processes of solution and desorption of elements previously accumulated in BS. Dissolved oxygen deficiency, pH, sedimentation of dissolved organic matter and suspended particles, live activity of aquatic organisms, precipitation, groundwater and season of the year are important factors regulating the content of metals in the BS including the reduction of Zn [3].

Actually, BSs are powerful components of biotic regulation of ecosystems and water regulation. They indicate cleaning ability of hydro ecosystems. Self cleaning ability of river (that is under technogenic load of civil aviation enterprises) is critically low. According to results of experimental investigations such river requires development of measures based on phytotechnologies to improve its quality.

In recent years numerous countries of the world have refused traditional methods of wastewater treatment due to their low reliability in work, complexity of operation and high energy demand. Phytotechnological methods of wastewater treatment are based on usage of natural processes of self-purification of water. These methods use higher aquatic vegetation (HAV), aquatic flora and microorganisms. The most popular HAV in technological process are Cane, Lake reed, Typha, Stuckenia pectinata and Potamogeton crispus [4].

Technologies for purification by HAV are key elements in the process of water quality restoration. The root system of HAV has a large surface area and is an excellent substrate for microorganisms. Microorganisms in its turn carry out further destruction of pollutants. In addition, the root secretion contains growth substances, vitamins, carbohydrates and amino acids. All these substances stimulate metabolism of microorganisms, increasing the effect of microbial degradation of oil products, pesticides, synthetic surfactants, heavy metals [4].

The most widespread engineering facilities which are used for treatment and additional treatment of domestic, industrial sewage and polluted runoff include "bioplato." Today, there are more than 2.5 thousands bioplato operating in different countries, including Ukraine.

Besides phytotechnological methods there are other methods of biological wastewater treatment: irrigation fields, fields of filtration, biological filters. Irrigation fields are designed for simultaneous treatment and utilization of wastewater as a source of moisture and nutrients during growing of agricultural crops.

Natural soils, especially in arable lands, are inhabited by various microorganisms that can destroy and nitrify organic compounds in process of nutrition. During the irrigation micro flora of fields receive a large number of microorganisms which get with sewage. These microorganisms quickly reproduce themselves as waste water continuously delivers nutrients, moisture and warm to the soil. Due to this even exhausted soils under the influence of irrigation wastewater are transformed into fertile. During entering the soil, microorganisms reproduce themselves, are adsorbed and form solid structural biological film around each particle. On surface of this film there are organic substances of wastewater.

Two factors are the most important for successful course of biological treatment in the fields of irrigation:

1) compliance with aerobic conditions of process due to oxygen contained in soil pores;

2) conformity of waste water amount supplied to the field and ability of soil for mineralization [4].

Filtration field or aeration field – is a plot of land on which surface sewage and other waste water are distributed for purpose of cleaning; is a kind of water treatment facility.

Method of natural biological treatment is used on the fields of filtration. To create aerobic conditions in soil, pores must get free from water and fill by atmospheric air. With this aim periods between irrigations are used. Sewage water contains suspended and colloidal substances. These substances are trapped and converted to mineral compounds in soil by soil microorganisms and oxygen [4].

Unlike irrigation fields, fields of filtration exclude possibility of growing crops because of the large volumes of waste water passing through them. Biological filter – is a facility where waste water is filtered through loading material which covered with biological film formed by colonies of microorganisms [5].

Biofilter consists of the following parts:

a) Filter loading material (filter body);

b) water distributive body;

c) drainage device;

d) air distributive device .

Oxidation processes in biofilter are similar to processes in other biological treatment plants, and especially in the fields of irrigation and fields of filtration. However, processes in biofilter are much more intensive.

During passing through loaded biofilter, polluted water left there non-dissolved impurities (that are not settled down in primary settling tank) and colloidal and dissolved organic substances, sorbing them by biological film. Biofilm is densely colonized by bacteria which oxidize organic substances. In this case oxidation process is a source of energy for life activity of bacteria. In such manner, organic substances are removed from waste water. At the same time mass of active biological film in biofilter body is increased. Exhausted and “numb” film is washed by flowing water and removed from biofilter body.

Conclusions. Self cleaning ability of aquatic ecosystems (those are under technogenic influence of civil aviation enterprises) is critically low and practically lost. Therefore necessity of means development for biotic regulation of hydro ecosystems to improve mechanism of biotic self-regulation is acute problem.

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Integral environmental evaluation of airports activity's of civil aviation

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In the article investigated the impact of air technology on the environment and presented an environmental assessment of hazard contamination airports civil aviation activities. Characterized factors that are adversely affect the environment. Effects of stationary sources of aviation engineering are base airports. The calculation of loss is presented from engine emissions during operations in the area of the airport.

Statement of the problem. With the rapid development of science and technology is become the term "aviation", which became a symbol of speed transport over long distances and eased the life and work of people. This innovation has raised humanity to the sky and become active path to space exploration. However, success has its negative aspects and achievements – shortcomings. Aviation has brought with it significant environmental problems. Aviation – is not only the aircraft, it is a powerfull infrastructure: airports, providing the necessary conditions for the operation of airlines; aviation enterprises and serving technical structure; state regulators and customs. At the airport we understand the place of departure and arrival of aircraft, but it is much broader concept: multifunctional transport company, which is part of the ground air transport system. The latter provides takeoff and landing aircraft, maintenance, reception and departure of passengers, mail and cargo. Today in Ukraine there are 21 certified airport. Of which: 13–municipal, 2–state and 5 other ownership. To the main airports of Ukraine should include: "Boryspil", "Lviv", "Dnipropetrovsk", "Kharkiv", "Odessa", "Kiev"" which provide about 97% of all traffic. Total passenger turnover airports in Ukraine 2014 is shown in Figure 1.

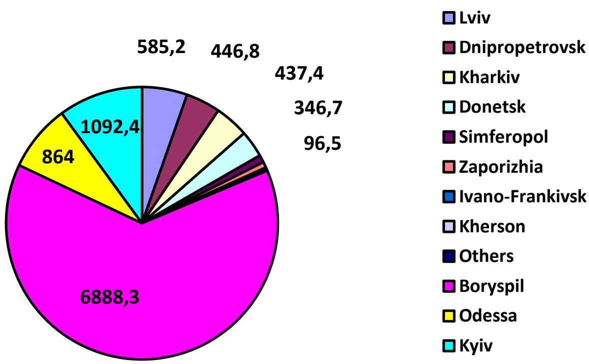

Figure 1. Passenger airports Ukraine for 2014, ths. Passenger [4, p. 1]

As you can see from the figure, the number of passengers is positively characterizes the work of domestic airports. However, taking into account positive factors in the airports are a number of negative aspects, the largest of which is the environmental issue. Indeed, as a result of air transport is pollution of soil, water bodies and atmosphere. Specificity of the impact of air transport on the environment associated with a significant effect of noise and emissions of various pollutants (Figure 2).

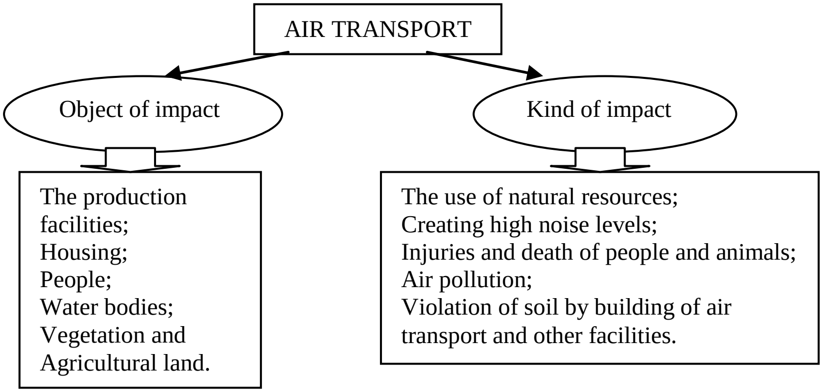

Fig. 2 The impact of air transport on ecosystems [2, p.14]

It is necessary to provide two types of environmental impact of airports on the environment, such as: physical and chemical. To the physical factors it can include sound and air blow noise and to the chemical – emissions of pollutants aircraft engines and their effect on the ozone layer of the atmosphere.

Typically, airports are located near large cities and densely populated areas. The population that lives in the area of the airport, feels more noise from aircraft flying than airport staff, visitors and air travelers. Consequently, the acute urgency is the issue of mutual existence of airport, and city and residential areas.

In addition to aircraft noise causes electromagnetic pollution, causing radar systems and radio navigation equipment airport and aircraft. Radar equipment may create electromagnetic fields of high tension and pose a real threat to people. Effects of electromagnetic waves on living organisms complex and poorly understood. Interacting with organisms electromagnetic waves partly reflected and partly absorbed and distributed them. The degree of influence depends on the energy absorption tissue, the frequency of the waves and the size of biological objects. At constant electromagnetic waves of low intensity appear nervous and cardiovascular system, endocrine and more. Man feels irritation, headaches, weakening of memory and so on. Adaptation to electromagnetic interference does not occur [6, c.46].

Equally important source of influence on the environment are emissions from the engines of air transport. Working aircraft engines has features such as:

- aircraft flying at high altitude and at high speed causing dispersion products of combustion in the upper atmosphere and over large areas, which reduces the environmental hazards in the environment;
- the use of gas turbine engines leads to another character of the processes and structure of exhaust gases;
- the use of kerosene as fuel leads to changes in the components of pollutants.

Active pollutants of the environment is a stationary source of avia technical base of airports. Aircraft also used a significant amount of oxygen. At airports accumulated a large number of solid and liquid waste is safe in terms of sanitary and epidemiological norms, but it happens and so the small part of that is extremely dangerous for the environment. Table 1 shows the emission source and composition of pollutants in manufacturing processes in operational and maintenance areas of airports.

Table 1

Emission sources and composition of pollutants in manufacturing processes in operational and maintenance areas of Airport [6, p.36-38]

Name of area	Manufacturing process	Pollutants emitted
Plot washing rolling stock	Cleaning the exterior surfaces	Dust, alkali, surface active synthetic substances, petroleum dissolved acids, phenols
Zone maintenance station diagnostics	Maintenance	Carbon monoxide, hydrocarbons, nitrogen oxides, oil mist, dust
Electrical department	Grinding, insulating work	Abrasive and asbestos dust, rosin, acid vapor
Rechargeable area	Collection, dismantling and charging operation	Wash solutions, couples acid electrolyte, slag, alkaline aerosols
Department of fuel equipment	Adjustable and repair work on the fuel equipment	Gasoline, kerosene, diesel fuel, acetone, benzene
Welding department	Electric and gas welding	Oxides of manganese oxide, chromium, hydrogen chloride
Reinforcing department	Cutting glass, repair of doors, floors, seats	Dust spray welding, wood and metal shavings
Plot tire and tire repair	Analysis and collection of tires and tire repair cells, balancing work	Mineral and rubber dust, sulfur dioxide, gasoline vapor

Plot refinishing	Removing old paint, degreasing, application of paint	Dust, steam solvents, aerosol paint, contaminated waste water
Parking lots traffic	Moving units of rolling stock	Oxides of carbon, nitrogen, hydrocarbons, ash, sulfur dioxide
The composition of fuels and lubricants	Receiving, storage, fuel delivery	Couples and liquid spills of fuel and oils
Galvanic separation	Putting metal platings	Hydrochloric and sulfuric acid, nickel, copper, sodium hydroxide, chromic anhydride
Boiler	Feed heat	Soot, dust, sulfur dioxide, carbon monoxide, hydrocarbons

Thus, the airport is the source of a significant amount of pollutants emitted into the air, water, into the soil and damage the environment.

The structure of the Civil Aviation is flying vehicles, helicopters, general aviation aircraft, aircraft local lines, mainline aircraft. Last used more than 86% of total fuel used first fuel in the world; for Ukraine this figure is much higher. Statistics show that quantitative emission of pollutants aircraft engines with the volume of fuel used. Thus, the calculation engine emissions impact on the environment can be carried out by the number of reductions for the above class of air vehicles that is the main aircraft [2, p. 15].

Calculation of losses emission engines in operations in the area of the airport is

$$Lea = Leai + Lead \qquad (1)$$

where: *Leai* – damage from emissions during operations in the area of the airport aircraft engaged in international voyages;

Lead – damage from emissions during operations in the area of the airport aircraft engaged in domestic flights.

The results of calculations of losses from the impact of air transport processes on the environment are reduced to the Table. 2.

Table 2

Performance losses from the impact of air transport on the environment processes [2, p.119]

Factors of impact	Emissions, t./year	Losses, ths. UAN	Specific weight, %
Emissions on the flight territory	21819	4890	60,2
Emissions in the area of airport	918	42,6	1,0
Noise		3150	38,8
Total	**22737**	**8124,6**	**100,0**

The biggest losses obtained from the issue during the flight – 4890 thousand UAH with the proportion of 60.2% of total emissions. Losses from the hustle and lot – 3150 thousand UAH or 38.8%.

As a result, we can say that airport of Civil Aviation cause significant damage and harm the environment, and therefore the health of people living in the area of the airport.

Conclusions

Thus, aviation cause considerable damage to the environment, particularly the effects of such exposure form the basis for changing the composition of the atmosphere, damage to the ozone layer, pollution of groundwater and soil in the placement airports.

To improve the environmental safety of civil aviation airports should:

- implement constant and thorough environmental monitoring areas and sources of pollution;
- bring in and update technology to protect the atmosphere, soil, water ingress of harmful substances;
- realise effective methods of air traffic control that dramatically improve the work of Civil Aviation and air transport.

Environmental safety of airports should be kept under constant review and resolve the issue comprehensively. It is proposed to calculate the integral indicator of environmental assessment of Civil Aviation airports.

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Features of climate change on Ukraine: scenarios, consequences and adaptation

This article is devoted to the analysis of the basic features of transformation of a regional climatic regime of Ukraine at 20th-21st centuries and to obtain an estimation of possible regional ecological consequences in Ukraine under influence of future global warming.

The modern global warming of climate in the future can potentially result in considerable changes in geophysical, geochemical and biological systems of Earth, and substantially influences on the ecological and socio-economic condition of life of people in different regions. List of the unfavorable ecological phenomena already presently show up intensively (raising of level of the World ocean, desertification, degradation of arctic and mountain glaciers etc) [3]. Therefore, four questions have specific importance: How the regional climate has changed, what to expect in the future, what consequences can be shown and how to adapt to these changes? These questions were conceptually considered regarding to situation of Ukraine.

1. Features of climate change in Ukraine. The climate of Ukraine has definitely reacted to global warming. The analysis of data of instrumental observations of a network of meteorological stations of Ukraine for last 100-130 years showed that its climatic conditions have reacted to global warming as follow [1,2,9,10]:

- the annual temperature increased by 0.6±0.2 ^{o}C/100 years which approximately coincides with estimations of a level of global warming;
- the effect of alignment of an annual temperature field was revealed: in northern and north-east regions the annual temperature increased by 1.0±0.2 ^{o}C/100 years; in southern and south-west regions − only by 0.5±0.1 ^{o}C/ 100 years;
- decrease of amplitude of a seasonal course of temperature by ~0.4-0.5^{o}C (effect of continentalization): significant warming in the cold period of year (1.0-2.0 ^{o}C/100 years), for spring (1.5-2.0 ^{o}C/100 years; warming was insignificant in summer months;
- insignificant increase of the annual sums of precipitations (5-7% for 100 years);
- the effect of alignment of a climatic field of the annual sums of precipitations was revealed. In northern and north-west regions, where the annual sum of precipitations was relatively high (650-750 mm/year), it decreased approximately by 10-15%; in southern and south-east regions, where the annual sum

of precipitations was relatively low (350-450 mm/year), it increased approximately by 10-15%;

- decrease of the sum of precipitation for some months: spring – May, summer-autumn – August-September;
- increase of repeated anomaly of high temperatures in May for the period 1891-2011 (in XX century – 16.5-17.5 ^{o}C and in XXI – 18.0-18.8 ^{o}C).

2. The regional scenarios of surface temperature change and precipitation in Ukraine for the 2050. Taking into account the established trends features of transformation of the climatic fields of surface temperature change and annual sums of precipitation in the territory of Ukraine for the period of 1900-2000 and possible scenarios of future global climate changes, the scenarios of possible changes climate of Ukraine for the 2050 were developed, namely [1,2,9,10]:

- Scenarios 1: it is likely than not to exceed ($\Delta T \sim 1.4 \pm 0.2$ ^{o}C);
- Scenarios 2: It is likely to exceed ($\Delta T \sim 2.4 \pm 0.3$ ^{o}C).

Taking into account global and regional features of climate change the following are offered scenarios of precipitation change in Ukraine for the 2050:

- Scenarios 1: increase of the annual sums of precipitations on 10±5% and aridity of climate in the warm period of year (May and August).
- Scenarios 2: differential territory distribution of annual sums of precipitations, namely increase in northern, northwest and northeast regions on 15±5 % and decrease in southern, southeast and southwest regions on 15± 5 %.

3. The basic ecological consequences from the change of climate on territory of Ukraine. The main potential adverse effects of climate change for Ukraine include:

- increase of level of World Ocean and levels of the Black and Azov seas;
- intensification of meridional circulation an atmosphere which will result in increase of repeatability of some anomaly synoptic formations (extreme weather events) above Ukraine;
- activization of catastrophic shifts and deformations in mountain regions of Carpathians mountains and Crimea through changes of a regime of humidity, water balance, ground and subsoil waters;
- increase of repeatability of catastrophic floods in region of the Ukrainian Carpathians mountains caused by an intensification of heavy rains and intensified by wood cutting;
- frequent downpours and flooding can cause a deterioration of potable water quality entailing increased infectious diseases rarely reported in Ukraine;
- structural drift and degradation of steppe phytosystems in Ukraine;
- sudden warming can cause drying entailing frequent fires;
- possibility of development of desertification process of southern and southeast regions of Ukraine.
- aspects of water resources: decreasing the total volume, the worsening of quality, the exhaustion of riverside ecosystems.

The some ecological consequences more in detail we will consider.

3.1. The modern spatiotemporal transformation of Ukrainian steppe phytosystem structure under the influence of climate. One of the sensitive indicators environmental changes is the steppe ecosystem. As a result of the monitoring and subsequent data analysis of the main typological varieties of Ukrainian steppes during the period of 1967-2012, the increasing spatiotemporal transformation in the ratio of xeromorphic, mesomorphic and ligneous component structures of steppe was revealed. For Ukrainian steppes in the second half of XX century – beginning of XXI century there is an established trend towards the decrease of xeromorphic component by 30±10% along with increase of mesomorphic component by 10±5% and ligneous component by 20±10 % [7,8].

The most probable warming level on the territory of Ukraine by the end of the first half of XXI century would be 1,25±0,25^{o}C. It means that in Ukrainian steppes we can expect full degradation of xeromorphic component along with ubiquitous advance of meadow on steppe and intensification of forests – steppe displacement processes [1].

3.2. The reaction of level of the Black sea and Sea of Azov on influence global warming. One of the main consequences of global warming is the increase of level of World Ocean and levels of seas that are connected with Ocean. The level of the World Ocean has risen on 12-18 cm for last 100-150 years [3].

The modern century course of a level of the Black sea (a) and Sea of Azov (b) increase of a level on 12-15 sm/100 years and scenarios for period 2050 - increase of a level of sea til 25-30 sm for $\Delta T \sim 2\ ^{o}C$ - is shown [10].

3.3. The effect of excitation of catastrophic events in territory Ukraine. On the basis of the analysis of historical records and manuscripts repeatability of the following catastrophic processes and phenomena in territory of Europe in last millennium is considered: droughts, rainy summers, high waters, cold winters, late spring, a cold in the beginning of a summer, catastrophic storms and thunder-storms etc. The rating of intensity of catastrophic climatic-ecological phenomena in Ukraine was always higher when the global temperature deviated more strongly in this or that side from some optimum level, than the index of climatic anomaly was higher [1]. The modern global warming on 0,5-0,6 ^{o}C became reason the increase of repeatability of the catastrophic phenomena in Ukraine almost in ~2 times, and at a further warming of climate of repeatability of the catastrophic phenomena can will higher till 2-5 times in comparison with pre-industrial epoch.

3.5. Aspects of water resources. The 2015 was selected as indicator of trend. The general hydrological situation in the basins of Ukrainian rivers was rather dangerous due to smallest volume of water in the reservoirs over all period of their exploitation in 2015 year. Such situation occurs due complicated climate conditions and increased water consumption. The intensive water pollution by waste water from industrial enterprises and municipal companies, wastewater from animal farms, surface run of snow melting and rain waters contaminated pollutants from the agricultural and urban areas, exploitation of water transport makes the situation in Ukraine even more complicated [4;5]. State of most as small as large rivers of Ukraine continues steadily to deteriorate. To some extent climate conditions may result in reduction of water volume in water bodies due to increased evaporation caused by elevation of surface temperature and precipitation reduction [5]. Regulation of most of rivers reached or even exceeds the upper economic and environmentally sound water-allowable limit up to the point of environmental destruction (above 75% of total length of channels at optimum 25-30%) dramatically reduced and often totally destroyed river self-purification capacity [10].

4. How to adapt to climate changes: pilot ideas in respect of water aspects as critical and manageable. Increased irreversible losses of water and reduced water volume of watercourses with a gradual temperature increase and rainfall decrease is observed in Ukraine. The answer to this challenge should be a change in attitude to water: maximum economy, adequate pricing, termination of pollution, groundwater use, maximum treatment and swivel water use, recovery of natural rivers, lakes, flood plains, deltas, coastal zones, swamps and wetlands, reduced surface area of reservoirs.

Accordingly, the adequate revision of the Water Code, and national strategies in water management, education of water users and sustainable water consumption. Ratification of the Protocol on Strategic Environmental Assessment introduced the new legal instrument to be applied *inter alia* to the water management schemes and plans. The necessary revision of the draft law on Environmental Impact Assessment, its expert discussion and approval by the Verkhovna Rada of Ukraine currently shall be accelerated in Ukraine to full extent address to water saving issue in each investment project.

Summary and Conclusions.

The characteristics of a present global warming and reaction of climatic conditions of Ukraine on global warming are considered. The analysis of the basic ecological consequences of global warming, which already are, or can being on Ukraine is carried out:

- increase of level of World Ocean and levels of the Black and Azov seas;
- activization of catastrophic shifts and deformations in mountain regions of Carpathians mountains and Crimea through changes of a regime of humidity, water balance, ground and subsoil waters;
- increase of repeatability of catastrophic floods in region of the Ukrainian Carpathians mountains caused by an intensification of heavy rains and intensified by wood cutting;
- frequent downpours and flooding can cause a deterioration of potable water quality entailing increased infectious diseases rarely reported in Ukraine;
- structural drift and degradation of steppe phytosystems in Ukraine;
- sudden warming can cause drying entailing frequent fires;
- possibility of development of desertification process of southern and southeast regions of Ukraine.
- aspects of water resources: decreasing the total volume, the worsening of quality, the exhaustion of riverside ecosystems.

So, the most vulnerable to climate changes in territory of Ukraine are the coastal regions of the Black Sea and the Sea of Azov, the Carpathians and mountains of Crimea and steppe.

As new legal instrument the updated Water Code of Ukraine lined up to European water legislation and the Protocol on Strategic Environmental Assessment shall be applied widely. Further development of Ukraine as a strong democratic state is impossible without strict and obligate compliance with environmental legislation as a way on which depends experience, craft, environmental knowledge and level of sustainable development of state and society in future.

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Ion-exchange extraction nitrates from water

In work efficiency of extraction from water of nitrates using ion-exchange methods is defined. It is established efficiency highly - and the low-main anionit which were applied to extraction nitrates from water. Methods of effective regeneration of anionit with receiving the products normal for further use are developed.

Pollution of the water is very important environmental problem, now it gains the increasing value. In industrial regions people consume water with higher level of salts. As a result of anthropogenous influence a large amount of water resourses has the high level of a mineralization, the most negative influence is come by the shallow rivers [1, 2]. One of quite serious problems requiring the immediate solution is water pollution by nitrates owing to both anthropogenous, and natural factors [3, 4]. Because of nitrates being widely used as mineral fertilizers in agriculture, the enterprises for production of nitrogen fertilizers is one of the largest polluters. A large amount of nitrates gets to water when people are dumping the purified household sewage. Nitrates increase the problem of water supplying of the population with normal water as a result of excess of admissible level. Also high concentration of these pollutants lead to considerable negative impact on superficial waters as they lead to strengthening of an evtrofikation of reservoirs, causes violation of developments of the existing biocenoses and changes in parameters of an ecosystem.

The methods of water purification existing for today have a number of shortcomings. Particularly, it should be noted that biological destroying of nitrates passes rather slowly, besides this method has restrictions in application for drinking water as there is a bacterial pollution of water. At electrochemical restoration of nitrates [5] there is their destroying with forming of toxic substances - nitrites and ammonia, besides this method is rather energy-intensive. An obstacle for widespread introduction of baromembranny methods are high requirements to preliminary preparation of water and a suspense of conditions of effective processing of concentrates, which at the same time are formed. Therefore there is a perspective method of water purification from nitrates as an ionic exchange as it is rather easy and cheap way where conditions of preliminary preparation of water are severed [6]. But there still is an unresolved question of effective regeneration of ionites and processing of elyuat.

Work purpose. Studying of processes of water purification from nitrates on highly – and the low-main anionita, and also definition of conditions of their effective regeneration and ways of utilization of the fulfilled regeneration solutions as a part of fertilizers.

Presentation of basic material. The process of water purification from nitrates studied using highly basic anionite AV-17-8 in Cl^- and SO_4^{2-} forms and low core anionite DOWEX Marathon WBA in Cl^- form. As environment was used modeling grout. The grout was passed through anion volume 10 cm^3, while water consumption was – 10–15 cm^3/min (Filtering speed – 2,12–3,18 m/h).

While conducting tests on selected regeneration 10 cm^3. Consumption regeneration solution is 1–2 cm^3/min. (Filtering speed – 0,2–0,4 m/h).

The full dynamic exchange capacity (FDEC) resin was determined by the formula (1), based on the mass of ions adsorbed on anion:

$$FDEC = \frac{\Sigma (C_{primary} - C_i) \cdot V_n}{V_i} \tag{1}$$

where $C_{primary.}$ – primal concentration of ions in grout, mg-eq/dm^3, $C_{i.}$ – the concentration of ions in (i-тий) test after sorption, mg-eq/dm^3, ($V_{п)}$ – volume of test, cm^3, ($V_{i)}$ – the volume of ion exchanger, cm^3.

The degree of ion exchanger regeneration after passing n samples regeneration grout was calculated using the formula (2) as a ratio of desorbed and adsorbed ions:

$$Z_n = \frac{\sum_{i=1}^{n} M_{i.}^{d.}}{M_{a.}} \cdot 100\% \tag{2}$$

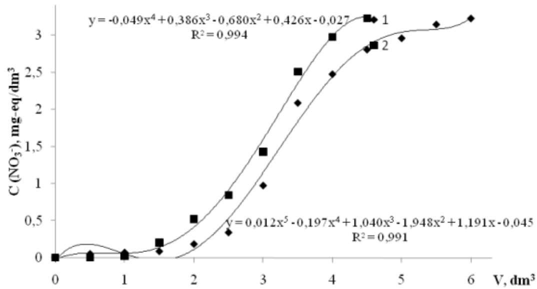
where ($M_{i.}^{d.}$) – the amount of adsorbed ions with (i) test of regeneration grout, mg-eq/dm^3; $M_{a.}$ The amount of adsorbed ions, mg-eq/dm^3.

The concentration of nitrates in the wastewater can be at the level 1 mg-eq/dm^3. But with such a low concentration of nitrates in water is difficult to determine the exchange of capacity ion exchanger as the duration of the experiments significantly increased in transmission of large amounts of water. Therefore, in the model grout containing nitrates were used 2,7–38,7 mg-eq/dm^3, sorption results presented in pictures 1–3.

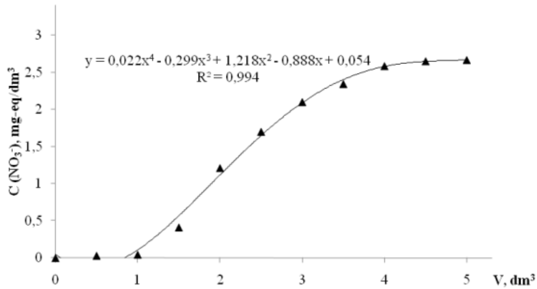
If you use low primary anionite Dowex Maraton WBA in Cl^- form for sorption of nitrate concentration 3,2 mg-eq/dm^3 was determined that FDEC is 1,014 g-eq/dm^3, which is quite an arbitrary measure (pic.1).

As shown in picture 2, the concentration of nitrates 3,2 mg-eq/dm^3 anion AV-17-8 in Cl^- form a dynamic exchange had full capacity at level 1,027 g-eq/dm^3, and in SO_4^{2-} form 0,992 g-eq/dm^3. This can be explained by higher selectivity ion exchanger sulfate, compared with chlorides.

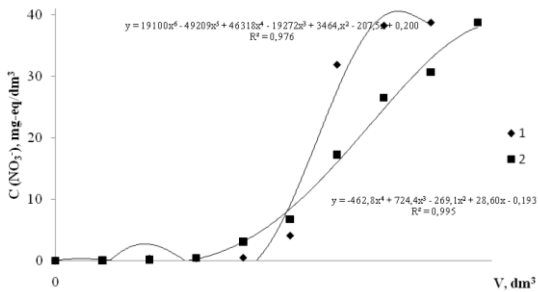
If you use saturated solutions of concentration $NaNO_3$ 38,7 mg-eq/dm^3 full exchange capacity for highly dynamic core anionite reached 2,048 g-eq/dm^3, for low primary – 1,733 g-eq/dm^3. The difference in values of FDEC more significant than using data for anion sorption from dilute grout In these conditions, high capacity anion exchange in the sorption of nitrate due to concentrated grout of equivalent sorption. This phenomenon has a significant importance, as is the real prospect of using nitrate anion exchangers for sorption from dilute grout. This important achievement of working capacity resins nitrate at level 0,8–0,9 g-eq/dm^3 can be entirely satisfactory outcome.



Picture 1 - Initial curves of sorption of nitrate to ion exchangers AV-17-8 (1) and Dowex Maraton WBA (2) (V_i=10 cм^3) in Cl^- in the form of filtration grout $NaNO_3$ with concentration 3,2 mg-eq/dm^3



Picture 2 - Dependence on sorption of nitrate anion AV-17-8 in SO_4^{2-} form at filtering grout $NaNO_3$ with concentration 2,7 mg-eq/dm^3 with the volume of ion exchanger 10 cm^3



Picture 3 - Initial curves of sorption of nitrate to ion exchangers AV-17-8 (1) and Dowex Maraton WBA (2) (V_i=10 cm^3) in Cl^- in the form of filtration grout $NaNO_3$ with concentration 38,7 mg-eq/dm^3

However, relatively effective removal of nitrates from water to ensure complete anion does not solve the problem selection nitrates from water to obtain useful products.

In conducting regenerations anionite AV-17-8 using the chloride and ammonium sulfate, chloride and calcium carbonate. The choice of these reagents explained by the process of regeneration produced ammonium nitrate or potassium fertilizers which have and which can easily be used. If you use sulphate regeneration it is quite inefficient. The best results are received after using chlorides, and the regeneration efficiency increased with increasing concentration of regenerative solutions. But an excess of chloride in the regeneration grout complicates the use of grout such as fertilizer.

Functional groups low basic anionite Dowex Maraton WBA at pH >10 moving in dissociated form, that is why anions are easily adsorbed. This may explain high degree of regeneration anionite using solutions of potassium carbonate, ammonia and ammonium chloride. The most effective regenerative grout was ammonia: when its concentration 1,5 g-eq/dm^3 the degree of regeneration at $q_п$=5 sm^3/sm^3 was 90 %, and at $q_п$=10 sm^3/sm^3 – 97 %. One of the ways of regeneration recycling grout is electrochemical recycling, which allows to separate the excess ammonia or ammonia grout and get grout of nitric acid. But the process has a significant disadvantage because of low core absorbs nitrate anion is not in the main form due (pidluzhnennya) grout. Therefore to solve this problem and ensure effective sorption of nitrate anion solution to be processed with hydrochloric acid to transfer it in Cl^- form.

Conclusion

So as a result of research on nitrate removal from water shown that highly basic anion AV-17-8 and low basic anion Dowex Maraton WBA provide the degree of removal of nitrates at level of 90 %. Found that high efficiency sorption main anionite higher chloride form than in sulfate form, and low basic anion better absorbs nitrates in chloride form, the main form of nitrate adsorption doesn’t occure. In conducting regenerations it was determined that high efficiency regeneration main anionite AV-17-8 using higher chloride grout and increases with increasing concentrations of regeneration grouts. The efficiency of regeneration of low basic anionite Dowex Maraton WBA suits while using basic grouts – potassium carbonate and ammonia.

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Purification of mineralized water

The work shows the results of ion exchange separation sulfates and nitrates, chlorides and nitrates and chlorides and sulphates on high-basic anionite AV-17-8.

Pollution of the water is a very important environmentally problem becoming increasingly important at the moment. In the industrial regions population use water with the high level of salt. As a result of human impacts a significant quantity of reservoirs has a high level of mineralization, the most negative impact expose shallow rivers. One of the very serious problems that require immediate solution is water pollution with nitrates as a result of anthropogenic and natural factors. Factories producing nitrogen fertilizers are one of the biggest polluters, because nitrates are widely used as mineral fertilizers in agriculture. A large amount of nitrates gets into the reservoirs during the discharge of treated municipal waste water. Nitrates aggravate the problem of water supply of population due to exceeding the permissible level. Also, high concentrations of these pollutants result in significant negative effects on surface water, because they lead to increasing eutrophication of reservoirs , which causes the violation processes of development of existing biocenoses and changing the parameters of environment.

At the end of XX century humanity was faced with the global environmental crisis. It was a general degradation of the environment. Under the influence of human activities has been changed every component of the biosphere: atmosphere, hydrosphere and lithosphere. Improving the various spheres of human activity requires the involvement of more natural resources for production processes.

In every industry we use water in different volumes. The most water-intensive industries are pulp and paper industry, mining and extractive industry and agriculture. As a result of production, produced large amount of wastewater. These waters generally characterized by high levels of rigidity, elevated concentrations of chlorides, sulfates and nitrates. Discharging of this water to surface reservoirs increases the level of its mineralization.

It should be noted that the problem of protecting water from pollution with highly mineralized effluents more difficult than the problem of obtaining demineralized water. In this case, when we apply methods of desalination we know there are available fresh high-quality water, but as a result, it produces large amount of concentrated salt solutions. Recycling of these solutions is a complex problem and disposal of such waste leads to further environmental degradation. So the problem of protection of surface water objects can only be solved with application of complex technologies for sewage treatment, providing further processing of concentrated salt solutions obtained in order to obtain useful products.

At this time widely considered the removal from water sulfates using reagent method [2], chlorides and sulphates – ion exchange [3] or reverse osmosis, and chlorides and sulphates – electrodialysis [4]. The presence of nitrates in wastewater complicates the situation.

The purpose of this work was to study the processes of purification of sulphates, chlorides and nitrates by their division into high-basic anionites , which allows processing regenerative solutions into useful products.

The processes of ion exchange separation was performed using a highly basic anionite AV-17-8. During the division of sulphates and nitrates anionite was used in NO_3^- form, chlorides and sulfates and nitrates and chlorides – in CI^- form. The full exchange dynamic capacity (FEDC), exchange dynamic capacity (EDC) and the degree of regeneration of resin was calculated by known methods [5].

It is known that in natural waters, the concentration of nitrates reaches 50–200 mg/dm^3 in some cases, in concentrates baromembrane separation of water their concentration reaches 1000 or more mg/dm^3.The content of sulfate in mine water reaches 400–2000 mg/dm^3, and the concentration of chloride can be up to 1000 mg/dm^3.

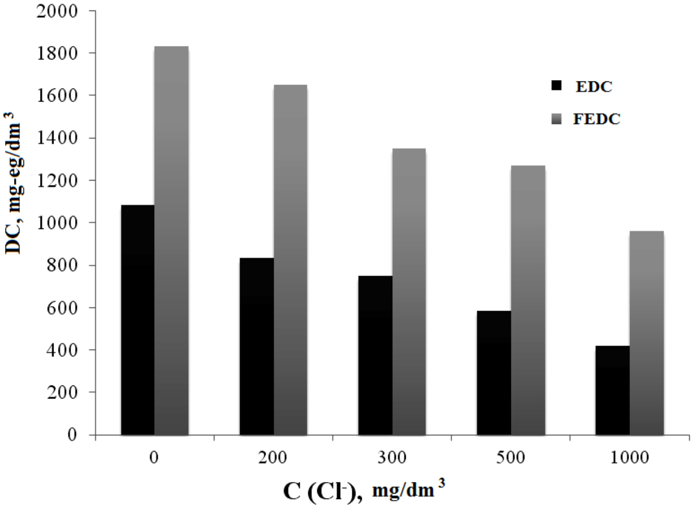
Where the mine water containing chlorides, sulphates and nitrates it is necessary to develop methods of splitting data of anion for efficient processing regenerating solutions in products suitable for further use. Therefore, were carried studies of efficiency of separation processes sulfates and chlorides. As shown in Picture 1, the efficiency of separation of chloride and sulfate anionites on the AV-17-8 in CI^- form depends on the initial concentration of chlorides and sulfates. The efficiency of the separation process during the sorption decreases with increasing concentration as chlorides and sulfates. In this case, the increasing concentrations of sulfate reduces exchange dynamic capacity of the resin to slippage and significantly increases the full exchange dynamic capacity.

For regeneration anionite while transferring it into a CI^- form – used 10 % solution of sodium chloride. Sulphate comprising regenerating solution was treated with calcium chloride, which allows to remove sulfates as gypsum and re-use regenerative solutions.

Thus we get the solutions containing chlorides and nitrates, because sulphates can be separated as gypsum. Therefore, the second stage of our work was to study the effectiveness of nitrate removal and impact of chloride ions on the process. In this case it is important to measure exchange capacity of the resin on nitrates to slippage. This figure is chosen basing on the maximum permissible value of concentration of nitrates in the water – 40 mg/dm^3.

The effect of reducing nitrate exchange capacity with increasing chloride content decreases with increasing concentration of nitrates. EDC to slippage decreased with increasing concentrations as nitrates and chlorides. Thus, the nitrate concentration of 500 mg/dm^3 FEDC on NO_3^- is reduced from 1703 to 735 mg-eq/dm^3 EDC from 1008 to 403 mg-eq/dm^3 at higher chloride content of 0 to 1000 mg/dm^3. For nitrate concentration of 1000 mg/dm^3 FEDC by changing the content of chlorides in the same range reduces from 1700 to 1152 mg-eq/dm^3 EDC from 1129 to 480 mg-eq/dm^3; and at 1500 mg/dm^3 – PODYE reduces from 1,680 to 1,408 mg-eq/dm^3 and EDC of 720 to 345 mg-eq/dm^3. If you apply resin in Cl^- form for its regeneration appropriate to use sodium chloride, potassium or ammonium.

Sodium chloride is available reagent. When applying potassium or ammonium chloride waste solutions can be used for producing fertilizer.



Picture 1 – Dependence EDC pr. FEDC anionite AV-17-8 in Cl^- form depending on the ratio concentrations of sulfates and chlorides in solution to concentration sulfatdependence of ratio 800 mg/dm^3

If water contains the significant concentration of sulphates and nitrates in the absence of chlorides it is appropriate to use the method of their separation on anionite in NO_3^- form, so that other ions don't get into the water, except nitrate.

When the concentration of sulfate 800 mg/dm^3 in the presence of nitrates anionite capacity on sulfates reached 917 mg-eq/dm^3 and FEDC reached 1,744 mg-eq/dm^3. Later when the concentrations of nitrates in the water increase, the selectivity of the resin sulphate fell. Also with increasing concentrations of sulphates and nitrates in the water efficiency of their separation decreases. During the regeneration of the resin in sulfate form use 10 % solution of sodium nitrate. The degree of desorption of sulfate was 76–96 %. After treatment the regenerating solutions of calcium nitrate, we obtain the precipitate of calcium sulfate.

Conclusion

In the work studied the processes of ion exchange separation sulfates, chlorides and nitrates on high-based anionite AV-17-8. Established that if the anion concentrations up to 1000 mg/dm^3 ion exchange separation is very effective. Also were proposed methods of effective regeneration with obtaining useful products suitable for further use.

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Contact nonequilibrium low-temperature plasma for treatment of water and wastewater purification

It was developed a novel technique of the treatment of water, aqueous solutions It is shown that the liquid medium in the process of plasma treatment or thereafter undergoes significant transformations. Was demonstrated removal of micropollutants, heavy metals, organic and inorganic compounds under the action of CNP/

There is a continuing need for the development of effective, cheap and environmentally friendly processes for the degradation of organic, inorganic pollutants from water and wastewater purification.

Discharge plasmas in contact with or inside liquids are recognized to have a potential for applications to wastewater treatment, sterilization based on their distinctive properties such as ultrahigh density, high reactivity, high process rate, and so on. Recent advances in the generation of plasmas using arc, streamer, pulsed direct current grow and microwave discharge in the liquids [1]. However, first of all in these cases, the discharge is sustained in gas bubbles generated in the liquid and it is difficult to analyze the properties in the interfacial region of the bubbles because of their dynamical behaviors in the liquid. Furthermore is achieved by large energy costs due large expenses of electric power for the formations of the discharge plasmas.

We present the development a novel, environmentally friendly technique of the treatment of water under the influence contact nonequilibrium low-temperature plasma, in which the discharge current goes through the electrolyte substantially modifying the properties of the plasma–liquid interface [2]. Therewith, plasma may be formed in the initial plasma-forming gas containing solvent vapors or in the vapor shell produced inside the liquid phase as a result of temperature instability. In this review mechanism, kinetics of organic, inorganic compounds decomposition and micropollutants under the action low-temperature plasma treatment will be presented.

The contact nonequilibrium low-temperature plasma is generated in a glass cell between astainless-steel anode electrode and the surface of a liquid solution with cathode electrode. Figure 1 shows schematic diagrams of experimental setup.

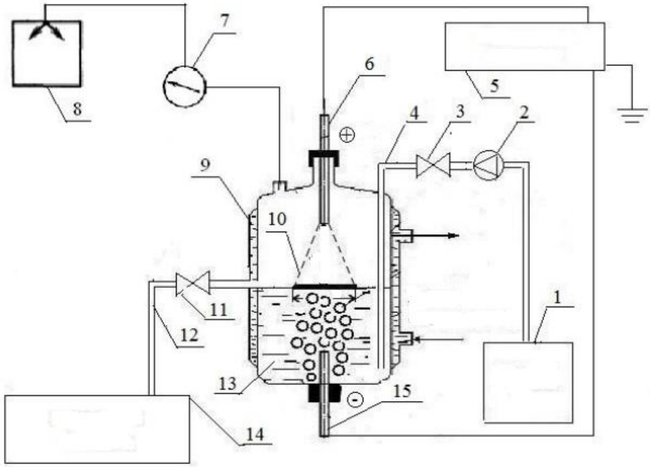

Figure 1 Schematic diagrams of experimental setup for discharge contact nonequilibrium low-temperature plasma
1 – vessel with the feed solution; 2 – pump; 3 – shut valve; 4 – incoming pipe; 5 – power supply; 6 – an anode; 7 – vakuometer; 8 – vacuum pump; 9 – a gas-liquid reactor with cooling; 10 – plasma discharge cone; 11 – shut-off valve; 12 – a branch pipe coming out; 13 – solution; 14 – reception capacity; 15 - cathode.

Processes at the liquid–gas interface induced by contact nonequilibrium plasma are most easily expressed in terms of the classical scheme adopted for chain reactions. At the chain initiation step in aqueous media, hydrogen and hydroxyl radicals are formed:

$$H_2O + e_c^- \rightarrow H_2O^* \rightarrow H\cdot + \cdot OH. \ (1)$$

At the following chain propagation steps, the main products are the hydrodioxyl radical and atomic oxygen:

$$OH + OH \rightarrow H_2O + O, \ (2) \ \cdot$$
$$OH + O_2 \rightarrow HO_2^{\cdot} + O, \ (3) \ \cdot$$
$$OH + O \rightarrow HO_2 \ (4)$$
$$H^{\cdot} + O_2 \rightarrow HO_2, (5)$$
$$H^{\cdot} + O \rightarrow HO. \ (6)$$

Chain termination steps may occur, yielding stable molecular species part of which may then react with radicals:

$$H + H^{\cdot} \rightarrow H_2, \ (7)$$
$$O + O \rightarrow O_2, \ (8)$$
$$HO_2 + OH \rightarrow H_2O + O_2. \ (9)$$

The formation of hydrogen peroxide as a final product can also be ranged as a chain termination step: ·

$$OH + \cdot OH \rightarrow H_2O_2, \ (10)$$
$$HO_2^{\cdot} + HO_2^{\cdot} \rightarrow H_2O_2 + O_2, \ (11)$$
$$HO_2^{\cdot} + \cdot H \rightarrow H_2O_2. \ (12)$$

Hydrogen peroxide accumulating in the course of chemical transformations tends to polymerize to form hydrogen polyoxides. In general, the process can be described by the following overall equation:

$$(n - 1)H_2O_2 \rightarrow HO_nH + (n - 2)H_2O. \quad (13)$$

However, the main reagent involved in the formation of hydrogen peroxide is deemed to be the hydrodioxyl radical. This radical forms a water-bonded complex, thereby facilitating hydrogen peroxide formation.

Owing to its virtue of producing in water oxidative species ($OH^{\bullet}$, $H^{\bullet}$, $O^{\bullet}$, H_2O_2, H_2, O_2, ect.) as well as initiating a variety of chemical and physical processes in water for decomposing micropollutants, toxic compounds, its operational simplicity (realized under the conditions of an ambient temperature and pressure), its variable reactor configuration, and its good-performance degradation of different concentration pollutants compounds from water.

Contact nonequilibrium low-temperature plasma can be used for the removal micropollutants, heavy metals, organic and inorganic compounds under the action of CNP. Was determinate kinetics and mechanism of the degradation heavy metals, organic and inorganic compounds in model aqueous solutions and different wastewaters.

Investigated the processes and optimal conditions for the removal of arsenite, phenol and other micropollutants from model water solutions under the action of discharge contact nonequilibrium low-temperature plasma. It is found that arsenite(III) gets converted to arsenate(V) via oxidation state(IV) under the action of CNP. The steady state analysis shows that the arsenite(III) abatment efficiency depends on pH and current density. The maximum abatment of arsenite(III) is at 45 minutes of plasma duration, current of 120–220 mA (table 1).

Table 1

Results influence contact nonequilibrium low-temperature plasma using the steady state method of analysis.

pH	Arsenic concentration(ppm)		Abatement efficiency (%)	Duration of discharge (min)	Current (mA)
	Initial	Final			
3.0	1.70	0.26	83.1	45	120
	16.0	0.10	99.4	45	120
7.0	1.70	0.21	86.7	30	220
	16.0	0.06	99.7	30	220
8.0	1.70	0.16	88.4	30	220
	16.0	0.05	99.1	30	220

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Study of ecological changes factors of the tourist destinations environment

Environmental impacts of the tourism industry activities were studied in the article. It was revealed that tourist activity affects the state of air, water resources, landscapes within tourist destinations. Connections between indicators of tourist flows and amounts of generated solid waste within tourist destinations were found.

The issue of sustainable tourism development is relevant in the agenda of the recent international meetings on environmental protection and tourism development. The increase in tourist flows and development of tourism infrastructure lead to significant ecological changes within the territories due to their recreational use. In general a tourist destination is an area of arrival and location of tourists. According to the definition of N. Leiper tourist destination is a place of tourists arrival which is considered as a geographical category. Therefore the systematic analysis of the tourist destinations functioning as economic and geographic categories is a relevant scientific research. An important part of the system analysis of tourist destinations functioning is the ecological component. Thus, 84% of European tourists called environmental safety of the area the main criterion for selecting areas for recreation. Therefore ecological study of tourist destinations environmental ecosystems and development of precautionary scientific and technical means of tourism impact minimization in the context of sustainable (balanced) development of the recreational natural areas are relevant.

Ecological state of tourist destinations affects the tourism system as tourism industry depends on the integrity of the environment more than any other sector of the economy. The growth of the tourism industry leads to the high concentration of tourists and infrastructure. The main environmental impacts of tourist destinations are changes of the original landscape, water pollution, air pollution from road, rail and air transport, waste management, etc. [1].

Construction of tourism infrastructure leads to changes of the original landscapes. The growth of the tourism industry has a direct impact on the natural landscape. The intensive construction of accommodation facilities, roads, airports, use of soil resources as building material for housing infrastructure construction result in the degradation and depletion of landscape elements and its radical change. The destruction of large forest areas in the process of tourism infrastructure construction in Ukrainian mountainous regions is an urgent environmental problem. Thus, tourist complex “Bukovel” is constantly expanding, now occupying about 822 hectares of land with a total length of ski trails 53 km [2]. These lands are removed from the total land area of traditional nature use.

Life support systems of tourist complexes require great amounts of energy and water resources. The intensive water use and its pollution is a result of tourist infrastructure functioning. For example, the average water consumption in Antaliya

(Turkey) is 250 liters per day, while in tourist areas of Antaliya the average daily consumption reaches 600 liters. In Mallorca (Spain) daily water consumption in rural areas is 140 liters, in the city areas, about 250 liters, and in Mallorca tourist complexes it is about 880 liters a day [1]. According to similar general calculations for Ivano-Frankivsk region tourists can additionally use from 100000 to 450000 m^3 of water per day during peak tourist seasons. Considering large amounts of water supply, we believe that the most promising water supply of tourist destinations is the use of groundwater. For example, tourist complex "Bukovel" uses groundwater for drinking water and production of artificial snow. This leads to the removal of significant amounts of water from the subsurface horizons, but does not dehydrate surface water streams. Removal of wastewater from small hotels and rural estates stays the problem because the vast majority of tourist destinations have no centralized wastewater drainage systems. The study of quantitative and qualitative changes in underground hydrosphere and surface water stays relevant in the context of tourist destinations ecological safety.

Hotels and other tourist facilities use large amounts of electricity, more than average local residents. Thus, according to EU experts on energy efficiency, energy use per 1 m^2 in the hotel with no category is 157 kW/h, in the four-star hotel it is 380 kW/h [3]. So, power consumption increases with increasing of accommodation comfort.

In many tourist areas energy systems were not designed for such significant energy consumption. For example, the local power supply system in the area of tourist complex "Bukovel" has undergone extensive reconstruction for its improvement.

In the areas of construction and operation of tourist complexes problem of solid waste management is very relevant. Waste management system in tourist destinations of Yaremche City Council can be studied as an example. The existing landfill in Nadvirna is overloaded due to the increased amounts of waste from tourist destinations.

Thus, the main ecological impacts of tourism infrastructure are primary landscape changes, changes in quantity and quality of water objects within tourist destinations, air pollution as a result of transport infrastructure impacts, and pollution with waste within tourist destinations.

However, especially the problem of solid waste accumulation and management within the tourist destinations is among the major unexplored and unresolved environmental problems in tourism and recreation in Ukraine, especially in mountainous Ivano-Frankivsk region, which is particularly vulnerable to human impacts. Therefore prognosis of generated waste amount and analysis of the factors affecting its amount become necessary for developing the effective waste management methods.

The amount of waste generated within tourist destinations is influenced by many factors, the impact of which can be evaluated by the means of statistical methods of data processing. The current state of such means allows to create and use multifactor models in order to establish effective connections between the result feature and the main factors.

The goal of this study is to explore and analyze the factors impact on the waste amount generated within the tourist Ivano-Frankivsk region. The following factors were selected as ones that influence the amount of waste within this tourist destination:

- number of tourists and excursionists (as the number of tourists can greatly exceed the number of local people during the tourist season peaks, and therefore the amount of waste increases too);
- exchange rate (as it is a factor of the purchasing power of tourists which affects the amount of waste);
- population (as the data on the waste amount includes waste generated by tourists, excursionists and local population as well).

The effective way of avoiding difficult calculations is to use the package "Data analysis" in the software complex MS Excel, which allows conducting quickly and qualitatively economic and mathematical calculations, constructing multifactor linear and nonlinear models and so on.

The interaction of resulting indicator (Y) and the factors (X1, X2 ... .Xn) is traditionally described by the linear multivariable regression equation.

The parameter of generated waste amount was selected as the resulting indicator (Y), and the following parameters were selected as the factors:

- X 1– number of tourists and excursionists, th. pers.;
- X 2 – exchange rate in Ukraine, UAH/USD.;
- X 3 – number of population, th. pers.

The analysis of these factors impact on the amount of generated waste in Ivano-Frankivsk region allows to evaluate the situation resulting from tourism activities during 2000-2015.

First let's consider the results of regression analysis of data on the amount of waste in 2000-2009 [4,5]. The obtained coefficient of multiple regression R = 0,877 shows the strong connection between the indicator and factors. As for the obtained determination coefficient of regression model R^2 = 0,769, the dependence on the amount of generated waste is 80.5% on the selected factors.

As the result of the goal solving of the three-factor regression analysis the following economic and mathematical model was built:

$$Y = 1,02 - 0,46\ X1 - 1,07\ X2 + 0,53\ X3$$

However, more recent data for 2010-2015 is more important, particularly due to the inclusion of waste generated in households [4,5].

The obtained coefficient of multiple regression R = 0,722 shows the strong connection between the indicator and factors. As for the obtained determination coefficient of regression model R^2 = 0,522, the dependence on the amount of generated waste is 52.2% on the selected factors.

As the result of the goal solving of the three-factor regression analysis the following economic and mathematical model was built:

$$Y = -32,50 - 0,16\ X1 + 0,32\ X2 + 33,20\ X3$$

Thus, the municipal solid waste is the most common within tourist destinations [4,5], the regression analysis for this type of waste was also carried out.

The obtained coefficient of multiple regression R = 0,779 shows the strong connection between the indicator and factors. As for the obtained determination coefficient of regression model R^2 = 0,607, the dependence on the amount of generated waste is 60.7% on the selected factors.

As a result of the goal solving of the three-factor regression analysis the following economic and mathematical model was built:

$$Y = -30{,}75 - 0{,}02X1 - 0{,}29X2+31{,}86X3$$

After carrying out the regression analysis of the depending of the generated waste amount on the selected factors such as the number of tourists and excursionists, exchange rate and number of population, we have discovered the strong connection between them. It is confirmed by the high correlation coefficient. However, due to the imperfection of statistical data and understanding that the share of waste from tourism in popular tourist destinations like Yaremche, Verkhovyna and Nadvirna regions is higher, it becomes clear that the impact of the factor of tourists and excustionists number within the tourist destinations is more significant. In addition, the economic and mathematical models were built for the further prognosis of possible amount of waste within tourist destinations, especially solid waste, taking into account such factors as the number of tourists and excursionists, exchange rate and number of population.

Conclusions

As a result of the study it was discovered that tourism activity is a major factor of environmental changes within tourist destinations. The main environmental impacts of tourism destinations are changes of the original landscape, water pollution, air pollution from road, rail and air transport, accumulation of solid waste. With the help of MS Excel program the effects of factors on the amount of waste generated within tourist Ivano-Frankivsk region were analyzed. The significant factors that affect the amount of waste within such tourist destinations were discovered to be: number of tourists and excursionists, exchange rate, number of population. As a result of the regression analysis of the dependence of the generated waste amount on the selected factors there was found a strong connection between them. It is confirmed by the high correlation coefficient. Taking into account the increasing tourist flows within tourist destinations in recent years the problems of choosing of effective waste management methods within such areas are of great importance.

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The use of biogas technologies in open sea conditions

This article is devoted to the use of biogas technology in the marine environment. The key idea is the possibility of removing units of a biogas plant overboard. The result is shown by offering a new type of marine structures.

The biogas as an environmentally safe way of producing energy is practically not represented in the aquatic environment.

For its effective use there should be both surplus of organic (anthropogenic or natural) and consumers of generated energy within a single location. Examples of such locations are the mouth of the Ganges (anthropogenic "junk" organics is predominant), and the Sargasso Sea (which coincides with the North Atlantic Garbage Patch) [1].

It would be logical to use the biogas production chain as part of the larger marine sewage treatment plants. In this context BSU, on the one hand, could process the organic part of the ocean debris, and, on the other hand, it could provide energy for the processing of other waste components, primarily plastic. The corps for such treatment plants in shallow waters can be platforms like oil ones, and in the open ocean - the large bulkers. In this case, the option with the cargo ship is considered.

Due to the large volume of some biogas plant units (primarily the fermenter), it is advisable to bring them beyond the limited space of the ship and place beneath the keel in an aqueous environment.

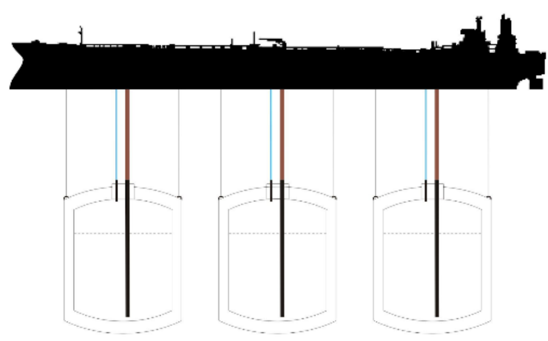

Fig. 1. Arrangement of the modules under the keel

To get the neutral buoyancy of outside units it makes sense to install a number of floating gas holders of variable volume on the fermenter body, they also will serve as additional biogas storages.

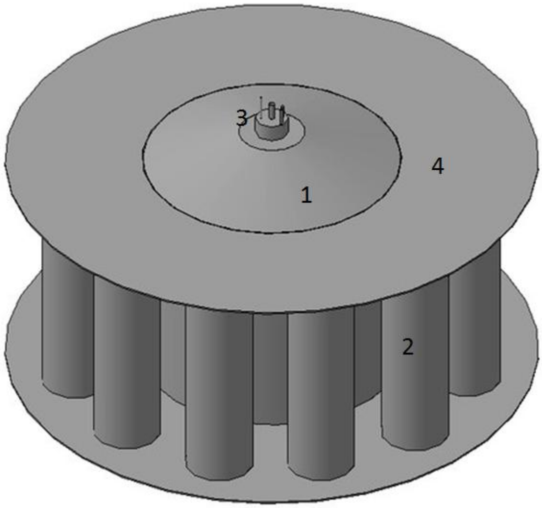

Fig. 2. Appearance of lower module: 2 – fermenter, 2 – floating gas holders, 3 – pump-distribution unit, 4 – firmly fixing system

Thus the biogas plant is divided into upper and lower units. The upper part consists of co-generation units, the main gas tank (because floating gas holders are of too small volume comparing to the ship needs and capacity of biogas plant), the control unit and a number of auxiliary equipment (especially the pumping system). The lower part consists of fermenter, floating gas holders and pump-distribution unit mounted in an integrated, firmly fixed system. A number of lower and upper modules may vary depending on the needs of the ship.

There is a number of tools for collecting and delivering waste and organics from the marine environment to the board of the ship, both long time known ones used for the mechanical collection of oil and relatively new (unmanned plants of Theoceancleanup project, SeaBin etc.). Firstly, the collected mass is sorted, after that its organic (and having no other value) part goes to the biogas reactor, that gives energy for processing the other part of the waste (mainly plastic).

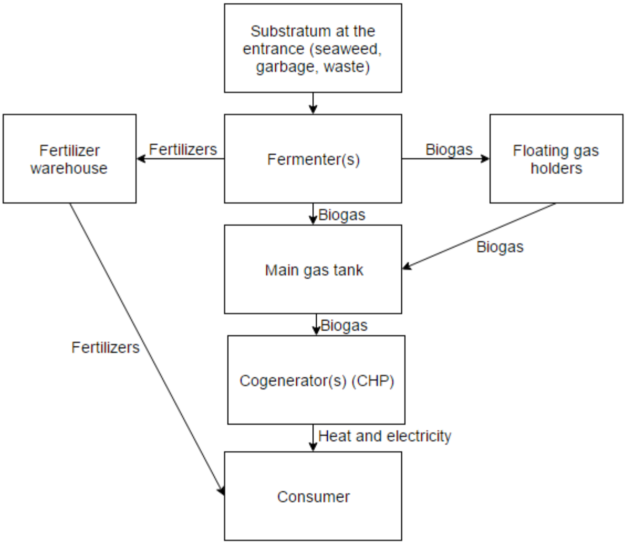

Fig. 3. The diagram of material flows

Also it is advisable to use other alternative energy sources such as solar panels and wave generators together with a biogas power plant.

It should be noted that the bottom module inevitably will adversely affect the maneuverability and mobility of the ship, turning it, in fact, into a state of semi-fixed or fixed offshore object.

Potentially biogas plants of such configuration can be used in any location where there is a sufficient water depth, an overabundance of organic matter and where there is no possibility to install similar arrangements on land. In particular, these units can be useful to large seaside megalopolises (Tokyo, New York, Shanghai, etc.) as sewage treatment plants and energy sources at the same time.

Conclusions:

The applying of biogas technology in the marine environment may have distinct ecological character. It is advisable to use them as stand-alone treatment facilities or as elements of a compound and multi-functional complexes.

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UDC 665

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Modern methods of improving operation properties

The possible methods of improving operational properties of modern petrochemicals are considered in this article. The results of studying the influence of hydrodynamic cavitation on the octane number of gasoline are presented. The results of gasolines treatment with hydrodynamic cavitation were defined to be the changes of octane number. The need to conduct more detailed research of gasoline component composition before and after cavitation treatment was established in order to define gasoline hydrocarbon structural changes after the impact of cavitation.

Technical progress in motor industry requires the proper decisions from the producers of petrochemicals in order to provide operation reliability of modern transport vehicles work. Currently, the solution of the problem of increasing fuels operation properties and simultaneous improvement of their environmental properties is known to be very important. Therefore, the modern prospects of of oil-world processing industry development are primarily considered through the prism of environmental safety of both petrochemicals production and delivery process.

The modern producers of motor-car petrols, in the first turn, pay attention to the improvement of the major operation property of petrols, which is detonation resistance. As a rule, it is provided by adding various high-antiknock components, including biotcomponents, to petrols. The purpose of our research was to study the influence of hydrodynamic cavitation treatment on the value of petrol octane number.

Petrochemicals are known to consist of hydrocarbon factions. Faction is a group of hydrocarbons, which have the proper lengths of molecular chain, consequently, proper temperature limits of evaporation (boiling). The shorter the length of hydrocarbon components chains within the certain fraction is, the lower the temperatures of their evaporation are and, vice versa, the greater the lengths of hydrocarbon chains the higher the temperatures of their evaporation are.

As a result of treatment of A-92 graded gasoline with hydrodynamic cavitation the long hydrocarbon chains will be torn into shorter ones, and that will provide complete combustion and reduction of exhaust gases toxicity.

The treatment of A-92 graded petrol was carried out with cavitation on the experimental installation, the principle hydraulic scheme of which is illustrated at Fig. 1 and Fig. 2. The source of pressure is a pump *1* of volumetric type. Pressure of liquid at the entrance to a generator of vibrations *6*, is regulated with a throttle *4*, and necessary pressure at the exit from the generator of vibrations *6*, is regulated with a throttle *8*.

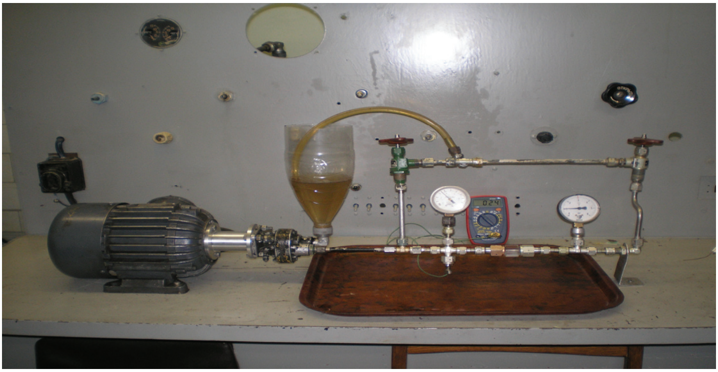

Fig. 1. General scheme of experimental fluidizer for liquids research

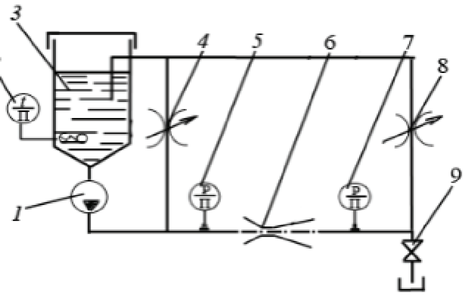

Fig. 2. The principle hydraulic scheme of fluidizer for treatment of liquids:
1 - pump; *2* – thermometer; *3* - tank with the liquid; *4,7* – throttles;
5,8 – manometers; *6* – generator of vibrations; *9* - faucet for sampling

Treatment was conducted with cavitator (generator of vibrations) with the diameter of the central part opening of 0,7 mm.

The period of treatment of each sample was 1 min.

As a research sample was chosen the gasoline grade A-92. The results of gasolines treatment with hydrodynamic cavitation in the form of the octane number changes were defined with the devise for octane number testing SX-300.

The results of cavitation treatment influence on A-92 octane number are presented in Table 1.

Table 1

Results of cavitation treatment of gasoline A-92

Parameter	Initial date	Initial pressure at the entrance to the cavitator			
		$P_{initial}$ = 0,5 kg/cm^3	$P_{initial}$= of 1,0 kg/cm^3	$P_{initial}$= 2,0 kg/cm^3	$P_{initial}$= 3,0 kg/cm^3
Temperature, C°	20,2	20,3	20,6	21	21
RON	95	95,2	95,4	95,35	95,3
MON	85	85,2	85,4	85,4	85,4
AKI	89,9	90,2	90,4	90,3	90,3

The analysis of data resulted in Table 1 shows that octane number of petrol A-92 sample after the treatment meets the requirements of technical regulations in terms of all indexes (RON, MON and AKI).

Conclusions

As a result of studying the influence of hydrodynamic cavitation on the octane number it was defined that treated samples quality meets the requirements of technical regulations. However, as a result of research, we can see, that the increase of contra pressure causes octane number reduction, that it is possibly conditioned by the destruction of short hydrocarbons. The increase of pressure at the exit from the cavitator also causes increased sample temperature.

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Investigation of aircraft gas turbine engine lubrication system operation

The effect of aviation oils foaming on lubrication system performance characteristics was found. The performed results of the tests demonstrated the dependence between increased oil foaming and characteristics of engine oil system and GTE abnormal operation. New approaches for evaluating the oils foaming properties were developed

Gas turbine engine (GTE) with electric drive pumps of lubrication system are one of the promising engines [1]. For their development a physical research of oil-air flows is necessary to perform.

Experimental researches were carried out by authors on the demo electric lubricating oil system (DELOS) with electric scavenge and feed gear pumps with variable rotating speed [2]. Experiments have shown the complexity of the hydro- and gas-dynamic processes which affecting on characteristics and performance of DELOS: a rise of oil-air mixture foaming, an excitement of polyharmonic pressure fluctuations, an exceeding of gear pumps power on calculated values when oil-air mixture pumping etc. There is observed a shutdown of electric drive pumps when air content in oil was changed caused by deaeration properties worsening.

The investigation of lubrication system characteristics was conducted at triple change of oil supply by feed pump, the supply ratio between scavenge pump to feed pump varied from 2 to 4. The rotation frequency of oil chamber's bearings was varied in the range of 4,000-12,000 rpm. Tests were conducted with MS-8P oil without antifoaming additives.

Air volume fraction in oil-air mixture was increased from 0.40 to 0.55, that leaded to the excitation of polyharmonic oscillations of system parameters (pressure, air content, etc.), increasing the pumps power to critical values and disable their electric drives.

Fig. 1 shows the transient processes in DELOS during 18 minutes at operation mode with fixed rotation frequency of pumps and bearings. On the steady mode by hydraulic and thermal parameter's of the system comes out in about 80 seconds. The main parameter's values at the 2nd minute: feed pump flow rate Qr=17.5 l/min and feed pump outlet pressure Pp=4.2 bar.

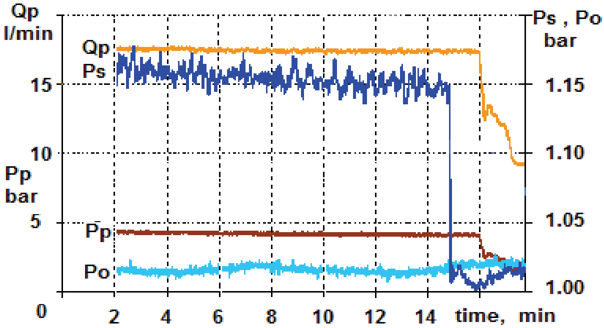

Fig. 1. The DELOS transient processes in mode with fixed rotation frequency of pumps

A smooth decrease the pressure of feed (Pp) and scavenge (Ps) pumps takes place starting from fifth minute at fixed volumetric feeding of feed pump Qp. After this time a sharp (in 0.5 s) pressure drop Ps after scavenge pump to the pressure Po in oil chamber takes place. The pressure drop is caused by disconnecting the electric drive of pump due to exceeding of admissible current value.

Video record of oil-air mixture flows at the pump inlet and outlet in combination with spectral analysis of records showed that the pumps are transferred a fine dispersed mixture.

Slow reduction of pressure after pump indicates a smooth increase of the volumetric air content in oil-air mixture before the electric drive disconnection.

The lubricating systems are usually includes gear pumps of volumetric type (Fig. 2). The mixture flow rate in hydraulic net is determined by flow characteristic of the pump Qr=f(np) which expressed the dependence of the volumetric flow rate at the pump output (input) Qn from rotation frequency of its shaft. It is choosing taking into account the condition of providing the required pumping of oil-air mixture with a calculated air content (αp) value with a given pump rotation frequency. The volumetric flow rate at the outlet (inlet) of pump at current rotation frequency characterizes its traffic capacity.

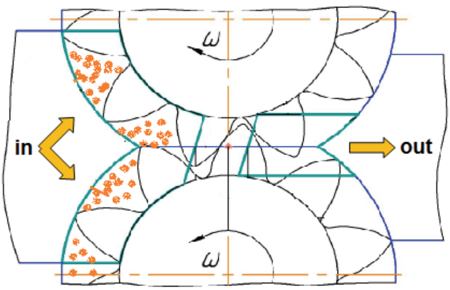

Fig. 2. Scheme of gear pump

Increased oil foaming can be one of the possible causes of the mixture formation with large volumetric air content [3]. In this regard special tests with the addition of antifoaming additive in MS-8P oil were conducted.

Comparison of DELOS characteristics under operation with MS-8P oil showed that the adding of antifoaming additives:

– decreases the pressure fluctuation at 23-40%;
– there is a harmonics shift from the frequency of 110 Hz to 80 Hz in pressures Ps;
– decreases of power consumption by the pump during the operation on the dispersed mixture.

Improvement of flow conditions as the reducing of oscillation amplitudes means an increasing of the number of small bubbles in oil. The frequencies in the range of 80-110 Hz are caused by weight of the liquid phase participating in the formation of oscillation period. So at their pulsed nature the bubble size reduction leads to increasing of the current mass and hence reducing the oscillation frequency.

Influence of additives on the pump power is illustrated in Fig. 3 which shows the change in the electric drive power of the pump depending on the coefficient Kp. The last one is the ratio of flow rate from the oil chamber to flow into the chamber. During the tests the changing of Kp was conducted by increasing the rotation frequency of scavenge pump at a fixed frequency of feed pump. At such technology the volumetric air content increases with growth of Kp at the scavenge pump inlet, which leads to an increasing of their consumed power. The additive give positive effect on pump power, but it decreases with increasing of volumetric air content of mixture (increasing Kp) and it disappears at Kp=4. This fact confirms the shutdown of electric drive.

The workspace of Kp changing in GTE is in the range 2-3 where the influence of additives is significant. The power consumed by the pump is reduced in 2 times under K_p =2.

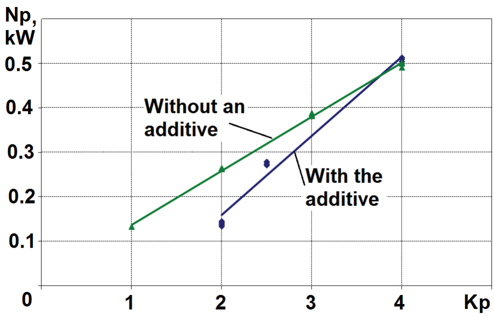

Fig. 3. Pump power vs. K_p with and without additive

Thereby testing of DELOS at the gear pumps operation with fixed rotation frequency establishes the reason of air saturation increasing of the oil in lubricating system. It is caused by changes in the oil properties during operation at its contact with air. Oil falls into breather system of GTE and then into the environment, causing fuming of engines.

Bench tests of demo electric lubricating oil system with antifoaming additive have shown that the additive reduces the power consumed by the pumps and improves the performance of GTE lubricating system. It is shown on a fourfriction machine according to GOST 9490-75 that the aeration of oil does not effects on it tribological characteristics.

The obtained data of aviation oils foaming have an interest for the developers and operators of aircrafts.

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New approach for creation of aviation lubricating oils

Paper describes the advantages and disadvantages of existing and promising methodology for development of lubricating oils. Strategy for improving performance characteristics of lubricating oils for aviation gas turbine engines in the near future is determined. Paper defines the main advantages of new and promising Russian lubricating oils for aviation gas turbine engines with the existing couterparts.

The lubricating oil is an important constructional component of engines which is used for cooling, lubrication, corrosion prevention and removal of wear debris from friction units. Engine parameters depend from oil characteristics, i.e. its quality.

Requirements to oils technical characteristics are increased with engine evolution. The rising of engine heat intensity requires oils with enhanced thermal oxidative stability [1].

The Russian oils for aviation gas turbine engines (GTE) are operated up to 200°C, while overseas the oils corresponding to MIL-PRF-23699 HTS specification can be used up to 225°C [1].

Russian modern aviation GTE are operated with synthetic oils, which can be used up to 200°C. The stock of thermal-oxidative stability of these oils is enough to ensure a specified life. However the oils with operation temperature 225°C and higher within the next few years will required for advanced engines [2].

Research for development of high-quality oils has high cost and duration. These difficulties are due to the lack of modern methods of oil production [3].

For the oils creation it is nessasary to conduct a scientific-theoretical substantiation of oil components selection and composition optimization studies. At the stage of scientific research the automated methods of designing and optimizing the composition of oils samples it is nessasary to apply. The effect of additives concentrations variation on composition properties is investigated by enumerative technique within a given range. Selection of the optimal composition is produced by well-qualified experts.

The amount of additives in aviation oils is 4-5. Searching the oils even in a small concentration range leads to a large number of test samples. In addition the selection of optimal composition by the expert can lead to errors and have high financial cost of experts labor [3].

The qualification tests shows the expediency of oils prototype further development. It is necessary for the quality determination of prototype oil generated for industrial production (experimental-industrial batch). It means the fixation of composition and technology of prototype production. Research results must be informative and the costs of their implementation much lower than the cost of research at serial aviation engine [2].

The complex of methods for qualifying assessment (CMQA) is outdated and does not allowed to identify operating characteristics of the oils effectively. The deficient informativity of methods leads to increasing of effort for estimation the oils quality. It is advisable to take into account the need for optimization of approaches to research of the oil quality at the modernization of qualifying assessment methods [4, 5] due to the wide cooperation with foreign partners: the application of foreign oils in Russian technics and vice versa.

Conclusion about the quality of experimental-industrial batch of oil is based on expert method assessment of quality and doesn't allow compar of oil's same type and to evaluate the quality reserves of produced oil [2].

Reduction of cost and time and improving the produced oils quality requires the development of innovative experiment-calculated complex for creation a new oils for GTE. This package should include the method of computer-aided design and optimization a composition of oils sample, improved methods for qualifying assessment of oils quality and a new method of assessment by the results of qualification tests.

The development of innovative experiment-calculated complex creation will ensure a safe and reliable operation of current and perspective GTE by the acceleration and cheapening of high-quality oils creation.

This complex has been designed in CIAM at creation of a new generation of oils ASMO-200 and VASMO-225 under the Federal Target Program for the restoration of strategic materials production.

It was developed the oil ASMO-200 instead of regular standardized synthetic lubricant B-3V, having a number of faults: a tendency to deposit formation, corrosion activity to copper and “altaks” precipitation.

Improved composition of ASMO-200 provides technical advantages in comparison with B-3V. The exclusion of “kaptaks” additives provides a significantly less corrosion activity to copper and lack of "altaks." The new lubricant has good lubricating characteristics and a high thermal oxidative stability in comparison with regular B-3V.

New high-temperature lubricant VASMO-225 is developed for perspective high heat turbofan engine (TFE). The results of qualification tests were shown that the long-term operation at 225°C is a distinctive feature of VASMO-225. At present the introduction of ASMO-200 and VASMO-225 into operation is in progress.

The applying of innovative complex allowed to find the extremum of objective function of oils samples most exactly and reasonably and reduce the number of experiments.

The developed united program of qualification tests has provided highly informative researches of experimental oils. Additionally we investigated the impact of oils on the flexible hose rubber of 4410-1 and IRP-1313 brands, biostability and conservation properties. In support of optimization with international specifications MIL-PRF 23699 and MIL-PRF 7808 Russian laboratory methods of research were duplicated by the foreign analogues.

The quality of Russian oils is determined by the technical conditions of companies, state standards and organizations standards. Each brand of lubricant oils corresponds to a separate document.

The quality of oils is determined by the specifications overseas. One specification determines the quality of different producers’ brands of the same type of lubricant. This approach simplifies the quality assessment of lubricant oils and makes the developing of new oils more transparent – the requirements to all types of oils are known in advance.

It is offered Russian analogs of overseas specifications developed by taking into account the features of quality assessment of oils in Russia. The mathematical modeling is used for the computer-aided design and optimization of compositions of oils prototypes.

The method is based on building and research of the surface of “composition-property” of lubricant by obtaining the experimental data. The concentration of additives is variables and improved quality is optimization criterion.

The database of experimental results for determining the quality of test samples is created in iterative process of building a surface response. Integrated approximation of the experimental results combined with the database greatly reduces the amount of experimental research.

The quality assessment of experimental-industrial batches of new oils is made by using a new method based on the building of preferences matrices. The new method makes it possible to present the results of experimental researches of samples in points.

For each quality parameter it is selected the range of possible values where the lower limit corresponds to the requirements of normative documents or compared sample worse parameter and the higher limit corresponds to the best value of parameter among the trade oils. Further the ratio between the value of test sample and selected range is determined.

Depending on the importance of quality parameter the certain number of points is assigned to it. The ratio between the value of test samples and the selected range multiplied at selected number of points will be the experimental results' expression in points.

The squaring of quality parameters in the category allows to evaluate and compare the lubricating and starting properties, thermal-oxidative stability and impact on the constructional and packing materials in scores. The comparison of qualification tests results shows the advantage of lubricant ASMO-200 over his regular B-3V in the thermo-oxidative stability and lubricating properties [6].

Conclusions

Russian lubricant oils for GTE is operable at temperatures up to 200°C, supports the reliable operation of modern aviation techniques, but in near-term outlook a higher thermal-stable lubricant with operation temperature over 225°C will required.

The problems of development a new high-quality lubricant oils for advanced GTE in Russia are high cost and duration of the research, insufficient informative value of existing methods of qualification assessment of oils quality and the lack of quality assessment methods suitable for comparison of the same types of oils and assess their quality stock.

The innovative experiment-calculated complex of development of new lubricant oils for aviation GTE consisting of automated method of designing and optimizing of the test samples compositions is developed. The methods of qualification assessment of oils supplemented with estimates of the impact on flexible-hose rubber, biostability and conservation properties are advanced. In order of optimization with overseas specifications Russian laboratory methods are supplemented by foreign ones.

At the first time the method of building the preferences matrices is used to assess the quality of experimental aviation oils.

The application of developed innovative complex during the development of ASMO-200 and VASMO-225 have provided a decreasing of experimental researches more than 5 times and improving of operating properties in comparison with regular lubricant B-3V, LZ-240 and IPM-10.

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Aliphatic alcohols as a component of aviation gasoline

Environmently consider alternative anti-knock additives which reduce the toxicity of exhaust gases of the engine and improve the physical and chemical properties of fuels.

Aviation gasoline for use in aircraft piston engines. They used the forced injection of fuel into the intake system in most cases, some defining features of aviation gasoline compared to road.

Stringent conditions determine their application requirements for high quality.

The quality of the aviation gasoline is characterized by a number of indicators that are governed by the relevant standards and technical specifications that ensure economic and reliable operation of the engine during its operation. These include the following indicators:

- Volatility. Fractional composition and vapor pressure of gasoline should provide easy engine starting at low temperatures (but not the form of vapor lock) and stable operation in various modes and completeness of evaporation in the engine cylinders;
- Group hydrocarbon composition, which provide stable, process of combustion without detonation at all engine operating modes;
- Chemical stability, the ability not to change its composition and properties during prolonged storage, does not form sludge and tar deposits in the system of fuel and carbon deposits in the combustion chamber of the engine;
- Low-temperature properties, ie paraffin crystals form at low temperatures;
- Do not contain more than 2.7 - 3.3 grams of tetraethyl lead (TPP) per kg of gasoline depending on the brand of gasoline;
- Have its own color, so you can easily distinguish them.

One of the main indicators for aviation gasoline is their detonation resistance, which is a measure of octane grade and a rich mixture.

Under GOST 1012-2013 provides for the production of two types of aviation gasoline: B-91/115 and B-92. Mark of aviation gasoline determines the octane number by motor method, which is specified in the numerator, and a rich mix grade - in the denominator.

Developed specifications for aviation gasoline brands B-100/130 and B-100/130 with low ethyl level - TU 38.401-58-197-97. Established norms specified quality gasolines meet ASTM D910 and European specifications for gasoline marks 100 and 100LL.

Today the world marks used low ethyl gasoline Avgas 100 containing 0.85 g / dm^3 tetraethyl lead, Avgas 100LL - 0,56 g / dm^3, Avgas 80 - 0.14 g / dm^3.

Since the moment has not yet created alternative aviation gasoline, which would have been completely absent leaded liquid and met all the requirements of the regulations. In the world continue to work towards a new alternative aviation fuel.

Setting objectives. Research on the use of aliphatic alcohols as additives to aviation gasoline to improve physical, chemical, operational and environmental properties are maintained around the world and confirm the promise of modifying traditional fuel oxygenates [1-13]. The aim of our work is the study of prospects replacing ethyl with oxygenated liquid additives consisting of aviation gasoline. Object is a modification of aviation gasoline additives aliphatic alcohols. Purpose of the study: physical and chemical properties of aviation gasoline and ethyl prospects replacement fluid set of oxygenates.

Problem solving According to the analysis of the literature [1-13] conclude that the addition of the aliphatic alcohol consumption improves its properties.

Fuel containing ethanol is most suitable for use in practice due to large volume production and low toxicity. Compared with methanol it is less aggressive and corrosive hygroscopic, is more soluble in hydrocarbons. Thanks to ethanol gasoline enriched with oxygen and promotes more complete combustion.

Butanol fuel advantage is that it is less aggressive to structural engine parts, has the greatest stabilizing effect with respect to the alcohol-gasoline blends has good antidetonation properties and reduces the amount of toxic emissions.

Experimental part

Experiments were conducted studies using ethanol, butanol, isobutanol, izoamilu, n-propyl and isopropyl in the fuel containing no lead additives, followed by determination of octane number by motor method, as the most important indicator of the quality of aviation gasoline.

Table 1

Change octane modified base gasoline mixture (BGM)

Test	Research sample	Density at 15°C, kg/m^3	Knock Rating	
			MON	experimental
1	BGM	746	80,4	86,5
2	BGM + annex	745	81,3	86
Ethanol				
3	BGM + 5%	750	81,3	93,0
4	BGM + 10%	751	82,7	111,6
5	BGM + 15%	753	84,6	> 120
6	BGM + 15% + annex	752	87,2	> 120
Buthanol				
7	BGM + 5%	755,1	80,4	90,2

8	BGM + 10%	753	80,4	94,2
9	BGM + 15%	757	80,4	> 120
Isobutanol				
10	BGM + 15%	754	81,2	109
11	BGM + 15% + annex	754	81,2	> 120
Isoamyl alcohol				
12	BGM + 5%	750	80,4	89,7
13	BGM + 10%	752	80,4	92,1
14	BGM + 15%	756	80,4	96,2
n-propanol				
15	BGM + 5%	751	80,4	90,7
16	BGM + 10%	753	80,9	97,5
17	BGM + 15%	755	81,6	> 120
Isopropyl alcohol				
18	BGM + 5%	749	80,4	91,0
19	BGM + 10%	751	80,4	95,2
20	BGM + 15%	754	80,4	> 120

The data of Table 1 shows that the addition of 15% ethanol additive Octamar FK och increased by almost 9% compared to the baseline fuel. When the detonation stability of gasoline (octane number) increases the completeness of combustion, which in turn is accompanied by increased engine power and reduced smoke exhaust.

Conclusions

Because today the main source of aviation fuel remains oil, aviation gasoline to trade continue to add thermal power plants, gradually reducing its concentration.

So in aviation gasoline Avgas 100 brands, Avgas 100LL, Avgas 80 used today TPP content ranging from 0.14 g / dm 3 to 0.85 g / dm3.

The new alternative jet fuel must meet many requirements, in particular, have the necessary raw materials, low cost, do not degrade the performance of the engine as possible to throw out hazardous substances, possibly combined with established fuel supply system and others.

Our study confirmed the hypothesis that the substitution fluid aliphatic alcohols ethyl possible. Thus, modification BBS 15% ethanol increases its octane number by 5 units compared with the original, and adding to this mix additives

Octamar FK - 9 units. In view of the results and given that the final formula of the new fuel has not yet been invented, the study tracks with several aliphatic alcohols and additives must continue.

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Study of the low-temperature properties of biofuels for jet engines

The work is devoted to the development of alternative jet fuel blended with rape oil-derived biocomponents and studying their low-temperature properties. The influence of rape oil-derived biocomponents on the low-temperature characteristics of blended jet fuels was studied and explained.

As it is known the world energy needs are constantly increasing, and therefore the question of replacing oil, from which more than 90% of all motor fuels are produced with other raw materials raises. Searching for a new source of raw materials, development of advanced technologies for the production of alternative fuels and their rational use in aviation are one of the priorities of the day. In addition, international organizations such as ICAO, IATA pay more attention to the greening of civil aviation. Taking into consideration the poor state of the environment renewable, environmentally safe aviation fuels must be used. At the same time, alternative fuels must meet a number of requirements related to the efficiency, reliability and durability of aircraft.

One of the most common alternative fuels for the jet engines is a synthetic jet fuel produced from various kinds of biomass. The technology for producing kerosene by hydrogenation of oils and animal fats is also studied. In addition, there is a successful experience with aviation biokerosene: mixture of crude-oil fuel for the jet engines and biocomponents in an amount up to 50%. Biocomponents which can be used in mixtures with conventional jet fuel are fatty acids ester produced in the process of transesterification of vegetable oils or animal fats by simple alcohols (methanol, ethanol, rarely butanol). Taking into account the variety of vegetable raw materials in Ukraine the most promising "biofuel" crop is rapeseed.

As is known, one of the main operational properties of jet fuels are low temperature properties, which characterize the ability to retain fuel fluidity at low temperatures. Traditionally, there are strict requirements to low-temperature properties, because of the operating conditions of aircraft. These properties are commonly characterized by such indicators as the freezing point and the viscosity at low temperatures

Within the framework of this work the effect of bio-components based on the rapeseed oil methyl and ethyl fatty acids esters on the low-temperature properties of the samples of biofuels for jet engines were studied. Low-temperature properties of jet fuel, tree kinds of biocomponents and their blends with jet fuel was investigated during the experiment. *Freezing point* of fuel samples (denoted as t_f) was determined according to standard *ASTM D7153* Standard Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method). Biocomponents are characterized by significantly high values of freezing point comparing to conventional jet fuel. It was found that biocomponents possess higher values of the freezing point (-19 ° C, -18,5 ° C, respectively) comparing to petroleum fuel of grade Jet A-1 (-59 ° C). Such high freezing point biocomponents explained the chemical structure of the molecules and the forces of van der Waals interactions that exist between them. Length of esters' molecules stipulates their high viscosity and its dependence on temperature. Due to the molecules' size their mobility is low (comparing to jet fuels). When temperature decreases, association between molecules quickly rises: due to the depression of heat motion from one side and reduction of heat motion between molecules from another side. When temperature continues decreasing esters cool down and completely loose their mobility. For these reasons, a modification of jet fuel with biocomponents increases freezing point of mixed jet fuels. At the same time it was established that the addition in the jet fuel in an amount of biocomponents up to 30% has no substantial effect on the freezing point, and the numerical values of this index is staying within regulatory documentation requirements. Fig. 1. describes the rise of freezing point of blended fuels with increasing content of esters

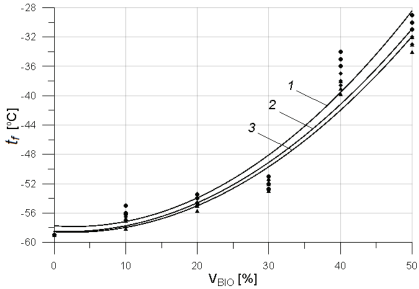

Fig. 1. Dependence of blended jet fuels freezing point on the content of biocomponents: *1* – jet fuel Jet A-1 + FAME, *2* – jet fuel Jet A-1 + FAME(M), *3* – jet fuel Jet A-1 + FAEE(M)

Research of viscosity of aviation biofuels at low temperatures (- 20 ° C) also showed that the addition of bio-components leads to higher viscosity of mixed fuels but requirements of normative documents on traditional jet fuel are still satisfied.

As a result of the method of linear regression analysis the mathematical equations which will allow obtaining biofuels for jet engines with desired low-temperature properties were obtained.

CONCLUSION

In a result of the work the low-temperature properties of jet fuel and rape oil esters were studied. The results have shown that the main characteristics of biocomponents differ from conventional jet fuels. The dependencies of jet viscosity and freezing temperature on the content of biocomponents were obtained. It is found that blending jet fuel with rape oil esters results in increasing of fuel freezing point. It was found that modification of conventional jet fuel by rape oil-derived components is possible in a quantity up to 30%.

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Development trends of modern aviation gasoline

Currently aviation gasoline in Russia is not manufactured. Abroad, there is phasing out the use of leaded aviation gasoline and the transition to unleaded. The urgency of carrying out research on the development of national unleaded aviation gasoline. Results of domestic research for the development of corresponding technical requirements specified prototypes unleaded aviation gasoline

The increased requirements to the specific weight, efficiency, reliable operation in a wide range of climatic and altitude conditions are submitted for aviation piston engines (PD) fuelled by gasoline. Typical aircrafts which using an aviation gasoline as a fuel are the aviation equipment of domestic (aircrafts AN-2, Yak-18T and helicopter Ka-26) and foreign (Cessna aircrafts and Robinson helicopters) production.

The aviation gasoline compared to the motor gasoline have a less volatility, more narrow fractional composition, a greater knock resistance on poor and rich mixtures (Table 1), which provides the best power characteristics of the engine. Unlike to motor gasoline the aviation gasoline must meet the demands of an increasing number of physic-chemical and performance properties.

Table 1

Physic-chemical and performance properties

Property	Limits		AI-95 (GOST R 51866-2002)
	B-91/115 (GOST 1012-2013)	100LL (ASTM D 910-15)	
Knock Rating: Lean Mixture Motor Method Octane Number, min Performance Number, min	91 115	99,6 130	85 -
Tetraethyl Lead Content, gPb/l, max	2,5 (g/Kg)	0,53	absence
Net Heat of Combustion, MJ/Kg, min	42,947	43,5	-
Vapor pressure 38 °C, kPa	29,3-48,0	38,0-49,0	45-100
Distillation: Initial BP, °C, min: 10 % recovery, °C, max 50 % recovery, °C, max Final BP, °C, max	40 82 105 180	report 75 105 170	- - ~70-110 210
Exictent Gum, mg/100 ml , max	3	-	5
Freezing point, °C, max	-60	-60	-

The two standards on leaded aviation gasoline are adopted in Russian Federation: GOST 1012-2013 - for leaded gasoline of B-91/115 and B-92 brands, GOST R 55493-2013 for leaded gasoline Avgas 100LL. Today, the industrial production in the Russia of aviation gasoline is not available. The main reason for the lack of production of aviation gasoline, a ban on the production in Russia of tetraethyl lead [1], which significantly increases the octane number, but at the same time being very toxic compounds.

The entire volume of aviation gasoline consumed in Russia is imported from abroad. To meet the needs of small aircraft imported two grades of aviation gasoline: B-91/115 according with WT - 06 / OBR PR / PD / 60 manufacture of company OBR PR (Poland) and 100LL according with ASTM D 910-15 manufacture Shell or ConocoPhillips. Because of the high cost and the lack of imported gasoline volumes for the needs of small aircraft is also used motor gasoline AI-95.

Abroad, there are standards of ASTM D 910-15 and DEF STAN 91-90 on leaded gasoline. At the present timethe main brand of leaded aviation gasoline is 100LL. In the US, there are standards for unleaded aviation gasoline brands 82UL and 87UL ASTM D6227 and 91UL ASTM D 7547. In the United States to reduce the lead content of aviation gasoline is working. One of the latest results was the introduction to the standard ASTM D 910 new brands of gasoline - 100VLL, which lowered the maximum content of TEL by 19% compared with the brand 100LL.

In addition to developing brands unleaded aviation gasoline in the United States developed the standards for test unleaded aviation gasoline ASTM D 7592 94UL 102 and ASTM D 7719 UL [2], however over the past 15 years, create the equivalent brand unleaded gasoline 100LL failed. In the present time creating unleaded gasoline it is the main world trend in the development of aviation gasoline.

Currently, the Russian Federation, work on the resumption of production of leaded aviation gasoline B-91/115, GOST 1012 has begun. For this it is necessary to solve the problem of the import of ethyl fluid, production of which is prohibited. The creation of unleaded aviation gasoline we are working.

Institute of Russian Research Institute of Oil Refining commissioned by Gazpromneft-Omsk Refinery has developed technical requirements (TR) for unleaded gasoline B-92/115 with an octane number 92 of motor method. Based on the components provided "Gazpromneft-Omsk Refinery" prototypes of unleaded aviation gasoline were created and in the Institute of Russian Research Institute of Oil Refining and in the Central Institute Aviation Motors (CIAM) on the quality of the samples obtained compliance TR was tested. This prototypes fully meet the standards of TR and this gasoline can be considered as an analogue of leaded gasoline B-91/115. Based on the results of the tests, and TR project of standard “Aviation gasoline unleaded G-92, B92 / 115” was created, which has passed the agreement of the CIAM and the State Research Institute of Civil Aviation. Started phase of the industrial design for bench acceptance tests.

Technical requirements (TR) for unleaded aviation gasoline with an octane number of motor method 100 has developed by CIAM, which is the equivalent of leaded gasoline 100LL. According to these requirements of Institute of Russian Research Institute of Oil Refining created laboratory samples and sent to the CIAM.

The sample number one consist of only the hydrocarbon components, the sample number two is a mixture of hydrocarbon components with the addition of oxygenated compounds (a mixture of dialkyl esters).

According to tests of the sample number one fully meets the TR, with the exception of the octane number of motor method - 96, at the rate of "min 99.6". The sample number two fully meets the the TR, with the exception of the Vapor Pressure - 30.7 kPa at a rate of "38,0-49,0 kPa" and Net Heat of Combustion, - 42.8 MJ / kg at a rate of "min 43 5 MJ / kg. ". Of the studied prototypes unleaded gasoline of particular interest is a sample number one. Getting the value of the octane number of motor method at the level of 96 units can be considered the achievement and the sample number one has some stock quality in property of "vapor pressure". This makes its possible you by to change the composition of the hydrocarbon components to increase its anti-knock properties. CIAM recommended that the change rate of TR octane number of motor method with "min 99.6" to "min 95" and continue studies to developed the equivalent brand gasoline 100 LL.

Expedited domestic small aircraft with PD domestic gasoline made in Russia can only be realized of industrial production of standard leaded aviation gasoline B-91/115 is organize (GOST 1012-2013).

Prototype unleaded gasoline B-92/115 developed of Institute of Russian Research Institute of Oil Refining passed qualification tests with a positive results and admitted to the bench tests of the second phase of state acceptance tests, as the equivalent leaded gasoline B-91/115 (GOST 1012-2013).

It is necessary carry out of state acceptance tests to the use of newly developed unleaded gasoline B-92/115 on a par with aviation petrol B-91/115 (GOST 1012-2013).

Should continue research on the development of domestic unleaded aviation gasoline, the equivalent of knock resistance properties for gasoline 100 LL.

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UDC 665

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Research electrization of aviation fuels

Aviation fuels electrization process has been researched in this article. The given work proves that electric energy is obtained from distribution of charges in dielectric liquids and also grounds the application of the phenomenon of electrization in useful aims. A development of the technological method and the device for electric energy is given as a result of electrization of dielectric liquids.

Introduction. Intensifying of energy problems induces to the search of new energy sources that must in a complete measure satisfy the requirements of humanity in necessary thermal and electric energy, and must also provide herewith a high ecological cleanness, simplicity and safety in service. The scientists of many countries work on creation of alternative fuels by a hydrocarbon energy source, and also on the search of alternative energy sources.

Paradoxical is the fact that some physical phenomena known to humanity from very old times, in this time has been studied in the least , as for example static electrization: first mentions about it are marked by Thales of Miletus about 2500 years ago. The study of static electricity had actually begun from a classic experiment of electrizations amber at wool, we aquained with this experience at school. An idea about absence of any prospect of practical application of this phenomenon existed for a long time and it removed any interest of researchers to it. The intensive study of electrization began at the beginning of the XX century, when, in connection with a rapid technical progress, the consequences of formation of electrostatic charges began to appear: explosions, fires, etc. Many cases of negative electrization influence are known in different fields of industry [1, 2]: chemical, textile, cellulose-and-paper, rubber, in surgical clinics, coal mines, transport etc. According to statistical data, the loss, that static electricity inflicts only, for example, at the enterprises of the USA, which deal with the dust of different substances, is close to 100 mln dollars per year [2, 6]. The most dangerous electrization is in the fields of industry, related to the production and consumption of flammable substances, such as hydrocarbon liquids. Not by chance the initiators of a systematic study of electrization of oil products were the largest petroleum corporations "Shell" and "Esso", which created special purpose laboratories for the study of reasons of static electricity occurrence and improvement of methods of its elimination [5, 6].

Therefore such an electric energy source as static electricity cannot remain regardless, but problems that have appeared at the market of energy resources these days make us not to fight with static electricity, but work on the methods of it useful application.

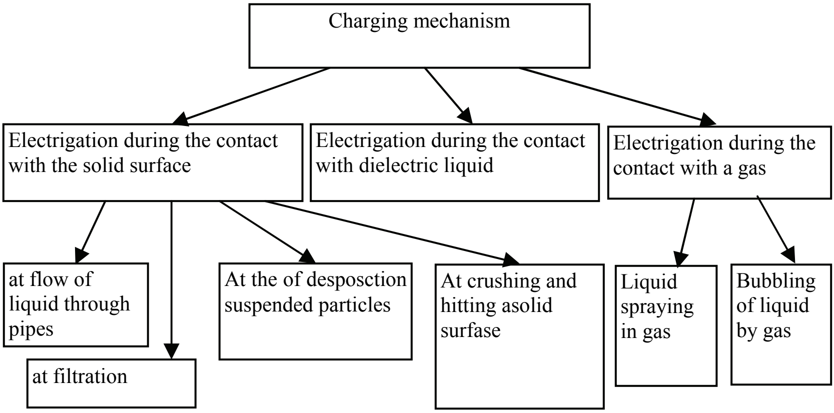
Task. The aim of this work was a research of electrization phenomenon of aviation fuels and a ground of possibility of application of static electricity to obtain electric energy from distribution of charges in dielectric liquids.

Researches and publications analysis. The use of static electricity that occurs in technological equipment as a result of distribution of charges at friction of a dielectric liquid at the surface of the equipment, as and oxidants is an urgent theme of present time. Modern high-performance pumps a positive phenomenon is timely and new. Electric energy aquisition without large expenditures of energy resources and oxidizers allows to provide fuelling of a large airplane in 20-40 minutes. The obligatory element of the aircraft fuel system is the filter of the thin cleaning made of fibred plastics with a carrying capacity (3-4 thousand l per min.), high degree of cleaning and low cost. However, at the moment of the airplanes fuelling it results in intensive occurrence of static electricity charges [3]. The cases of static charges display have been found out on the net in the transfer pump of the airplane, and also burn-out of a filtration material in the filter of petrol tankers. A considerable display static electricity has achieved at gasoline stations during fuelling of motor transport and during transfer of light oil. As the result, the enormous amount of cases of spontaneous combustion of technological equipment and cars has been fixed exactly during the fuelling process [3 - 6].

As it is known, electrization of dielectric liquids is connected with occurrence of double electric layers on the surfaces of splitting of two liquid environments, or on the borders of splitting “a liquid - a solid body. A double electric layer is a spatial distribution of electric charges of different signs which are "motionlessly" connected with the pipe wall (Helmholtz layer - 10^{-6} м) and a diffusive layer of ions of the opposite sign (Gui layer) [4]. Due to the motion of a liquid in relation to the pipe wall and moving of Gui layer charges in a reservoir, there is a difference of potentials between the pipe and the reservoir. During friction of liquids and metals in the processes of flow or splashing there is electrization of dielectric liquids due to the electrolytic division of charges on the border “a metal - a liquid”. Electrization during friction of two liquid dielectrics is a result of existence of double electric layers on the interphase of liquids with different dielectric penetrability, the liquid with a greater dielectric penetrability is being charged positively, and with less - negatively (Cohen rule) [4]. The charges of static electricity are also observed at: mutual friction of two dielectrics; semiconductors of metals of a different chemical composition, or of an identical composition, but of different density; during friction of metals at dielectrics; at friction of two identical dielectrics; at friction of liquid dielectrics at each other, or at the surface of solid bodies etc. At this process these two bodies are being electrified, and their charges are identical of value and opposite of sign. In connection with the fact that hydrocarbon fuels due to the physical nature have a low specific conduction, they are being actively electrified, and they keep and accumulate an electric charge. At certain density of an electrostatic charge the tension of the electric-field can reach critical values, that will induce an electric charge.

Descriptions of discharge in hydrocarbon pairs have been researched by many scientists of the world [1 - 6], calculation techniques of the electrostatic fields have been worked out, but only for the simplest cases that coincide with the results of the experiment. In a counterbalance to it, a question about the conditions of formation and piling-up of charges is not enough studied. The attempts to prove electrization of liquids led to divergences with the data of the experiment. It is not quite clear what is more wrong: the basic assumptions in the basis of the theory, the technique of the experiment or both.

All possible charging mechanisms can be classified according to the following groups:



Two determinant mechanisms occur during operation of a dielectric liquid : formation of charge at a flow through pipes and during filtration. The experiments [4-6] determined the quality pattern of the fuel behaviour in the cases, on the basis of which the following conclusion can be made: electrization of dielectric liquids is determined by three factors - physical properties of a liquid, structural features of the equipment and a set of external conditions. Researches of electrization of a liquid have been usually fully conducted, without an exception of any of these factors. As the result the conclusions achieved from such sort of experiments are often controversial. So some assumptions have been repeatedly made that the material of the equipment practically does not influence on the degree of electrization, however the practical results show the opposite fact [5].

It is difficult to deny the fact that in equal conditions different liquids are being electrified differently. We can assume that such property of liquids exists and can be determined at presence of corresponding data of the experiment. The concepts fixed in basis of the phenomenon do not explain the fact that pure hydrocarbons are not being electrified. The above given examples are not the list of all contradictions and discrepancies, but only a short illustration of imperfection of our knowledge in this area. Many researchers confess [6] that the study of static electrization, and not only of liquids, is in the stage of piling up of experimental material.

On the aviation fuel supply enterprises the neutralization of charges of static electricity at the loading points at fuelling the reservoirs is carried out by induction neutralizer of static electricity (ICSE), that is mounted behind the filters on the line the oil product delivery. The neutralizer allows to increase the productivity of filling of cisterns on 70% (taking into account the capacity of the equipment). But ICSE is not the only means of control of the static electricity charges. Besides, in these cases metallization of constructions is successfully used to equalize the potentials, or simply dangerous areas are grounded for flowing down the charges in the ground [1]. Taking into account the actuality of defence of fuels from the accumulation of static current in aviation fuels are added the complex additives "Assa", "Sigbol", that have anti-static properties. In a concentration 0,003 % they increase electroconductivity of oil products and their electrization.

However, the above given protective measures from electrostatic charges are not effective enough. So anti-static additives only decrease electrization of oil products, increasing their conductivity, but does not eliminate the occurrence of electrostatic charges and require additional costs on their acquisition. The application of ICSE allows to output the charges of static electricity from the objects of their formation in the ground, but not to use this energy source in useful to humanity aims.

Methods of researches. The size of the charge obtained by a liquid during its motion through the pipes is determined by the known "capillary method" [5]. This methos determines the size of the charge, that the unit volume of the liquid acquires during running back in a capillary. The investigated liquid from the reservoir 1 (fig. 1) runs back in the isolated reservoir 2. The appeared charge in the liquid during a motion through the capillary 3, accumulating in the reservoir 2, changes its potential. By the measured size of the potential and the known capacity of the system the size of charge which is obtained by the liquid is determined by the relation:

$$Q = CU$$

According to the size of charge and to the known volume of the liquid that have been already overflowed, the average density of the charge is determined. Variable condenser 5 works for compensation of change of the system volume. The size of the potential is measured by the electrostatic voltmeter 4.

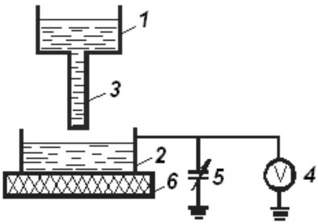


Fig. 1. The basic chart of determination of electrization by a capillary method.

The size of charge in the filter and behind the filter was determined according to the known method of "Esso" of the English corporation "Shell" [5, 6]. The basic chart of "ER" device, that "Esso" corporation uses for the evaluation of electrization of liquid is shown in fig. 2.

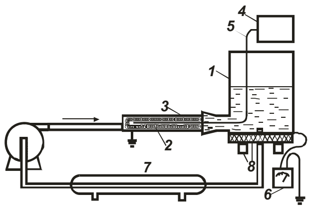


Fig. 2. A basic chart of "ER" device for the evaluation of fuels electrization.

In the isolated reservoir 1 3,75l of a liquid is poured that is continuously pumped through a 25 mm pipe from stainless steel 2, filled by glass-wool, with speed of 15,2 l/min. The size of charges that occur in a fuel at pumping is estimated by the amount of discharges in the filter 3, which are registered by a radio receiver 4 with antenna 5, and by the current of the flow from the reservoir to the ground by a measuring microammeter 6 through 10 min of pumping. The refrigerator 7 serves for stabilizing of temperature of the liquid. For the natural experiment to research the electrization of hydrocarbon liquids a corresponding test-bench has been made. The basic chart of the bench is represented in Fig 3. The investigated liquid (aviation fuel TC- 1) from tank 4 through the pipeline by means of a centrifugal pump 6 is supplied to filters 11 (one of the filters has a metallic filtration net, the other one - standard filtration paper) and in accordance with the theory of electrization, in the filters the investigated liquid gets the maximal level of natural electrization. Then through the pipeline the investigated liquid gets to the device to get electric energy of high voltage15 (development of the authors [7]), then the liquid gives the obtained electrostatic charges on a metal hollow ball. Then the liquid is supplied to tank 1, from the tank it is possible to take the samples of TC- 1 to estimate their operating characteristics, or they can be taken from faucet 18. For the account of the liquid the rotameter 19 is set in the bench. By means of manometers 9, 13 the necessary pressure is set in the system. The indexes of manometers also testify to the operability of the filters, or their abnormal operation. By cutting of the faucets 10, 12 it is possible to replace the filter material, as the bodies of the filters are easy-break. To achieve the most substantial effect it is recommended to open faucet 3 and some time to pipe the liquid on a circle to reduce the case of the charge relaxation. For research of electrization of hydrocarbon medium it is necessary to put off device 15 (in such case the device is used as a source of natural electrization) and put on electrometric amplifier 17 ("У1-6"), that not only amplifies the electric signal from the sensor of electrization 16 but also has a built-in micro ammeter and voltmeter of a wide range of measuring.

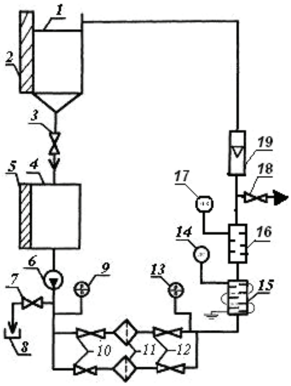


Fig 3. The basic chart of the test-bench : 1, 4 reservoirs; 2, 5 measuring glass; 3, 7, 10, 12 faucets; 6 pump of the liquid pumping; 9, 13 pressure manometers; 11 filters (they differ by a filter material); 14 a source of current; 15 a device getting of electric current of high voltage (development of authors); 16 an industrial sensor of electrization; 17 electrometric amplifier "У1-6"; 18 a faucet for samples; 19 rotameter.

The size of charge in the tank was registered by the electrostatic voltmeter. Conductivity was measured by the electrometric amplifier "У1-6" with the adjustable source of current. Inductivity was determined by the pathways of alternating current 19 (P- 570). Determination of specific resistance and inductivity were conducted discretely by sampling. In this fuel chart there are a few mechanisms of electric charge formation: at flowing in the pipeline, filtration and due to splashing of fuel in the tank. In this connection the measuring chart suggests control of charge that occurs, on three sections of the bench: in the pipeline, onthe filter and in the tank. Density of the charge that occurs in the pipeline is connected with the current of the outflow from the pipe walls of by the relation :

$$q_T = I_T / V_T \qquad (1)$$

where: q_T is volume density of the charge;

I_T is current of outflow from pipe the walls;

V_T is volume consumption of fuel.

While measuring V_T and I_T it is possible to determine the average value of q_T. Structurally sensor 16 (see ig. 3) which is made as a segment of the pipe with the diameter that equals the diameter of pipelines. For the elimination of obstacles the sensor is placed in a screen. As it has been above mentioned, density of the charge that occurs in thefilter is characterized by the size of current of outflow from the filter and by volume consumption of fuel through the filter according to the relation (4.2) :

$$q_{ф} = I_{ф}(1\text{-}e^{-t/\tau}) / V_{ф} \qquad (2)$$

where

Iф is current of outflow from the filter;

Vф is volume consumption of fuel (in our case it equals the consumption through the pipeline);

qф is volume density of the charge that occurs in the filter;

t is time of the liquid in the filter.

In equalization 2 the constituent e- t/&#964 takes into account the charge relaxation in the filter. Estimation of time of t and &#964 has showed that they equal about 0,08 sec. and 1,5 sec. accordingly. It means that it the constituent of equalization (2) can be taken for a zero. The experimental verification that consisted in registration of the current of the flow in the pipe behind the filter, showed the correctness of the above-mentioned estimation. Current of the outflow from the pipeline with relaxation in the filter (thefilter is grounded) and at its absence (the filter is electrically isolated from the system) was identical. Due to this it is possible to make a conclusion, that, the filter grounding of does not substantially influence the formation and distribution of thecharge in the system. It became the basis of the use of the filter as a sensor, on condition that it is electrically isolated from the test-bench by fluoroplastic insulators.

It is known that the charge obtained by the fuel in the filter and thepipeline, is being transported with it to the tank. On the way the charge is being dispersed in the pipeline. Therefore the size of the charge that got to the tank is less than the size of thecharge that occurred in the filter and the pipeline. However, there can be the formation of the charge in the tank due to splashing, interfusion, barbotage, besieging etc. For the estimation of the charge in the tank of the fuel test-bench inside the tank the electrode has been brought to the tank, which is isolated from the wall to the tank. The difference of potentials on the capacitor plates of the condenser is connected with the charge in the tank by the correlation:

$$Q_{б} = C_{o}Uk(h) \qquad (3)$$

where: Qб is the sum charge in the tank;

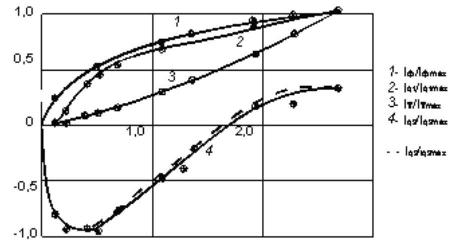
Co is a measuring reservoir: “the electrode - the tank” without fuel;

U is difference of potentials : “the measuring electrode - the tank”;

k (h) is a coefficient that takes into account measuring of reservoir of the system depending on the level of the fuel.

Experimental determination of the coefficient of k (h) from measuring of reservoirs in the function of height of the fuel level showed that its value has changed from 1 (at empty) to 0,99 (at full) tank. For the determination of time of relaxation and control of the results repetition measuring of specific resistance and inductivity has been conducted.

The research has been conducted on the aviation fuel TC- 1 at the following fixed values: temperature $T = 20\ ^{o}$C, $\rho = 4{*}10^{11}$ Om·m, $\varepsilon = 2{,}06$, $\tau = 7$ s, $\xi = 1{,}3$ sst. Dependence of current of the overflow from the sensor wall on the average speed of the flow is represented in Fig. 4 (curve 2) and it is by a function of degree with the index of degree 0,5 - 0,7. To make their comparison easier all the functions in Fig. 4 are presented in relative units. The maximal values of the investigated sizes are obtained experimentally. Deviation from the similar dependence that sets the index of the degree 1,5 - 2 known from literary sources is explained by the fact that at a limited length of the sensor starts the relation of time of the fuel in sensor and the relaxation time of the fuel. Time of being of fuel in a sensor becomes less to time of forming of double layer, the closeness of charge falls that is why. At the expense of 0,7 м^3/h through a pipeline with an internal diameter a 12 mm a fuel is in a sensor long a 320 mm during a 1 sec. Time of formation of a double layer is determined by the time of relaxation and specific resistance of fuel TC- 1, that equals 10^{11} Om and by the relative dielectric inductivity ε=2 that is 1,6-1,7 sec. By the known dependence that takes into account the relation t/τ, it is possible to eliminate the influence of the sensor length on the results of measures, defining I_{mo} - is current of the flow for a infinitely large length of the sensor (curve 3 Fig. 4).



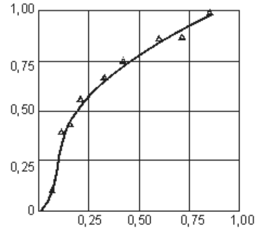
speed of the flow

Fig. 4. Dependence of electrization of fuel TC- 1 in filter (1) and the pipes to the filter (2) and behind the filter (4) on the speed of the flow.

The obtained dependence well coordinates with the known data [3, 6]. Density of the charge, which has been formed at a flow in the pipe, is found by the dependence (1). In order to compare the calculated results with the results of the experiment, some certain gradients of speed were determined on the verge of the viscous layer and the turbulent kernel. The lower limit of thelogarithmic layer was chosen as a limit. Determination *Δ* was carried out as follows. By the known dependence *Δ/Re = f(Re)* [6] for smooth pipes, the relation *Δ/R* was determined 916;/R at the investigated mode of the flow, that was set by a flow speed in the pipe, and then *Δ* by the known *R*. Value *grad υ(r)* was determined by differentiation *υ = f (r)* at the set motion:

$$\mathrm{grad}\, \nu(r) = \frac{4\nu_{\mathrm{cep}}(R - \Delta)}{R^2} \qquad (4)$$

Dependence of density of the charge formed in the pipeline on the gradient of speed of aviation fuel TC- 1 on the verge of the turbulent kernel is shown in Fig. 5. The character of the obtained dependence is similar to the dependence of density of the charge in the fuel on the gradient of speed that is obtained during at the laboratory research. It testifies the similarity of processes that take place in the pipe and measuring chamber and confirms the correctness of the conclusion about the determinative influence of the speed gradient on the process of division of charges.



speed gradient

Fig. 5. Dependence of the charge density in the pipe on the speed gradient of aviation fuel TC- 1.

Comparison of experimental dependences $I_т/I_{т\max}$ (Fig. 4) and $q_т/q_{т\max}$ (Fig. 5) shows that at a smaller length of the sensor, the current of sensor is considerably less proportional to the density of the charge obtained by the fuel at flowing in the long pipeline of the same diameter. As a matter of fact, already at $l=0,1\upsilon\tau$ we will obtain:

$$1-e^{-\frac{l}{\nu\tau}} \approx \frac{l}{\nu\tau}. \qquad (5)$$

Now the equalization for evaluation of the current of occurrence charges in the pipe is as follows:

$$I_т = kq \qquad (6)$$

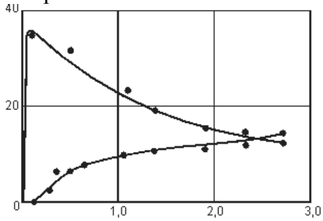
Fig. 4 (curve 4) shows change of the current of the sensor set behind the filter depending on speed of flow. Comparison of the current of the sensor to the filter (curve 2) shows that at the small fuel consumption the current of the outflow prevails, and as a result the direction of the sum current changed. When the consumption is increased the current of the outflow is decreased and at the large consumption there is less current that is provided by the fuel filling in the sensor. The sum current gets the same sign, that and current from the filter sensor, but its absolute value is less. An analytical conclusion results in the relation (7) :

$$I_{g_2} = I_т(1-e^{-\frac{lg}{\nu\tau}}) - I_ф e^{-\frac{lgф}{\nu\tau}}(1-e^{-\frac{lg}{\nu\tau}}) \qquad (7)$$

where: lgф is a distance from the filter to the sensor;

lg is a length of the sensor.

The determined by the formula (7) current Ig2 from the measured values Iт and Iф in the function of consumption is shown in Fig. 4 as a dotted line. It can be stated, that in the pipe of a small length the current found by the relation (7) equals the current of the flow only in the case when the uncharged fuel gets into it. At a hit in the pipe of the charged fuel a current from it is more difficult function of current of stream. With the increase of the speed the flow the current from the pipe is decreased in spite of the increase of the current of the flow. It is obvious, that ordinary estimation of the electrization degree by the current of the stream is wrong. The character of the processes which take place in the filter is probably similar to the phenomena in the pipes. This conclusion can be made out of dependence of the charge density in the filter on the speed of the flow of aviation fuel TC- 1 (Fig. 6).



speed of the flow

Fig. 6. Dependence of the charge density that occurs in the pipe and the filter on the speed of the flow of aviation fuel TC- 1 .

The largest density of the charge that occurs in the filter is observed at small consumption. With the increase of the speed, the charge density qф decreases and aims to reach a permanent size at a high speed. It can be explained by the same reasons that exist at a flow in the pipe. At a low speed of the flow the charge increases proportionally to the gradient of the speed. When value $\upsilon\tau$ becomes bigger than the thickness of the filter element, the double layer which is being destroyed by the forces of the hydrodynamic field does not have time to restore and the charge density decreases. At the infinite length of the pipe the size of the charge density approaches the permanent value and does not depend on the place, where it is formed - in the filter or in the pipe. As a result of theoretical and experimental researches it has been worked out and approved the device and the method of obtaining the electric energy of high voltage [7, 8], which are based on the positive use of the charges of static electricity, obtained by means of ICSE during the operation of hydrocarbon fuels. In Fig. 7 the basic chart of the device for obtaining electric energy of high voltage is shown.

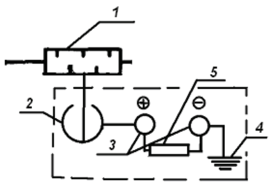


Fig. 7. Device for obtaining electric energy of high voltage : 1 - ICSE, 2 is a hollow metal ball, 3 is a discharger, 4 - grounding, 5 - loading.

The device works as follows: the charges of static electricity are constantly accumulated in the parts of the technological equipment and by means of ICSE 1 are taken on the metal ball 2, and then on the discharger 3, one end of which is connected to the ball 2, and the second with the ground 4. To the discharger 3 loading 5 is added, voltage on which brings to occurrence of electric current in the electric chain. Changing the size of the gap of the electric discharger manage the receipt of necessary size of potential on metallic to the bullet 2. In case of occurring of a dangerous level of potential an air discharge is provided and for this reason the discharger 3 is grounded. From the technological equipment (see Fig. 3) the charges of static electricity take ICSE 16. But unlike its standard application, when after it the charges of static electricity are take into the ground, in this method the charges of static electricity from ICSE 16 are taken to obtain electric energy of high voltage (Fig. 9) to the device, that allows to get electric current of high voltage of 20-30 kV.

Conclusions. The performed bench experiments of electrization of dielectric liquids at a flow in pipes and filtration showed the following basic results: analysis of the phenomenon of electrization and objects of its origin had been carried out; dependence of the current of the source from the sensor wall on the average speed of the flow has been set; dependence of electrization of fuel TC-1 has been confirmed in the filter and pipes to the filter and behind the filter on the speed of the flow; dependence is set of the charge density that occurs in the pipe and filter on the speed of the flow and the gradient of the speed; influence is set of the speed of fuelling speed on the value of the extra charge in the tank; a new device and a method has been worked out for obtaining electric energy of high voltage from division of the charges in dielectric liquids.

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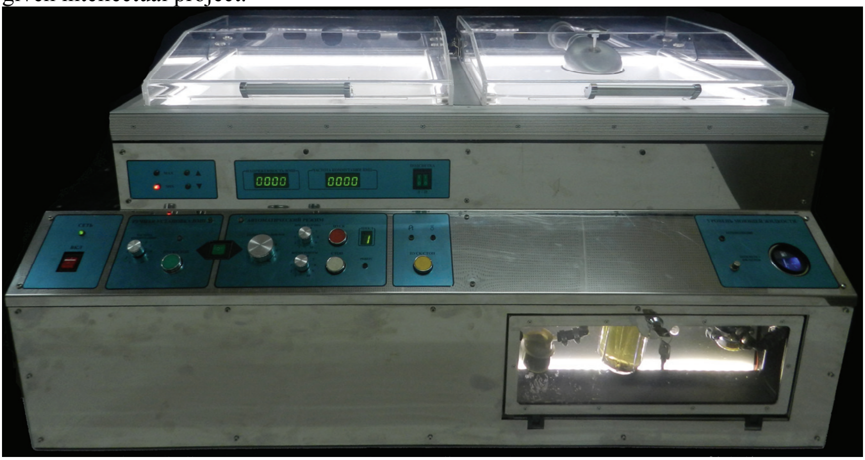
Non-contact pulsed magnetic turbulent cleaning of ball bearings in aviation engine building

Composed, rectified and appraised exploratory prototype of stand of non-contact magnetic –turbulent cleaning of ball bearings in assemblage. Method of non-contact cleaning of ball bearings in assemblage and exploratory prototypes of lodgments for aviation ball bearings has been developed. Evaluation of effectiveness of developed method has been conducted on created exploratory prototype of stand in production conditions.

Laboratory of nanotribotechnologies of National Aviation University has ended development of a new technology of preoperational preparation of undismountable ball bearings, which allows removing metallic and charged metallic-abrasive particles and other impurities from their work surface with the help of combined impulse electromagnetic and turbulent fields.

This technology, as an approach and device for its realization are protected by invention patents, and also by international patent RST [1, 2]. There is favorable conclusion of official authority of international organization of intellectual property (WIPO) about scientific novelty, practical realizability and patent novelty of the given intellectual project.



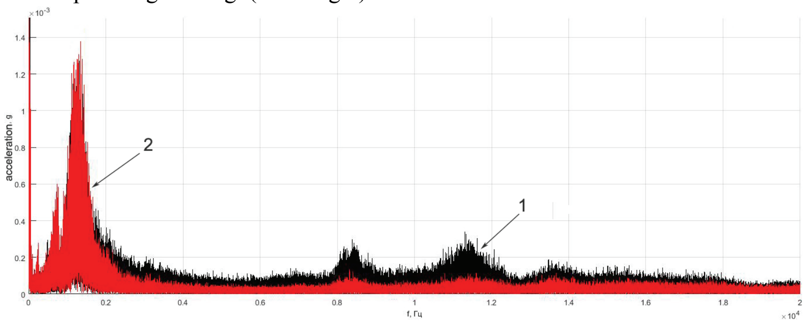
Drawing.1 Layout of CBB (Cleaning of Ball Bearings) stand

Traditional hydrodynamic, ultrasound and combined methods of cleaning of ball bearings do not allow removing those ferromagnetic and metallic-abrasive particles, which are charged in the surface of ball bearings' details, and also particles, which are kept by local electromagnetic fields on the surfaces boundaries of blast furnace-structured ferromagnetic details of bearings.

Aviation engines, from the point of view of mechanics present hardest complex of different friction knots (tribosystems) including rolling bearings. That's why technical condition of each tribosystem mostly determines working efficiency of each knot, assemblage and work piece (engine) in whole, according to these requirements of the reliability of each friction knot within regulations. Identifying feature of aviation ball bearings is that fact that they are hugely more expensive than similar with equal standard sizes of bearings of mass production used for mass consumption in general engineering, and also high (hugely more) bigger assets comparable to overhaul operation time of GTE (Gas-Turbine Engine) and its assemblage. That's why complete replacement of expensive ball bearings in the course of thorough overhaul of GTE – is one of the quite substantial expenditure item, which is incurred by overhaul agencies and, ultimately, airline companies-travel suppliers. Losses from unjustifiably often and premature replacement of airline ball bearings in the course of periodic overhauls of knots and assemblages of GTE are estimated from 10 to 25% of thorough overhaul cost.

Development of new highly effective methods of renovation of undismountable ball bearings is a vital task, decision-making of which allows cutting down exploitation expenditures for overhaul of airline technique substantially.

Presented technology of preparation of such a complicated tribosystem, as a ball bearing, on GTE stands allows to level down noises and vibrations substantially (up to 30%), to increase the resource of new, as well as used rolling tribosystems, which is vitally important for engine-building, assembly and another rotor products of aerospace engineering. (Drawing 2)

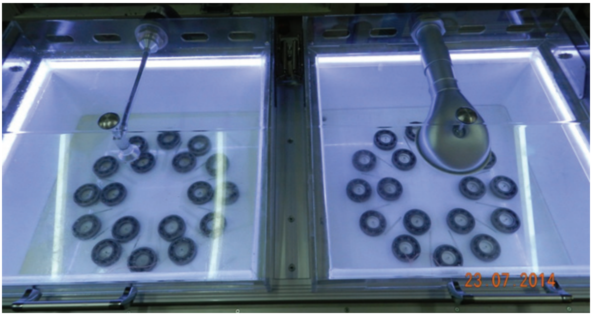


Drawing 2. Comparison of spectra of vibrational acceleration before (1) and after cleaning (2) of ball bearing on CBB stand under other equal conditions of stress load and rotation frequency

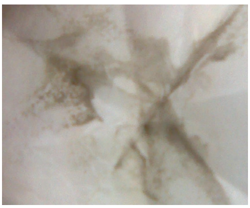
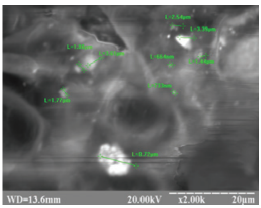
The given technology allows substantial improvement of quality of solid particles' removal, as well as hydrocarbon deposits and structure formations on rolling surfaces of overhaul bearings after long exploitation under conditions of high temperatures.

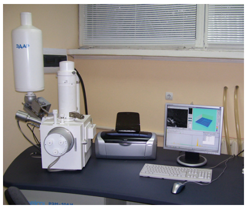
Besides, CBB stands allow improving methods of cleaning of ball bearings in assemblage, for instance, it is recommended to implement them not only in the stage of bearings' renovation in the course of GTE overhaul, but also as preoperational preparation of new bearings.

Provision of high purity of all surfaces of GTE details and ball bearings in particular while assembling new GTE is an actual problem in serial production. New plant ball bearings with preservation oil or lubricant, in vacuum package depressive, are cleaned and undergo ultrasound cleansing [3, 4]. Afterwards these bearings are installed into the camera of cleaning of CBB stand and undergo influence of combined impulse magnetic-turbulent fields on their surfaces in the environment of aviation kerosene TC-1 (Drawing 3).



Drawing 3. Layout in the course of cleansing of ball bearings in the left camera and simultaneous dewatering and demagnetizing in the right camera

a) 


b) 

Drawing 4. Distant particles from bearings of the first category (a), which has been studied in scanning electron microscope (b)

In a few minutes of such procedure in the bottom of camera accumulation of microscopic metal particles is viewed (5-50 mum), which are rushed out into the distant from bearings zones, where they are kept. Estimation of their sizes, quantity and chemical composition allowed determining range of regularities, which allowed optimizing regimes and duration of procedure of preoperational preparation of ball bearings directly before their installation into product (Drawing 4).

The given technology, besides aircraft industry finds wide application also in other industries of engineering from micro-mechanical systems of computer technique to automobile transport and underground railway system.

Innovation technology of preoperational preparation of aviation ball bearings on CBB-05 stand with the involvement of supervision module of their vibration characteristics «Kamerton 0001» in 2015 has undergone the wide approbation in the range of air transport enterprises and has received the high estimation of specialists, who recommend its usage while reconstruction and overhaul of bearings of engines of D-36, D-136, D-436 families and their modifications [5].

Nowadays the given technology of preoperational preparation of aviation ball bearings on CBB stand is penetrated into production, as progressive science based product, which allows substantial enhancing of quality of production and overhaul of GTE, increasing reliability of aero engines and, in such a way to increase the flight operating safety.

Conclusions

1. In the course of optimization of the speed of movable magnetic field it was established the appearance of involuntary movement of micro particles of pollution of ferromagnetic and another nature from the surfaces of bearing details into the area of maximum stress of magnetic field and their accumulation in this area.

2. Effectiveness criterion of cleansing of model rolling bearings after the total level of vibrations there has been chosen the presence of fairly large number of pollution, removed from new preserved ball bearings of FAG and SKF production, and also from used ball bearings after their preliminary cleaning by ultrasound methods using the modern equipment.

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Comparison of differential-phase method and method of dynamic focusing in defining of roughness parameters of surfaces

In this work you can find information about differential-phase method and method of autofocusing, which are used on differential-phase laser scanning profilograph-profilometer (DFLSPP) and microscope «MICROSCAN» correspondently. Also is considered experimental comparison of defining of 3D micro- and nano-geometrical surface conditions and standardized roughness parameters of surface with the help of those methods.

Almost all modern machines and mechanisms consist of friction nodes, which realize contact interaction of details with working surfaces in relative motion between each other. From tribology of boundary greasing it is known that there is great influence of surface roughness on tribological properties of rolling or sliding tribosystems. Due to this fact during production of details different quantitative methods for determination of roughness parameters are widely used (such as profilograph-profilometer CALIBR-201, “TEYLOR HOBSON”, “SURTRONIC-10”. Contac methods allow describing micro-geometrical surface structure only according to single profiles and they can’t give information about volumetric surface condition, which is very important during friction in dependence of direction of exploitation and influence on wear resistance of tribosystem.

Nowadays contactless optical methods and equipment such as laser contactless differential-phase method and method of dynamic focusing (in DFLSPP of Ukrainian production [2] and microscope “µscan” of German production correspondently) are used instead of contact, less informative and destroying methods. This new equipment and methods can give essentially new, qualitative and quantitative information about volumetric 3D micro- and nanometric geometrical surface condition. In this work are presented results of experimental investigations of rough surfaces done with a help of DFLSPP and “µscan”.

Today for controlling of working surface roughness of details with friction nodes contact methods still are used. In contact method needle with a circular diameter 2…4 mkm slides on a surface of sample in a linear direction. This method can be used for determination of wear traces after tribotechnical tests.

After experiments done on friction machine with a constant linear contact radial deviations are more then 1 micrometer, axial- 0,1 micrometer. That is why we can say that one of the main factors, which influence on results of tribological experiments of lubricating materials, is external structure of working surface of samples after friction.

But usage of contact method can provide us with necessary information about structure of surface, and can’t give full information about surface, such as roughness in a direction of sliding. This information have influence on character and value of wear [1].

Moreover, equipment which is based on contact method can scan surface only in one linear direction. In such conditions it is very hard to make volumetric estimation of surface structure. Indentor (needle) which is used for estimation of friction surface have circular radius (approximately 2 micrometers). That is connected with technological features and design of equipment and sensitive elements, which realize this contact method. Because of that we have such consequences like that hardware can’t fix geometrical character of surface if it has roughness less than diameter of needle. That is why only contactless optical method can provide us with full information about 3D volumetric surface structure.

DFLSPP of Ukrainian production was created for reception of true information about surface structure and reception of differential-phase picture. Principle of action of this equipment is based on acoustic-optical scanning of object with the help of laser beam, which is divided in two orthogonal directions in crystal of parateluryte. During scanning this beams are reflected from surface creating 3D differential-phase picture (fig. 1).

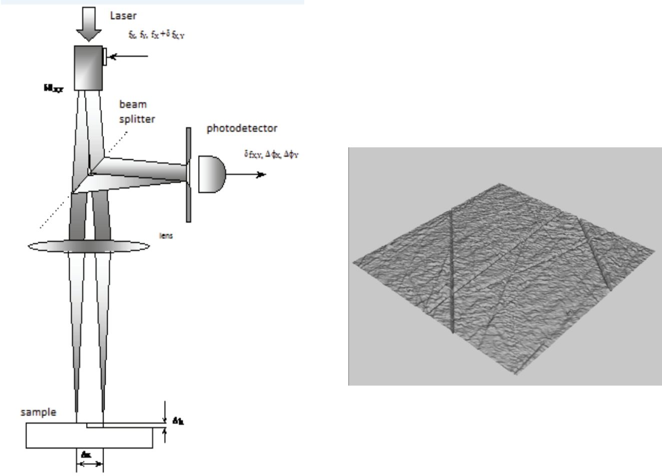


Fig.1. Laser contactless differential-phase method

For investigation of phase changing from reflected light waves in surrounding is used differential-phase method. This method allows creating optical scheme tolerant to vibrations.

Method is based on reception information about local difference of phases of two beams (basic and alarm), from which we can receive information about local curvature of wave front surface by scanning and integrating of defined values [3].

METHOD OF DYNAMIC FOCUSING Microscope μscan of German production by firm NanoFocus [4] was created for the same purposes as DFLSPP. But principle of action of this microscope is not the same. It has focusing sensor and movable lens, which provide auto-focusing by moving of lens along measurement scale (fig.2).

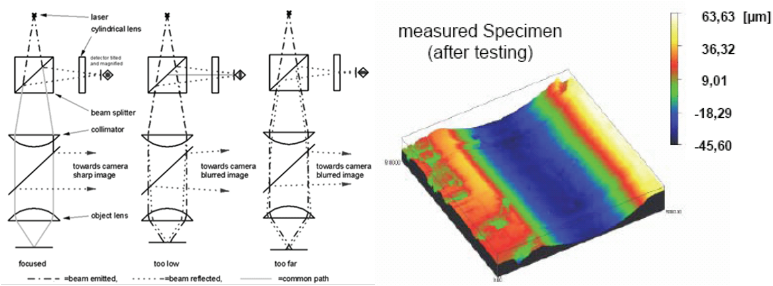


Fig. 2. Method of dynamic focusing method

Investigated object moves under laser beam with the set speed and information about moving of movable lens in dependence of height of surface relief goes to computer. The more focused points we will have the better picture will be received. The maximal investigated area is 10x10 cm^2.

Important peculiarity of DFLSPP and microscope µscan is possibility to define and calculate volumetric structure of rough surfaces. Software of that equipment allows defining main roughness parameters of investigated surfaces of samples. Both microscopes have different methods of calculation, that is why they also have different technical characteristics. Thus on DFLSPP can be calculated standardized roughness parameters of samples in a range 0,005…0,320 micrometers and on µscan in a range 0,025…1250 micrometers (Table1). But on microscope µscan this calculated roughness parameters are also compared with international standards ISO, which can be chosen for different materials.

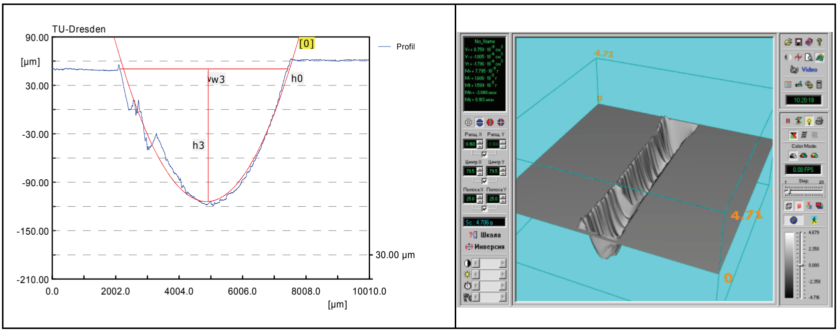
Also it has to be mentioned, that very important parameter during investigations of the sample is its reflection ability. For DFLSPP can be also investigated objects with reflection ability less then 50%, bun in this case lenses on profilograph-profilometer should be changed.

Microscopes Nanofokus and LDFSPP are used for definition size of deterioration of modeling bearings of sliding after friction in laboratory conditions. In the pic. 3 are presented profile of trek after friction, received on a microscope Nanofokus in the laboratories of the Tribotechnics of ILK TU Dresden and 3D image of a trek after friction received on LDFSPP in laboratories Nanotribotehnology NAU Kiev.

Table 1

Technical characteristic of microscopes

№	Technical parameters	Microscope			
		DFLSPP		µscan	
		Type of objective lens			
		PLAN, F=6,3, A=0,65	PLAN, F=16, A=0,3	autofocus	
				AF2	AF5
1	Max.scanning area, mm	2,5×2,5 0,8×0,8	5×5 3×3	100×100	
2	X, Y- resolution, mcm	0,8	0,6	1	1
3	Curvature of surface, degree/mcm	20	8	26	**19**
4	Reflection coefficient of the surface, %	≥50		0…100	
5	Height of measured step of relief, mcm	≤0,32		≤1500	
6	Resolution for relief, nm	≤10		≥25	
7	Type of scanning	Acousto-optical		mechanical	



a) b)

Fig. 3. Profile of trek after friction by NANOFOCUS (a) and 3D view of trek after friction by LDFSPP (b)

CONCLUSION

Choosing equipment for estimation roughness parameters consumer need technical and economical comparison of this equipment to decide which one is better for purchase. Comparison of technical abilities had shown that differential-phase method has next advantages:

- Is insensitive to vibrations;
- Microscope can provide measurements of surface parameters to 1 nm on height of relief;
- Investigated object is immovable;
- Object with any size can be investigated.

But in this method we don't have autofocus and have not so big working range (height of relief can be measured in range 1…320 nm). Disadvantages of differential-phase method are realized in method of autofocus. And we can name its advantages:

1. Wide measurement range;

Autofocus;

2. Sample with surface with any reflection coefficient can be investigated.

In method of dynamic focusing we have next disadvantages:

1. Sensitivity on height of relief is smaller then in DFLSPP;
2. Mechanical scanning, which lead to vibrations and decrease sensitivity of microscope.

Comparison of all this advantages and disadvantages, general technical characteristics and price of this equipment show that such investigations are very important for consumers for making of an optimal choice of microscope for work in definite conditions.

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Tribo-cavitation effect for aviation kerosene

For example, the linear contact tribo system slide shows that fuel systems together with hydraulic and acoustic cavitation arises "tribo cavitation" occurring in diffusion areas of friction units and downward pressure on local pressures to lower pressure values and cavitation threshold.

Analyzing the current state of Tribology, U.M.Luzhnov monograph [1] points out that «in view of the complexity of the processes that form the friction, there is currently no consensus yet on its nature». To date, friction and wear are considered from the perspective of disparate terms and notions about the nature of friction.

In 2008 was hypothesized compression-vacuum friction nature [2], which was his first experiment and demanded more reasoned evidence, part of which is presented in [3].

Established laboratory machine friction one-way linear sliding contact (fig.1) implementation of optically transparent contact. You can adjust the speed and axle load compression rubbing surfaces that enables basic modes of friction (hydro, elasto-hydro dynamical and friction in the face of marginal lubrication).

As a rotating counter body reproducing the shaft, made Teflon video (outer diameter is 80 mm, width of roll-9 mm) flat fixed parallelepiped was made of optically transparent material (disoriented Acryl glass).

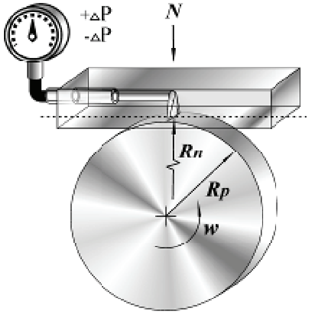
In the air, without lubrication, the surface forming vertical cylinder flat face clear movie box forms a linear contact in the form of a narrow rectangle. The length of the zone of such contact is clip 9 mm and the width of the axial force compression 4 N 0.7 mm and 40 mm h-about 0.8.

As a working environment has been used lubricating kerosene or TS-1, as a transparent, low-viscosity where friction sliding speed (0.2 ... 0, 8 m/s) and small loads (1…10 v) occurrence of hydrodynamic contactless friction is unlikely.

Experimental Conditions varied: linear speed gradually changed from 0.2 0.9 MPs, axial load changed between 4 and 200 m. after the linear contact around a symmetrical relative to line contact spot kerosene by wetting those surfaces (fig. 1).

Roughness of the surface of the roller set sufficiently broad and technically implemented in industry range from the r option and from up to 0,8 μm 20nm.

Visual phenomenon. When you turn on the drive roller casting cylinder Surface friction slip on the bottom edge of the transparent parallelepiped shape is flat in the perpendicular line contact direction. Viewing kerosene made roller contact, in a certain light, revealed, regular and natural behavior layer of kerosene simultaneously in two ways: through the side and the top edge of the transparent parallelepiped shape (fig. 2).



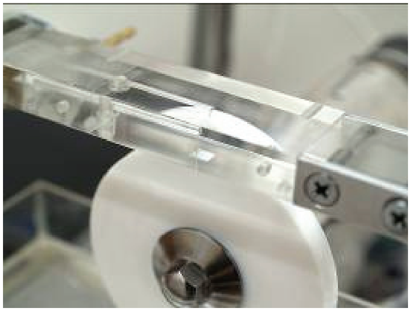
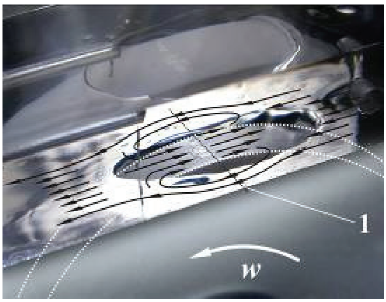
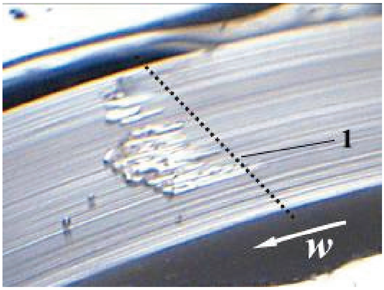


Fig. 1: diagram of machine friction with the top position of the contact (s) and the emergence of linear contact lubricated kerosene, visible through the side edge of the box

Sufficiently thick layers Caught roller kerosene delivered contact, along the edges of it started wrapping obstacles formed the contact, then these surface fixed prisms for macroflows meshed contact. While there has been a shift towards the most stains, soak the reverse direction. After establishing a permanent operating speeds, when the contact area under a certain angle, there has been a very intense, visually seamless fluid bolus passage of kerosene from the contact area for input clip into contact with the bottom surface of the box in the direction opposite to rotation. On exiting the working surface of contact visually observed intensified and continued for kerosene from wetting surface prisms of kerosene-contact, i.e. the slip road. The current kerosene when slide shown in Figure 2.



a)



b)

Fig. 2. *the current liquid surface friction sliding clips on flat edge of the box (a) and the formation of cavitation bubbles in cavities and linear contactdiffusion area (b), where 1 is the center line of contact surfaces*

Increasing speed of sliding clips on the surface of a 3D box led to greater offset pin spots of kerosene in the direction opposite direction of rotation. When the monitored heterogeneity of kerosene "from the contact area of the sign-clip in touch, and" contact "in the area access clip from contact became more intense. The same happened when you increase the load, at constant speed.

Gradual bring speed to 0.3 m/s, in the area access clip from contact in layers of kerosene was the emergence of gas bubbles which moved in the direction of slip, they made a moving surface generatrix clip over a distance of about 5 mm from the contact and then disappeared. Traffic generated gas bubbles (fig. 2 g) about contact took place against Jet currents of kerosene to "contact us" on the clip. These bubbles were randomly over the full width of the linear contact due to cavitation of kerosene. For kerosene TC-1 at 20 ^{0}, vapour pressure, in a State of dynamic equilibrium with the liquid phase is 919.9 PA at the liquid to the steam volume 4: 1. Hence, the vacuum in the area access clip from contact with speed 0.3 MPs and slight axial load of 4 h. That is, in the case of vacuum pressure boundary layers to below 919.9 PA. Further increases in speed resulted in an increase in the intensity and the number of bubbles that are merged and the eruption of steam-gas cavities. The latter took shape, similar to "flames" (fig. 2 g) with base in the middle of the field contact oscillating towards sliding on land-clip out of contact.

When you change direction sliding kerosene closely observed flows, also changed its direction in the opposite direction of the skid, "contact" in the field of log clip into contact with the surface of the box and "contact" in the area access being rubbed surface out of it. Change the direction of gliding almost symmetrical diversion caused contact currents.

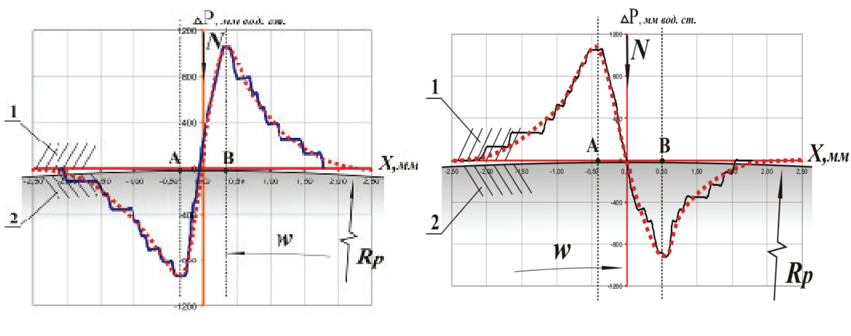
Thus, there has been a regular postback visually track friction currents kerosene near contact zone. The emergence of such currents caused by increased pressure in the resulting convergent channel in the direction of rotation of the cylinder and symmetrical relative minimum gap intake-diffusor channel, i.e. friction is a deformation resistance: its compression and evacuation operations.

Measurement of pressure distribution in contact: For pressure distribution measurement in contact area, inside the box are the channels that the contact surface came out as a hole or slot, probe (receiver) sphygmomanometers in lubricating layer to the side of the box via the choke off the brink joined pressure gauge to measure static pressure in contact and near contact areas by means of scanning contact appropriate probe

Measuring pressure in layers of kerosene near contact zone in the middle pane contact to the midline using resistive sensors pressure MDD-0-1. Sensing was step 0.05 mm.

Measurement results (fig. 3 a) showed that the pressure in the kerosene for login clip in touch increases of 2 mm to contact parallelepiped shape with rotating roller. Then, the front edge of the input pins, reaching a peak of over 1000 mm water column pressure dropped rapidly and declined to about the middle of contact atmospheric. A further shift of holes in the area access clip from contact resulted in diluted pressure reached extreme (about 1000 mm water column), but now below atmospheric and also on the edge of contact area output movie out of it. When you move the probe from the contact pressure kerosene, remaining below the atmospheric reliably began to gradually increase and atmospheric also leveled approximately 2 mm.

Conducted a similar measure, other things being equal, but in the opposite direction sliding (fig. 3) almost symmetrical inversion data demonstrating a plausible connection contact currents of boundary layers on the sending of slip. That is, as happened at the entrance to the contact pressure kerosene, and leaving him down on the air.



3. b)

Figure 3: distribution of pressure Δp at boundary layers of kerosene TS-1 Depending on the coordinates of the scan, perpendicular to the contact with slip-x, where AB is the width of the linear contact parallelepiped shape 1 and clip 2 with a radius R_p,ω-rotational speed, N-thrust compression, X-axis scanning

a) clockwise rotation; b) counter clockwise rotation

When you change direction sliding ceteris paribus pressure boundary layers of kerosene or TS-1 grades have changed for the middle of contact as well as visually observed lines (fig. 3). In the field of log clip in touch with parallelepiped pressure kerosene has edge contact has reached its maximum, and about the middle of contact has decreased to air. Then also jumps occurred in downgrading pressure kerosene layers that are scanned to a minimum, and in the area access clip out of contact, remove the probe from it fades in the measured pressure began to ambient pressure.

Consequently, adhesive force of friction (99% of the total friction force) that occurs at the edge-polymer tribocontact with lubrication as a result of the downward pressure environment between surfaces, moving towards diffusor of contact. Vacuolization environment between being rubbed surfaces, is one of the fundamental physical processes that are causing wear and friction surfaces.

Averting a decrease of pressure between surfaces of friction in the lubricant, the edge, such as the various techniques described in the paper [3], tribosystem slip can become almost wear-free.

CONCLUSIVES

1. Set a gradient aviation kerosene pressures on both sides of the contact type "tribosystem sliding shaft-sleeve" and, when entering in contact pressure is increasing, and by its withdrawal – falls on barometric pressure. These pressure differentials are causing Jet currents environment against the direction of rotation shaft.

2. it is shown that higher axial load and sliding velocity increases compression kerosene "at the entrance to the «contact» and its degree of dilution," contact ". These areas of high and low pressure kerosene symmetrical in relation to the maximum contact strain that exceed the length of the contact.

3. the example tribosystem slip with linear contact shows that fuel, oil or other hydraulic systems together with hydraulic and acoustic cavitation, there may be «tribo-cavitation» occurring in diffusor areas of friction units and downward pressure on local pressures to lower pressure values and cavitation threshold.

4. Confirmed the hypothesis coherent nature of friction and wear of the vacuum in aviation kerosene, which can be comprised of three sections of Tribology flowing, elasto-hydro dynamical and friction in boundary lubrication.

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UDC 665

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The noise of the airplanes as a source of energy

Abstract. Prospects of structures based on piezoelectric effect. The principle of sound vibrations management using products based on piezoelectric materials is described.

All of the airplanes make noise, and reactive – more than most other. As a result the level of noise, especially around the airport, is increasing as quickly as on airlines goes more and more jets and their power is going up. At the same time public disturbance is growing up too, so aircraft designers need to work hard to make airplanes noiseless. Why it is necessary to reduce the noise level? The researchers found that noise can destroy plant cells. Experiments have shown that plants which are subject to the noise load are wither and die. It is happening because of excessive secretion of moisture through the leaves: when the noise level exceeds a certain limit, flowers literally let the tears. Also, prolonged noise adversely affects the hearing organ, lowering sound sensitivity. It leads to a disorder of the heart, the liver, to the exhaustion and overvoltage of the nerve cells. Below is a table that shows the noise scale and the human perception of this noise (table 1) [1].

Table 1 – Human perception of the noise scale

Decibel, dB	Characteristics	Sound sources
50	Clearly audible	Conversation, typewriter
80	Very noisy	Shout, motorcycle with a silencer
95	Very noisy	Subway car (in 7 meters)
100	Extremely noisy	Orchestra, subway car (intermittently), thunder The maximum permissible sound pressure level for headphones player
105	Extremely noisy	In airplane (till 80-s)
110	Extremely noisy	Helicopter
115	Extremely noisy	Sandblasting machine

Continuation of table 1 - Human perception of the noise scale

<table>
<tr><td>120</td><td>Almost unbearable</td><td>Jackhammer</td></tr>
<tr><td>125</td><td>Almost unbearable</td><td></td></tr>
<tr><td>130</td><td>Pain threshold</td><td>Airplane at the start</td></tr>
<tr><td>140</td><td>Contusion</td><td>The sound of soaring airplane</td></tr>
<tr><td>145</td><td>Contusion</td><td rowspan="3">Rocket start</td></tr>
<tr><td>150</td><td>Contusion, injuries</td></tr>
<tr><td>155</td><td>Contusion, injuries</td></tr>
<tr><td>160</td><td>Shock, injuries</td><td>The sound of soaring jet</td></tr>
<tr><td colspan="3">When sound levels above 160 dB – possible disruption of eardrums and lungs, above 200 dB – death</td></tr>
</table>

According to the regulations of the World Health Organization [2], cardiovascular diseases can arise if a person is constantly exposed to noise level of 50 dB at night – this level of noise can produce the street with a light traffic. To earn insomnia it is enough a noise level of 42 dB, to become irritable – 32 dB (the sound of the whisper).

For example, airport “Borispol” has a lot of night flights. Arrival frequency of airplanes is 3-4 airplanes per hour. Airport is located at a distance of 1.5 km from the living area. The sound that comes to a living area is 50-60 dB, which is enough to earn cardiovascular diseases (pic. 1).

To prevent the effects of noise on humans and the environment scientists have begun to look for ways to solve this problem [3].

Research engineers from Ducommun Miltec, an aerospace contractor, realised the incredible roar of the jet engine, which revs at more than 130 decibels (enough to induce pain), could be changed into electrical energy. It can be possible with something called piezoelectric.

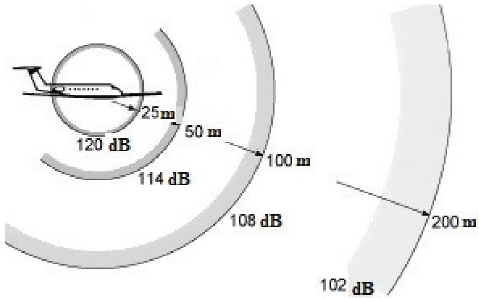

Fig.1. Sound propagation from aircraft

The direct piezoelectric effect takes the pressure and mechanical stretching and turns it into an electrical charge (pic. 2). This material is used in acoustic devices for the conversion of electrical oscillations in elastic and elastic vibrations into electrical [4].

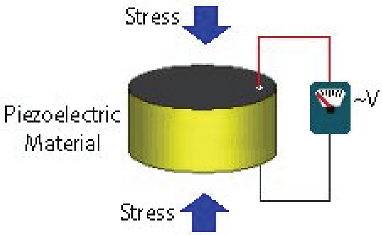

Fig. 2.The direct piezoelectric effect

Applying piezoelectric material, it is possible to build extremely sensitive thin membrane made of aluminum, which can convert the vibration caused by the noise of engine into electricity, which is enough to power a small sensor. The advantage of a sound-powered sensor is that you don't have to use batteries or wires to run the engine sensor, making it easier to maintain.

The next phase was to attach the membrane to a special liner that dampens engine noise by cancelling certain frequencies.

This process is based on the direct piezoelectric effect. The direct piezoelectric effect is the polarization in crystalline materials under certain deformations.

The charge quantity, which occurs when the piezoelectric effect, is given by:

$$q = d_{11}F_x,$$

where F_x – intensity of force which caused the deformation;

d_{11} - constant coefficient for crystal, called piezoelectric module.

The main technical characteristics of piezoelectric materials may be characterized by the following parameters, SI:

1. Electromechanical coupling coefficient

$$k_t = \sqrt{\frac{fa - fr}{0{,}405\,(2fa - fr)}},$$

where fa – resonant frequency (Hz),

fr – antiresonance frequency (Hz).

2. Material modulus

$$E = \frac{\sigma}{\varepsilon},$$

where σ – stress caused in the sample active force;

ε – the elastic deformation of the sample caused by stress.

3. Ratio of mechanical power on the piezo resonant frequency to the square of the amplitude of the electric field therein [5].

The efficiency of piezoelectric materials may be 40-70%. Other advantages of piezoelectric materials - high conversion efficiency and simplicity of design. That is why it is also used in:

Machine building and instrumentation:

1. Acoustics, optical instruments;
2. Electronic components;
3. Robotic equipment;
4. Safety and security equipment;
5. Medical equipment;
6. Military equipment, transport.

Conclusion

Using piezoelectric materials will reduce vibrations and as a result will reduce anthropogenic load on the environment and human health. It doesn't need huge energy costs. Thus, using thin membranes with piezoelectric materials it is possible to create materials and structures to control the characteristics of structural elements of aviation and civil engineering.

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UDC 66.081.544.77

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Saturation of hydrophilic/oleophilic granular structures with emulsions during imbibition process

This publication focuses on the hydrophilic/oleophilic porous media saturation with the emulsions as a result of the imbibition process. The results of experiments provided the possibility to define a dependence between the height of an imbibed emulsion front and porous structure saturation. The influence of the dispersed phase concentration and structure of granular medium on its saturation was investigated and discussed. The obtained results allowed to estimate the efficiency and peculiarities of two-phase liquids transport in the hydrophilic/oleophilic granular media driven by the capillary force.

Spontaneous imbibition as a physical phenomenon occurs in the porous media as a result of the capillary suction-pressure. The saturation has diverse explanations. However, in the currently discussed case it is represented as a volume of pores in a sorptive material filled with emulsions.

The saturation level is an important parameter in the sphere of liquids transport and frequently used to predict the effectiveness of applied sorptive materials due to describing the pore volume occupied by a permeant. The purpose of this research work was to study the saturation changes versus the height of penetration, and the effect of the dispersed phase concentration and fractions of beads in the granular media on this process.

Materials and Methods. The investigated granular structure consisted of spherical glass grains of 200÷300 and 600÷800 μm, which were produced by Alumetal-Technik (Poland). The porous bed revealed the hydrophilic-oleophilic properties. Its bulk density was equal to approximately 1600 kg/m^3 and porosity was ~0.36±0.01.

The stabilized-emulsions composed of a refined oil (EOL Polska Sp.z.o.o., Poland) as the dispersed phase and distilled water. The investigated two-phase liquids differed by the dispersed phase concentration, which was equal to 10, 30, and 50 vol%. The emulsion stability was obtained due to adding of a non-ionic emulsifier in fraction of 2 vol%. The emulsifier was composed of ethoxylated oleic acid (Rokacet O7, produced by PCC Exol SA, Poland). The granular medium saturation as a result of an emulsion penetration was investigated experimentally using the classical imbibition test. The tube with diameter d_t of 0.036 m was filled with the spherical grains and immersed in an emulsion in a beaker at the depth of 0.02 m. The height of emulsion penetration and imbibed mass were measured till the process reached a steady-state and values became unchangeable. After that, the granular medium was removed from the emulsion and its wetted part was cut into fragments with the defined size. The mentioned method of the investigation is precisely described in other publications [1, 2, 3].

The saturation level was calculated for each obtained sample of a granular medium in accordance with the following expression:

$$S_f = \frac{V_{im}}{V_f \varepsilon}, \qquad (1)$$

where S_f is the saturation level of a granular medium fragment f_n; V_{im} is the volume of an imbibed emulsion in this fragment f_n [m^3]; V_f is the total volume of this fragment f_n [m^3]; ε is the porosity of a granular medium sample.

Results and Discussion. The obtained data allowed to describe the changes of a granular medium saturation with the increase of the penetrated emulsion front in its structure. As an example, the results on medium (beads diameters of 200÷300 µm) saturation with 10%, 30%, and 50 % emulsions are plotted in Fig. 1.

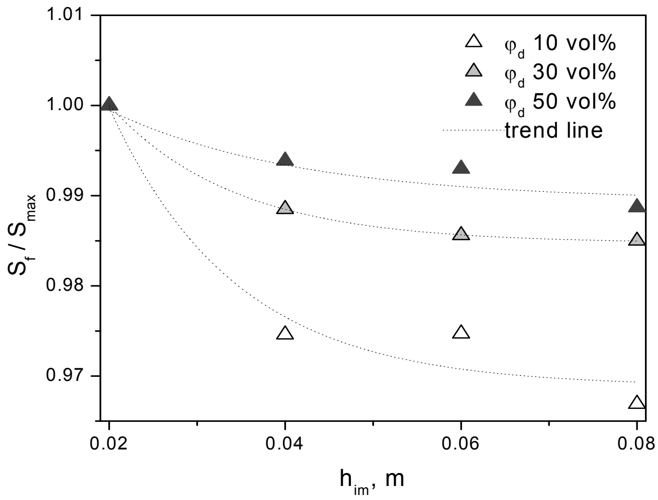

Fig. 1. Changes of the granular media saturation with emulsions versus the height of penetration (for d_b=200÷300 µm; ε=0.36±0.01)

On the graphs, the vertical axis represents the normalized value of the saturation level. It was calculated as a ratio S_f/S_{ma}, where S_f is the saturation of a granular medium fragment calculated according to Eq(1), and S_{max} is the maximal value of a fragment saturation in the investigated porous medium.

According to the obtained results, the highest level of a granular porous medium saturation was observed in case of 50% emulsions, but the difference between other emulsions was insignificant, i.e. ~1–3%.

The saturation of porous structures changed slightly with the increase of the height of emulsions fronts.

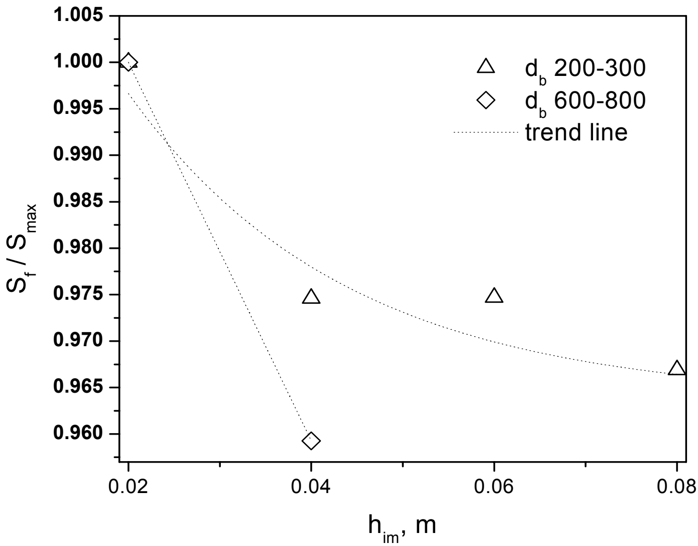

Fig. 2. Comparison of two granular media saturation in case of 10% emulsions

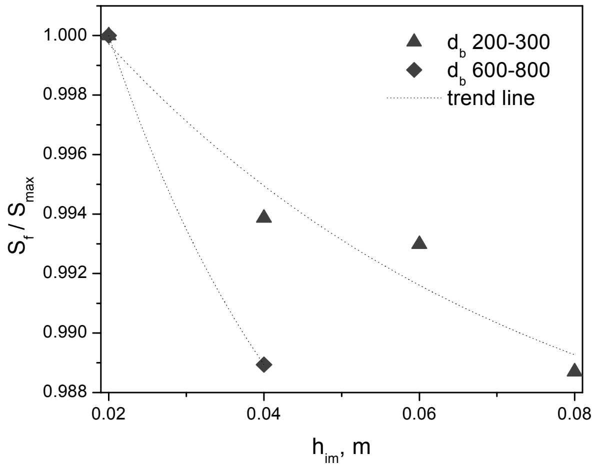

Fig. 3. Comparison of two granular media saturation in case of 50% emulsions

However, for the granular structure composed of beads with a fraction of 600÷800 μm, such variations were more appreciable and equaled up to ~12 %, as shown in Figs. 2 and 3.

The porous media saturation with two-phase liquids depended strongly on their morphology. According to the results obtained experimentally, the granular bed with lower beads fraction was characterized with the higher level of saturation and height of emulsions penetration in structure (Fig. 2 and 3).

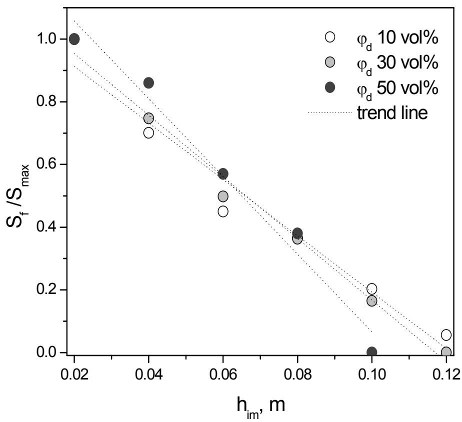

Fig. 4. Changes of the disordered porous medium saturation versus the height of emulsions penetration (for ε=0.93; nonwoven; polypropylene)

The results concerning the changes of the disordered porous structure saturation with the height of emulsion penetration are represented in Fig. 4. In contrast to the granular media, the saturation level decreased significantly with the increase of the height of permeant fronts (~10–30% per 0.02 m). Moreover, in case of 50% emulsions, the highest level of saturation was observed only at h_{im} <0.08m, after the tendency was changed, as shown in Fig. 4. For granular media, the saturation value was also the largest in case of 50% emulsions, but at all investigated heights of porous medium.

Conclusions

The analysis of the experimental data revealed the changes of porous structure saturation versus the height of emulsions penetration. It is of a practical importance in the fields of chemical and material engineering as well as in the sphere of the environment protection. The results proved that the initial dispersed phase concentration influence on saturation during imbibition process, but such effect is negligible in comparison with the effect of porous medium structure. For the investigated granular media, the highest level of saturation was observed in beds composed of beads with lower fraction, i.e. 200÷300 μm as the height of emulsion penetration.

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Process of hydrophilic/oleophilic granular media imbibition with oil emulsions

The discussed issue is transport of oil-based emulsions driven by the capillary pressure in the granular media. This phenomenon is of a practical importance in the different spheres, especially in the environment, material and chemical engineering. The imbibition process was investigated experimentally. The obtained results allowed to define the changes of an imbibed emulsions mass versus the height of their penetration in granular media. The effect of the initial dispersed phase concentration and granular media structure on imbibition kinetics was also analyzed.

Transport of a wetting liquid in a porous structure driven by the suction pressure is referred in literature as the spontaneous imbibition. This phenomenon is the fundamental process in a great deal of industrial technologies such as textiles and polymers production, printing processes, surface engineering, etc. [1, 2, 3]. On other hand, spontaneous imbibition is considered to be important in the sphere of the environment engineering as one of mechanisms of the absorption and migration processes in rock materials and soil layers.

The current work focused on rate of the different granular media imbibition with oil-based emulsions. The results of the conducted experiments can be used to predict the scenario of emulsions penetration in porous structures in case of the environment contamination or to develop the effective sorptive materials.

Materials and Methods. As previously mentioned, the investigated emulsions composed of a refined oil with the viscosity of 53.2±0.20 mPa·s and API density of 52.74°. The emulsions were stabilized by the non-ionic surfactant Rokacet O7 obtained from PCC Exol SA (Poland). The emulsifier was added in a fraction of 2 vol%. The prepared emulsions differed by the external phase concentration, i.e. 10 vol%, 30 vol%, and 50 vol%.

The porous media were represented by the granular structures composing of glass hydrophilic/oleophilic beads produced by Alumetal-Technik (Poland). Two types of media were studied, one was composed of the spherical grains with diameter of 200÷300 μm, and the second one had 600÷800 μm. The granular bed had the average porosity of ~0.36±0.01, and bulk density of ~1600 kg/m^3.

The imbibition process was investigated using classical test as described in the previous publications [4, 5]. The beads of the defined fraction were put into a tube with a diameter of 0.037 m and a height of 0.2 m. One end of the filled tube was closed with a membrane and immersed into an emulsion at the defined depth [4]. The changes of the imbibed emulsion mass and its height of penetration in a granular structure versus time were followed till process reached an equilibrium proved by invariability of investigated parameters values.

Results and Discussion. The experimental data concerning mass changes with the height of an emulsion front penetration are shown in Figs. 1 and 2.

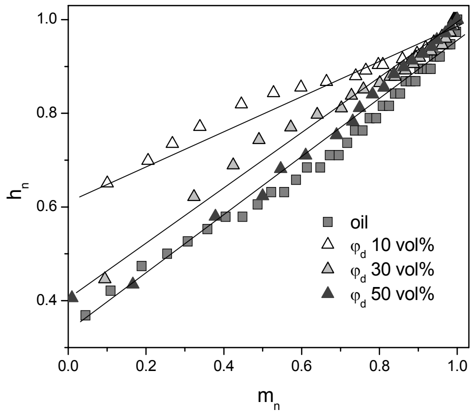

Fig. 1. Changes of the imbibed mass versus the height of emulsions penetration, for the granular medium with d_b=200÷300 μm

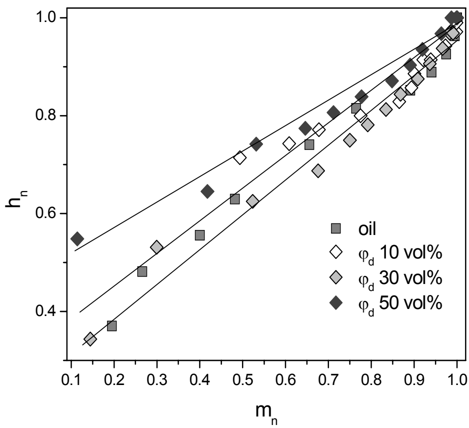

Fig. 2. Changes of the imbibed mass versus the height of emulsions penetration for the granular medium with for d_b=600÷800 μm

The vertical axis on the graphs performs the normalized values of the height obtained as a ratio h_{im}/h_{max}, where h_{im} is the height of a porous medium imbibition with an emulsion at time t_{im}, and h_{max} is the maximal height achieved by permeant in a sorptive material. On the horizontal axis, there are the normalized values of the imbibed emulsion mass. It was calculated as a quotient of m_{im}/m_{max}, where m_{im} is the mass of an imbibed emulsion in a granular structure at time t_{im}, and

m_{max} is the maximal value of an imbibed emulsion mass. According to the obtained results, the imbibed mass increased with the rising of the height of an emulsion penetration in porous structure. However, the rate of the discussed process was defined as meaning at h_n <0.06, and after it became to slow down, as shown in Figs. 1–2. In case of the granular bed composed of beads with diameter of 200÷300 μm, the highest rate of mass increase was obtained for 10% emulsions with the viscosity of 5.9 mPa·s (Fig.1). The observed tendency was almost the same for 50% emulsion (η=29.1 mPa·s) and pure oil (η=53.2 mPa·s), and was defined as the lowest in these experiments. It allowed to conclude that the viscosity of a permeant caused the significant influence on the mass increase with the height of penetration. For a granular medium with grains fraction of 600÷800 μm, the rates of imbibed mass changes versus the height varied dependently on the type of an emulsion, however such deviations were not so significant as in the previously discussed case (Fig.2).

Conclusions

To summarize, the imbibed mass increased with the rising of a liquid front height and its rate depended considerably on the dispersed phase concentration and consequently viscosity of a permeating emulsion. Moreover, the granular medium morphology, i.e. beads fraction, caused also the substantial influence on the process of mass increase with the height of an emulsion penetration.

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Sedimentation of microparticles in non-Newtonian fluids

Sedimentation of suspended particles is the important issue in study of fluid mechanics. On other hand, this pehonenon is considered to be complicated and requires complex approaches to be solved. In this publication, the new technique was proposed to investigate the process of suspension sedimentation in non-Newtonian fluid. The discussed method is based on turbidimetry and capturing of both a light transmission through the sample with suspensions and back scattering rate.

Sedimentation is the process of settling of solid particles falling in fluids as a result of the density difference. The mentioned process has many applications in industry and nature. Characteristic behavior of non-Newtonian shear-thinning fluid is frequently compared to the properties of mineral slurry. Moreover the most common use in the industry are exactly non-Newtonian fluids shear-thinning.

In literature, there is a plenty information concerning sedimentation in the Newtonian fluids [1, 2, 3, 4] using different measurement techniques such as photoacustic monitoring (PA) [5]; Laser Induced Fluorescence (LIF) [6]; dynamic ultrasound scattering (DSS) [7];Ultrasonic Doppler Velocity Profilers (UVPs) [8]; sedimentation image analysis (SIA) [9]; and the most popular technique of particle image velocimetry (PIV) [10, 11, 12]. There is also the increase of the number of publications discussing non-Newtonian fluids sedimentation [13, 14. 15, 19, 20, 21]; sedimentation of non-spherical particles [16, 17]; velocity of sedimentation [18]. However, there are a lot of issues need to be solved. There is need of new empirical data with well-known rheology of the tested fluids. Sedimentation at non-Newtonian fluids is still problematic and questionable because of many aspects which are noticeable during experiments [22]. The main phenomenon are: time effect, agglomeration of particles, wall effects, air bubbles, changing in time characteristic of fluid like viscosity, ageing of fluid. Sedimentation velocity as a particle motion parameter is not only a function of hydrodynamic force, but also a function of particle–matrix and particle–particle interaction. Various methods exist for the estimation of sedimentation velocity depending on the conditions and type of the suspension. In this work we will focus on turbidimetry and check whether it is possible to measure the velocity sedimentation at non-Newtonian fluids.

Materials and Methods. Solid micro particles in suspension are made of glass with a diameter of 105□m and a density ρ_s = 2600 kg/m^3 (Alumetal). Non-Newtonian fluids used in the experiment are a water solution an aqueous polymer solution of PEO (polyethylene oxide) of various molecular weight: $1*10^6$, $2*10^6$ and $5*10^6$ (Sigma-Aldrich). Poly(ethylene oxide) (PEO) is a flexible, non-ionic water-soluble polymer used in a wide variety of applications. [23] The measurements are also made at Newtonian fluids: vegetable oil with density ρ_{f1}=900 kg/m^3 and viscosity μ_{f1}= 56 mPas and silicone oil with ρ_{f2}=960 kg/m^3 and μ_{f2}=300 mPas. For these measurements are used identical particles as non-Newtonian fluids. In our work we use technology of multiple light scattering (MLS) with Turbiscan MA 2000. It's based on light source and two synchronous optical sensors. Electro luminescent diode in the near infrared (λ_{air}=880nm) send light to sensors: first one receive light transmitted through the sample and the second one receive light backscattered by the sample. The instrument detects changes in a sample, such as changing the particle size and concentration of the suspension.

Suspension preparation. PEO in powder form is dissolved in water and stirred by an electric mixer approx. 24h. After that it is poured into cells (used in Turbiscan). To each cell is added a measured amount of micro particles. Ready samples are leave for approx. 20 hours (for good wetting of the particles).
Prior to the measurement, samples are gently mixed to obtain a homogeneous suspension free of air bubbles. At the same time with the ongoing measurement in Turbiscan, take place measurement of the rheological properties of the liquid (Tab. 1) using a rheometer Anton-Paar.

Results and Discussion. Experimental sedimentation velocity compare with the theoretical velocity calculated according to the modified Stokes equation for sedimentation (Eq. 1) [24], is presented in the Tab. 1:

$$v = \frac{d^2(\rho_s - \rho_f) g \varepsilon^2}{18\mu_s} \tag{1}$$

where: v - sedimentation velocity, d - diameter of the particles, ρ_s - density of particles, ρ_f - density of the liquid, g - acceleration of gravity, ε - porosity and μ_s - viscosity of the suspension.

Table 1.

Experimental and theoretical sedimentation velocity in Newtonian liquids

Newtonian fluid:	Concentration of solids in suspension, φ [%]	Sedimentation velocity, v [mm/s]	
		Experimental	Theoretical
Vegetable oil	20	0,079	0,081
	30	0,081	0,050
Silicone oil	10	0,020	0,023
	20	0,014	0,015
	30	0,008	0,009

Similar results (Tab. 1) show good accuracy the chosen measuring method. For this reason, it has also been used for measuring the sedimentation of a suspension in non-Newtonian liquids In most practical cases, during the sedimentation of particles, we can observe more than one process, and on our results, we can also see it. Achieved results for one example are at Fig. 1, there are two charts, the first of them concerns the light transmitted through the sample (Fig. 1a) and the second - light backscattered by sample (Fig. 1b). The left side of the graph refers to the bottom of the cell, the right side to the top of the sample. At the bottom where it forms sediment can be seen a reduction in the value of transmitted light because the high concentration of particles is mainly caused its reflection - thus large increase in the value of the reflected light at the bottom of the sample. The central part of the sample is visible in the central part of the chart where the value of reflected light in time start to increase, which is equivalent to the formation of agglomeration between particles. Turbiscan creates during measuring the curve of sedimentation (Fig. 2), it allows us to calculate the average speed of sedimentation particles (Tab. 2).

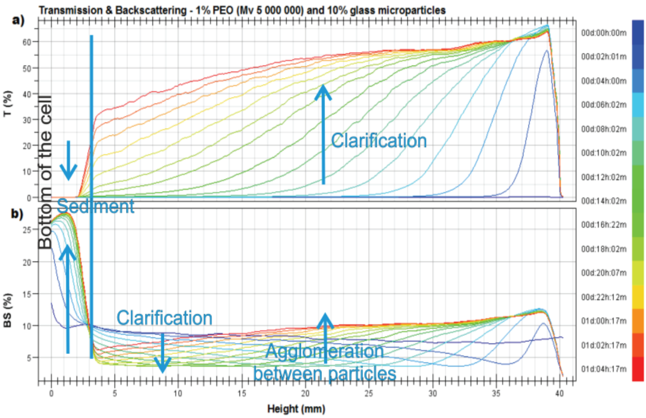

Fig. 1. Sample of 1% PEO ($Mv=5*10^6$) and 10% glass microbeads: a) transmission of light through the sample, b) backscattering light by the sample.

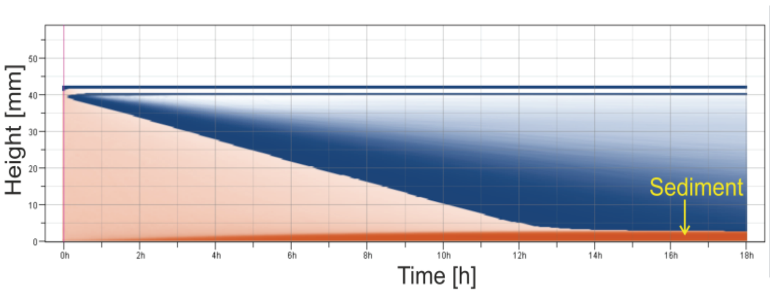

Fig. 2. Curve sedimentation from Turbiscan.

Sample of 1% PEO (Mv=5*106) and 10% glass micro particles.

PEO solutions of higher molecular weight in a high concentration have a higher shear-thinning properties to the solutions having a lower concentration and a lower molecular weight. We can see a relationship between the rheological properties of the fluid and the sedimentation velocity. The lower the value of fluid flow behavior index (*n*) and thus the higher value of consistency index (*k*) the lower is the sedimentation velocity.

Table 2.

Properties of fluids and some results of experimental sedimentation velocity

Molecular weight of PEO	Concentration of the polymer in water	Fluid properties			Concentration of solids in suspension	Sedimentation velocity
		density	consistency index	fluid flow behavior index		
Mv	*φ [%]*	*ρ [kg/m³]*	*k [Pasⁿ]*	*n [-]*	*φ [%]*	*v [mm/s]*
$5*10^6$	0,3	990	0,038	0,84	10	0,213
					20	0,127
					30	0,09
	0,6	991	0,35	0,68	10	0,012
					20	0,009
					30	0,007
	1,0	992	3,13	0,44	10	0,0008
					20	0,0007
					30	0,0005
$2*10^6$	0,6	993	0,09	0,83	10	0,07
					20	0,046
					30	0,035
$1*10^6$	2,0	994	0,62	0,85	10	0,008
					20	0,007
					30	0,005

Conclusions

Turbidimetry technique is considered to be convenient method due to providing the accurate results. The main advantage is the opportunity to observe other phenomena that may occur during the process of sedimentation. However, we still need more data, and the ability to compare the results with different measuring method. In the case of non-Newtonian fluid it is necessary to conduct measurement of the rheology of liquid simultaneously with the measurement at Turbiscan. Because as can be seen sedimentation velocity is dependent on the rheological properties of the fluid, and they must be known.

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Obtaining of alternative fuels from aquabiomass

The problem of traditional energy sources depletion were considered and the alternative fuels from aquabiomass obtaining in terms Ukraine were suggested.

Today, the question of alternative fuel obtaining very sound. Resources are exhausted and scientists have to find a way out of this situation through the development of alternative fuels. One of the such promising solutions could be the method of extraction of fuel from biomass.

First of all we need to consider alternative energy generation from biomass aqua and assess the potential of alternative energy generation from biomass aqua. World energy consumption refers to the total energy used by all of human civilization. Typically measured per year, it involves all energy harnessed from every energy source applied towards humanity's endeavors across every single industrial and technological sector, across every country. Being the power source metric of civilization, World Energy Consumption has deep implications for humanity's social-economic-political sphere. Global energy demand has increased significantly in recent decades. Between 1973 and 2007, global primary energy demand doubled. Even more energy will be consumed in the future unless energy efficiency measures are taken.

Algae biofuel can be grown virtually anywhere, on seawater and even wastewater. All that is needed is carbon dioxide, water and sunlight. Biofuels also release CO_2 and water when it is combusted. The key difference here is that the CO_2 is taken in by the plant (algae) during its growth and oxygen is released. CO_2 is re-introduced into the atmosphere only when the algae biofuel is combusted. Therefore, by using biofuels to begin with, we will not be introducing anymore carbon into our atmosphere that has been under the earth, it will only be recycling the carbon that was already in place. With this taking place, we would not be adding more CO_2 into our atmosphere which is causing global warming. When fossil fuels combust to produce energy, it will release CO_2 and water. Because CO_2 is a greenhouse gas, it is trapped within our atmosphere and is a major contributor to global warming. Thus, carbon in the fossil fuel that was trapped in the earth is now released back into our atmosphere as CO_2.

Fig. 1 Algal field

Algae biofuel is carbon-neutral . What do we mean by that?
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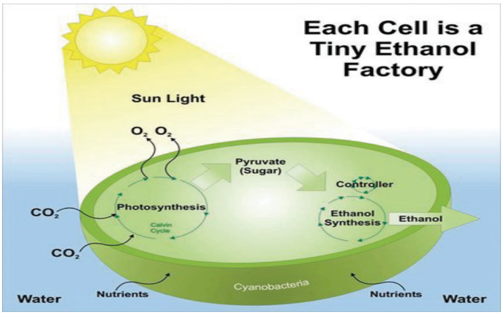

Fig 1.1. Chemical processes in algal cell

Water hyacinth is an aquatic tropical plant with unique qualities: it is able to reproduce ultra-fast and can purify water from various contaminants. In addition, water hyacinth perfectly acclimatized in the middle latitudes, and learned to survive even at zero temperature of water is a prerequisite for its rapid development is the presence in water of industrial and domestic waste water and waste, is a breeding ground for the plant. Already, researchers have learned how to get out of the green mass of water hyacinth biogas, 75% composed of methane and bio-oil.

One of the most promising areas of recycling water hyacinth – is to get biogas from its green mass, which used in the future for thermal and electric power generation by combustion. In 28 cubic meters of such biogas contains as much energy as 16.8 cubic meters of natural gas, 18.4 liters of diesel fuel, or 20.8 liters of oil. Production of oil from microalgae is an old idea, which keeps cropping up almost every decade, for 50 years now. Since the beginning of the new century, microalgae have persistently been considering as a possible good renewable source of diesel fuel. The algal fatty acids, converted into their methyl or ethyl esters, can be used as biodiesel. The idea has been fostered all over the world and often underpinned by wishful thinking proofs. In order to produce 1 kg biodiesel one has to grow nearly 12 kg dry microalgal biomass. At least 400 m^2 of open area ensures the daily amount of 12 kg algae if one stakes on the 365-days average yield of 30 g/m^2 dry biomass. The mean daily water evaporation of this area is 4 m^3.

Prior to conventional diesel fuel, biodiesel has a number of advantages, chief among them:

- It has lower level of harmful emissions, especially particulate matter (smoke);

- Practically neutral effect in terms of greenhouse gas emissions;

- Significantly better performance in terms of toxicity and biodegradability;

- Create less loading on engine (due to the lubricating effect exerted biodiesel) and, accordingly, increase engine life.

Advantages of algae:

1. Nonfood biomass and its use for the production of fuels does not endanger food security.

2. Grow in 20 ... 30 times faster than terrestrial plants (some species can double their mass several times a day).

3. Produce 15 ... 100 times more oil per hectare than alternatives rapeseed, palm oil, soya or jatropha.

4. The lack of hard shell and the virtual absence of lignin makes their processing into liquid fuel more simple and efficient than processing biomass of any terrestrial material.

5. Production and use of biofuels does not require changes in legislation, as is the case with ethanol.

6. Growing in fresh, salt water or industrial effluents, which are used to clean them.

7. Can be grown in bioreactors or industrial photo biological reactors, illuminated by artificial light source or open reservoirs at abandoned soils, including desert.

8. Photo biological reactors built production lines in existing industrial plants (TPP plants, petrochemical plants, cement plants).

9. Reduce emissions of carbon dioxide (Up to 90% CO_2 with oxygen production).

Biofuel production and its connection with the provision of energy security as the scale of the world economy and for Ukraine in particular, is the focus of many researchers. The existing structure today energy resources are threatening

Ukraine for the energy and national security. The need for energy consumption is only 53% covered by domestic sources, while 75% of the required amount of natural gas and 85% crude oil and petroleum products Ukraine to import. In these circumstances, the search for alternative sources of energy supply of the country is particularly important and urgent. According to the "Concept development of biodiesel production for the period to 2010" assumed the intensification of cultivation of rape, particularly by creating regional zones of concentrated cultivation area of 50-70 thousand ha. Thus to 2015 forecasted increase rapeseed sowing areas in Ukraine up to 8% of the total arable land. Pleas to 8% of arable land in Ukraine sown oilseed rape and processing 75% of the crop grown for diesel biofuel will enable to solve the problem of sustainable energy supply agricultural sector on the basis of their own renewable biomass resources. However, the document does not contain any analysis of the possible effects on exhaustion of soil humus. Implementation of algal fuel in Ukraine is hampered by the lack of stamps. Biological research institutes of the National Academy of Sciences of Ukraine and Ukrainian Agrarian Academy of Sciences have not retained to collect algae strains. Strains of algae used industrially are not cheap. To support alga biofuel production in Ukraine it is necessary to make following measures:

- to create and approve basic law for development of alternative fuel generation from algae;

– to formulate and adopt mechanisms for stimulating of enterprisers, consumers, sellers;

– to define single executive body for management and coordination in the production, storage, consumption and export of alternative fuels;

– establishment of interagency council for coordination of introduction of biofuels;

– studying by all the Ministries and departments of international experience introducing biofuels;

– to identify problem areas introduction of biofuels.

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Assessment of the impact of radioactivity from deposits granites at ecological environment

Structural and geological regularities of formation radiation physical field in the granite quarries were analyzed. Measures to reduce the volume of the formation of ionizing fields and radioactive contamination on the basis of the development and implementation of possible decontamination methods have been proposed. It will provide the economic, ecological and social efficiency of researches.

Development of granite deposits and their processing on the different kinds of building products is accompanied by a significant negative impact on the environment, namely, land resources are spent for the construction of quarries, placing dumps, processing plants, production warehouses, industrial waste and the like; intensive air pollution comes from the explosion products in the preparation of the rock mass to excavation, excavation of the rock mass, the processing of raw materials for the products, etc.; hydrosphere polluted from water outflow from the quarry; radioactive pollution is carried out in large quantities in the areas around the quarries. Works of such scientists: V.F. Kozlov, G.F. Novikov and Y.N. Kalkova, G.N. Flerov and N. Berezin, A.A. Yakubovich and others, devoted to the subject of research radiation exposure of open-cast mining [1-5].

It is known that all the crystalline rocks Ukrainian crystalline shield, including granite, are characterized by radioactivity which for different fields varies and due to the presence in the feedstock of accessory minerals containing a large amount of such radionuclide radium-226, thorium-232, uranium-238 and potassium-40, are characterized by long half-lives and high activity.

Research of change of ionizing radiation fields in the granite quarries with the development of mining operations and the development of measures to reduce the impact on people and the environment is an actual scientific and practical problem. The solution to this problem is improvement of methods of determining the radioactivity of rocks, development effective ways to determine the radiation-hygienic assessment of the quarry and the surrounding areas and objects, development of methods for determining the content of radionuclides in mineral raw materials in the exploration stage and mining, researches accessory minerals and their impact on the radioactivity of raw materials; research basic regularities of migration of radionuclides on deposits in the granite quarries of raw materials, generalization of the individual characteristics of the spread of radionuclides in the rocks, which are located within the Ukrainian crystalline shield, researches the most typical interconnections of radioactive elements in granites of the Ukrainian shield.

Researches regularities of the formation and development of the field of ionization and radioactive contamination in the quarries directly in the implementation of technological processes in the context of operations based on the study of physical, chemical and technological processes in the quarries and processing plants are also considered important. Development of structural schemes of formation of ionization fields and radioactive contamination as well as the study of the of regularities and their changes and management capabilities their impact should be given special attention.

Careful study of radioactivity of rocks, of which the building products are manufactured and then these products are widely spread in different regions is one of the most important directions of research about changes the ionizing radiation field. Accordingly, if the use of radioactive materials will be allowed for the manufacture of building products, and then constructed objects will be increased radiation background will negatively affect the people who are in these buildings. Unfortunately, in the world and domestic building practice there were cases when the radiation background in the room is much larger than the outside. It causes a thorough implementation of radiation-hygienic assessment of raw materials and comparison of assessment results with the requirements of the national "Radiation Safety Standards of Ukraine – NRBU-97" [6], that is, to determine the class of the mineral material, and according to this to identify all possible uses. It is required to carry out in order to prevent the increase of background radiation in the regions of large-scale and intensive building construction objects.

According to the requirements of the radiation safety standards, building materials, as already known, are divided into five classes on the possible types of use depending on the concentration of naturally occurring radionuclides (pCi / kg), i.e. the specific activity A:

$$A_C = A_{Ra} + 1{,}43\, A_{Th} + 0{,}077\, A_K,$$

then A_C – the total specific radioactivity; A_{Ra}, A_{Th}, A_K – the specific radioactivity ^{226}Ra, ^{232}Th, ^{40}K.

Since the specific activity, which is often called the equivalent content of natural radionuclides (C_{eq}) – the normal value, which determines the class and scope of building minerals, then the study of radiation-hygienic properties of the raw material for the production of crushed stone and cladding materials should be directed to the definition of C_{eq}, its measurement and correlation both in area and in depth of field.

The deposits of facing granites Korninsky, Korostyshevsky, Osinovo-Kopetsky and other deposits are characterized by medium-porphyry granites and plagiogranites. Land of occurrence of medium-grained rocks are characterized by dense development of individual cracks, their surfaces are covered with a thin layer of kaolin and painted in brownish-yellow color of iron hydroxides.

Features of the geological and radiation-hygienic structure granites of these fields are:

– the presence of radioactive minerals (apatite, monocytes, orthite, zircon, etc.) associated in pleochroic areas around biotite;

– the presence of pegmatite veins, which often there is a high content of radioactive elements, usually uranium-238 and thorium-232;

– diverse and often changeable mineral and petrographic composition of the rock deposits (gneiss, plagiogranite, porphyroblastic granite, etc.) [3, 4, 7].

Researches were carried out on a broad scale, covering methods of radiation-hygienic assessment of mineral resources in carrying out exploration work in the fields of building materials and raw materials in the assessment of existing quarries on the basis of comprehensive research and mathematical processing of the obtained data. The experimental data that were obtained from research are random values of statistical sets and methods of mathematical statistics should be used in their analysis.

A major role in radiation-hygienic assessment plays a one-dimensional analysis of the statistical aggregate for its implementation the it is advisable to make the histogram for the distribution of random variables for each parameter (C_{eq}, Th, U, K) (Fig. 1-4).

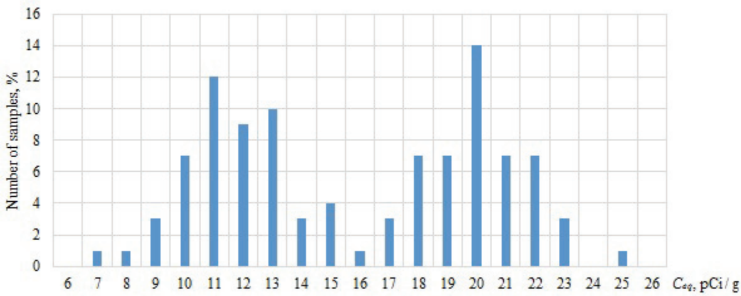

Fig. 1. The histogram distribution of equivalent concentrations in granites of Pinyazevitsky deposit

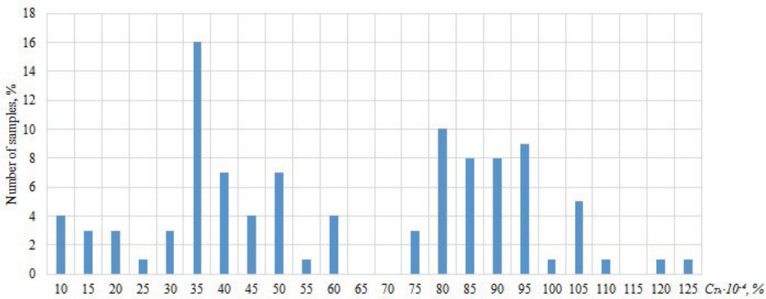

Fig. 2. The histogram distribution of thorium content

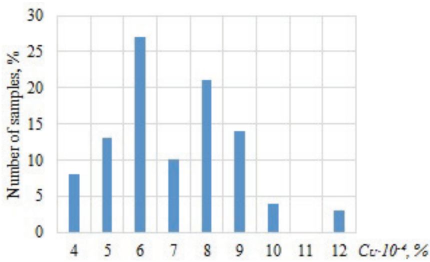

Fig. 3. The histogram distribution of uranium content

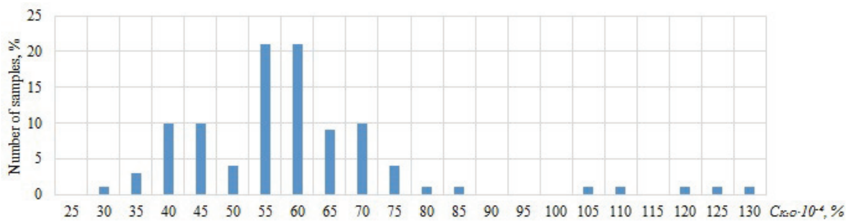

Fig. 4. The histogram distribution of isotope potassium content

The histograms are confirming that the element-wise distribution of radionuclides and distribution equivalent concentration close to the normal distribution law. This allows you to predict the approximate radioactivity granite according to the data the geological structure of deposit, mathematically describe the distribution of radionuclides in the rock and interrelation between them, receive a mathematical model an equivalent of radionuclide content graphical-analytical method, as well as solve a number of practical problems based on the normal distribution of random variables. [2, 7, 8].

The final result of carried out researches is the development measures to reduce the volume of the formation of ionizing fields and radioactive contamination through the development and implementation of possible decontamination methods, the implementation of which provides economic, ecological and social efficiency of researches.

One of the major of physical ways to prevent radiative contamination is shielding. A specially designed protective clothes and screens allow for enough safe stay of the person in the conditions of radiation. There are several types of ionizing radiation, each of which has its own characteristics in terms of interaction with matter. To counter them, various materials are used in the manufacture of protective equipment.

Alpha-radiation is characterized by low penetration ability and the effect on the body only in proximity to the radiation source. Therefore, even a piece of paper, rubber gloves, plastic glasses and a simple mask will be an insurmountable obstacle for it. This mask is particularly important part of the protective suit, because the alpha particles that get inside the body, accumulate in the cells of organs and did not break up, poisoning the body.

Beta-radiation is greater than the alpha-radiation penetration ability which depends on the energy of its particles. This means that methods for protection against alpha radiation is not effective when the beta-particle flow. Therefore, are used plexiglass, glass, a thin layer of aluminum and a gas mask.

Gamma-radiation is distributed over long distances and penetrate through virtually any surface. Exceptions are heavy metals such as tungsten, lead, steel, cast iron and others. It is they are used for protection.

Neutron-radiation is a product of nuclear fission with the penetration ability, superior to gamma-radiation. The best protection from the neutron-radiation are such materials as water, polyethylene and other polymers. Neutron-radiation is usually accompanied by gamma-radiation, so it is often used as a protection multilayer screens or liquids of hydroxides of heavy metals.

Conclusions

The recommendations on the protection of workers in the granite quarries from radiation and geo-toxicology, based on the protection time, distance shielding, using the effective radiation hygiene. This researches are point to the possibility of implementing measures to reduce radiation exposure to the processes of mining granite quarries of Ukraine.

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International legal opposition to cyberwars

The international legal opposition to the cyberwar at present is under formation. The article substantiates the need to adopt a universal international legal agreement which would contain the prohibition of the cyberwarfare.

Implementation of the priority objective of modern international law - being the maintenance and protection of peace in the world - is not possible without the ban and exclusion of war as a means of national policy.

Based on the basic principles of international law, in particular the peaceful settlement of disputes and non-use of force and threat of force, as well as the goals of the UN Charter, the international community must take collective means for the prevention and removal of threats to peace and suppress acts of aggression or other breaches of peace.

With the development of social relations should note the transformation of international disputes are now resolved not typical methods and means. As noted, M. Tukhachevsky in "The contemporary strategies' (1926):" It is impossible to answer the question - what will be the nature of all future war - it changes its form and its character as it develops and it is impossible to predict these in advance " [1]. Under such conditions, the international rule-making should react to the challenges of our time, including the origin of the emergence of new trends to asymmetric power sources, including cyber capabilities to influence.

One of the features of modern wars is the use of new technologies in the confrontation between states. As stated by the Finnish scientist Erik Castren "technical development that began in the last century and continues at an accelerated pace in the present, creating new opportunities for such weapons as submarines, aircraft, nuclear weapons. This development increases the role and value of rules governing the conduct of hostilities on land and sea "[2]. However, modern technological advances are changing not only the means of armed struggle known to mankind, but also tactical strategy of modern warfare. At the same time there are new threats, which primarily include - cyberwar.

The term "cyberwar" is not new, but its generic definition is missing. In the doctrine and practice of international law simultaneously used terms such as «cyberwar», «cyber warfare», «cyber attack», and a number of similarities to them, the content of which means confrontation and warfare in «cyberspace».

J. Andres and C. Vinterfild state it is difficult to determine what cyberwar is. In fact, the two definitions – «cyber» and «war» - are a subject of debate [2, 2]. A.A. Merezhko notes that in international law there are no clear criteria on which to separate the ordinary acts of computer hooliganism from such attacks, which due to its seriousness have the character of an armed attack on the state, or the beginning of armed aggression against a state [3, 150].

Although the international community has repeatedly expressed concern that the latest technology can potentially be used for purposes incompatible with the objectives to ensure international stability and security and is able to affect the integrity of the infrastructure of states to the detriment of the safety of both the civil and military sectors (Tunis Agenda for the information society, Code for the protection of user rights in cyberspace UNESCO Resolution UNGA a / HRC / 20 / L.13 on 29.06.2012; UNGA Resolution a / HRC / 17/27 dated 16.05.2011 etc.) as of today, there is no international legal instrument that would contain a definition of "cyberwar" and forbade it.

Cybernetic war - a systematic struggle in cyberspace between states (groups of states), political groups, extremist and terrorist et al. groups, which is held in the form of attacking and defensive actions. The main objectives of both attack and defense in cyberwar are information resources properties are in terms of security (integrity, availability and confidentiality) may be affected [4, 90]. Considering this systemic struggle means that the actions of the parties have a certain integrity, consistency, unity, subordination to the given purpose, combined with other actions.

In his book "Theory of international public and private law" A.A. Merezhko offers draft Convention on the prohibition of cyberwar in the global information network of information and computing resources [5, 152]. In Art. 1 of the draft provided a definition of "cyberwar - use of the Internet and related technology and information means one state to harm the military, technological, economic, political and information security and sovereignty." The project by offering the Internet to recognize common heritage of mankind, to be used exclusively for peaceful purposes.

We consider being slightly inaccurate narrowing cyberwar only to Internet use. We believe that cyber war is happening in cyberspace, which is one of the essential features of this phenomenon. Despite the rather controversial interpretation of the term cyberspace, which was first used by the science fiction writers: V. Gibson, B. Sterling, John. Barlow, today it is often used in international legal treaties and acts of international organizations (UN, ITU, UNESCO, NATO, etc.).

In particular, Okinawan Charter of the information society provides: "The efforts of the international community aimed at the development of a global information society must be accompanied by concerted actions for making a safe and free from crime cyberspace" (p.8) [6]

Interesting in this context is the US Senate adopted in 2009, according to which cyberspace officially recognized the new environment (domain) combat actions and determined the feasibility of its association with the outer space within the framework of the new challenges, "geocentric theater of Action» (Spherical Area of Operation).

To act in cyberspace are able not only to individuals, groups of individuals or organizations (including terrorism), but also the states or coalitions of states. Especially beneficial to "blur" the boundaries between war and peace. In fact committed "cyber attacks" may be alone or in combination with other attacks and threaten the sovereignty and security.

Despite the extraordinary activity of international political processes associated with the development of the global information society, international legal normalization of information sphere, including the determination of rules of conduct of related states and other actors is at the initial level. As a result, attacks committed in cyberspace can not be classified under international law. In such circumstances, the only way to counter is the qualification of these attacks just as certain cybercrimes, responsibility for which falls under national laws of countries and some regional international agreements.

In the absence of a unified international legal agreement on combating cyber-warfare particularly important doctrinal developments leading lawyers in international affairs. Tallinn guide the application of international law to cyberwarfare, published in 2013, prepared by experts in international law to order the Joint Center for NATO to exchange best practices in cyber defense (NATO Cooperative Cyber Defence Centre of Excellence) [7] became extensive research in the specific field.

The manual specifies that cyberattacks using malware Stuxnet may be considered "armed attack." The victims of such attacks have the right to strike back in self-defense. Hackers involved in the conflict between states automatically acquire the status of combatants. The second edition of the manual should include provisions on human rights in cyberspace and will be published in 2016.

Conclusions

Thus, we conclude that the international legal opposition to the cyberwarfare at present is under formation. We consider the adoption of a universal international legal agreement, which would contain the prohibition of conduct of the cyberwarfare, where the definition of a key term would be: "cyberwar is a struggle between states (groups of states), implemented by means of systematic cyberattacks in cyberspace and threatening national sovereignty and security".

In addition, it is useful to recognize the universal level "cyberattacks" an act of aggression and attacks that are systematic - armed conflict of an international character.

We considers important extension of the principles of international humanitarian law with the "cybernetic" component. In particular, the principle of ratione loci should be extended to digital heritage sites and cultural heritage in cyberspace, and ratione conditiones - the "cyber weapons" that can cause excessive damage especially important or dangerous infrastructure (eg nuclear power plants).

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Characteristics of the universal norms of International Law in the sphere of combating human trafficking

This article is dedicated to the main features of the universal norms of international law in the sphere of human trafficking. The authors pay attention on the possible ways of structuring international standards in the sphere of combating human trafficking and its development in modern times.

Considering the issue of international legal regulation of combating human trafficking, it is worth to divide the regulatory framework into the parts according to certain criteria, in particular to make the division of universal and regional norms. This approach will make it possible, despite some contentious issues that exist in the doctrine of international law, comprehensively and fully examine the system of international legal instruments that form the policy of combating human trafficking in the world and in Ukraine in particular.

According to modern opinions, there are some universal rules governing the relations of all subjects of international law and provide general international law [4, p. 23]. Other researchers, such as A. Haverdovskyy suggest considering the meaning of "generally accepted norm" and "universal norm" as equal [3, p. 26]. The last statement caused some debate in the scientific literature. It is known that universal international law strives for the universal acceptance, but in real international life there are many obstacles on its way. French researcher F. Manena noticed: "Standards can be considered common only when they get the consent of all entities of the system" [7, p. 15].

Several Western researchers propose that the term "generally" and "universal" norms to be identical. Universality refers by them geographically, despite the social nature of contemporary general international law. It should be noted that bilateral and multilateral agreements on cooperation in the framework of legal assistance in criminal matters; cooperation; participation in the operative-investigative operations, investigation on the territory of another state; joint operational developments and investigations; information exchange; participation in international cooperation projects and operations are effective at the regional level, but do not have massive influence on human trafficking in comparison with universal norms of international law. [1]

Thus, universal norms govern relations the object of which represents the general interest, and get recognized by the overwhelming majority or all states. Characteristics inherent to universal standards are united by the cause. These standards are recognized by most or all nations because of their interest in the controlled object.

Universal norms of international law constitute its basis, regulating the most important spheres of international relations. These include rules embodied in agreements such as the Charter of the United Nations, Vienna Convention on Diplomatic Relations, International Covenants on Human Rights, Fourth Geneva Convention and so on.

On the basis of international law, practice and states experience, views of such scientists and researchers in the field of combating human trafficking as D.H. Kaznacheyev, V.V. Maksimov, A.M. Orleans, M.P. Danyluk, A.L. Melnikov, D. Leydhold, M. Specter, I.K. Suhoplyuyev, A. Shlenhard and others, attempts to create universal classification of acting international norms in the issue of human were made. Thus, in our view, universal norms of international law can be divided into:

1) Universal norms of international law of a general nature, which are indirectly related to combating human trafficking. Often, those are international norms concerning human rights and have universal nature.

2) Universal international law of a special character that directly relates to combating human trafficking. This category includes:

a) international standards for combating transnational organized crime that have transformed human trafficking into one of the most stable and most lucrative shadow "businesses";

b) international standards regarding combating human trafficking (preventive measures).

The abovementioned categorisation is based on the trend of modern political and legal cooperation of states in combating human trafficking, which, in its turn, consists of three elements, or basic directions:

- The protection of human rights and assistance to people who became the victims of human trafficking;
- The fight against transnational organised crime in the sphere of combating human trafficking;
- Prevention and cooperation regarding the suspension of human trafficking.

Even the Declaration of Human Rights and the citizen (1789), which was recognized as "the true measure of rights" argue that the sole cause of social ills and governmental vices is the disregard of human rights [5, p. 250]. After the World War II, international law gets to a new phase of development. According to A.P. Malanchuk, one of the main features of this phase is the recognition of individual. Nowadays the general principle of international law is a deep respect for human rights and freedoms. For the first time at the universal level, these issues have been put down in the Universal Declaration of Human Rights of 1948, consolidating in Article 3 that "everyone has the right to life, liberty and security of person". In Art. 5 Convention on Human Rights and Fundamental Freedoms, adopted on 4 November 1950 in Rome says: "Everyone has the right to liberty and security of person. No one may be deprived of liberty except in cases and in the manner prescribed by law". Foreign researchers determined the above documents as the most important in establishing common standards of human rights.

International agreements on combating trafficking in human beings can be related to different aspects and directions of such cooperation, be different in content and form, as well as have various practical outcomes. Typically, specific and practical issues of cooperation of this problem are resolved bilaterally. Some questions of such cooperation are governed by different types of bilateral agreements: consular conventions, agreements on readmission (return and receiving back), legal aid. Among the agreements of universal character the Slavery

Convention of 1926, as amended by the Protocol of 1953, the Convention on forced and compulsory labour 1930, Supplementary Convention on the Abolition of Slavery, the Slave Trade and Practices Similar to Slavery 1956, Convention on the Elimination of all forms of discrimination against women in 1979 should be noted down. Extremely important document that directly regulates cooperation in preventing and combating trafficking in human beings is the Convention for the Suppression of the traffic in persons and of the exploitation of the prostitution of others in 1949. These multilateral agreements on combating certain types of international criminal offenses are of particular importance.

In January 1999, the standard principles of human rights of the victims of international trafficking, developed by the Foundation against Trafficking in Women (Netherlands), International Law Group for Human Rights (USA), Global Alliance Against Trafficking in Women (Thailand).

Successful combating of human trafficking depends on the legal support to solve this problem at the level of both international and domestic law.

At the plenary session of the OSCE Parliamentary Assembly, the July 16, 2003 resolution calling for the respect for human rights in countries under NATO and EU enlargement was adopted. The resolution consists of two directions: for the members of the OSCE - "to ensure that their national legislation envisaged funds and institutions to combat trafficking in human beings", and for the EU and NATO - with the admission of new members "to maintain high standards of democracy, human rights and the rule law" in these countries.

The Platform for Action as the final document of 23rd special session of the Economic and Social Council of the UN General Assembly (March 2005) marks existing strategies, priorities and areas to create effective social oversight of human trafficking, and especially women and children.

Considering the universal norms of international law which are directly related to combating human trafficking, we should remember that they are divided into the provisions regarding the combating of transnational organised crime and provisions for combating and preventing human trafficking.

It should be noted that transnational organised crime has evolved into a phenomenon present in many different cultures, societies and countries. It has become global and not limited to specific geographical areas, ethnic groups or social systems. Human trafficking is a major source of profit of transnational organised crime and ever-growing criminal business.

Differences in legislation in some regions of the world make human trafficking relatively quiet business. Some countries still have no criminal liability for this type of crime. Globalisation has opened the door to criminal organisations that got easy access to other countries, created international routes, developed and used many ways of both illegal and legal transportation. Criminal organisations try to maximize their profits in the same way as legal organisations do.

The goal of combating transnational organised crime should be the extermination of organised criminal structures, but not mythical arrest of the leaders who run all alleged criminal syndicate [8, p. 258]. This international effort is one of the most effective tools in the fight against transnational organised crime. In 1994 at the World Conference on Transnational Organised Crime, held at the ministerial level in Naples, UN member states adopted the Naples Political Declaration and Global Action Plan against Transnational Organised crime as the best response to the problem of internationalisation and improvement of methods of criminal gangs. In the fight against organised crime, Naples plan focuses on national capacity and international cooperation. Later, the Commission on Crime Prevention and Criminal Justice was requested to examine the possibility of preparing the text of the Convention against Transnational Organised Crime.

The final informal preparatory meeting of the Open intergovernmental ad hoc committee to develop the text of the International Convention against Transnational Organised Crime held in Vienna (Austria) in March 1999. This Convention (including the Protocol to Prevent, Suppress and Punish Trafficking in Persons, especially women and children, on the initiative of Argentina and the United States, supplementing the UN Convention against Transnational organised crime and the Protocol against the Smuggling of migrants by land, sea and air, supplementing the same Convention on the initiative of Italy and Austria) was finalised in 2000.

The United Nations Convention against Transnational Organised Crime, approved by General Assembly resolution 55/25 of 15 November 2000, has a detailed list of actions and measures that are aimed at promoting cooperation in the sphere of effective prevention of transnational organised crime and its combating. Art. 3 of the Convention lists the features the determine crime as transnational: if it is committed in more than one state; committed in one state but a substantial part of its preparation and planning took place in another state; committed in one State but involves an organised criminal group engaged in criminal activities in more than one state; committed in one state but have consequences in another. [2]

Human trafficking may have such features in different cases and can be considered as transnational crime. In its turn, this Convention complements the above Protocol to Prevent, Suppress and Punish Trafficking in Persons, especially Women and Children. The Convention applies mutatis mutandis to the provisions of Protocol.

The protocol aims to coordinate a common criminal policy of the member states regarding trafficking. The purpose of the document proclaims the promotion of cooperation of member countries in the prevention, investigation and prosecution of illegal international movements of people, especially for the purpose of forced labour and sexual exploitation, with special attention to the protection of women and children as the most frequent victims of such actions (Article 2). Protocol on human trafficking obliges member states to take steps to investigate and prosecute human trafficking, giving special importance to international cooperation, as well as protection and assistance to victims of trafficking, and to take preventive measures. The Convention provides the general measures to combat organised crime, including measures for the confiscation of funds and the protection of victims and witnesses of organised crime, and also applies to the fight against human trafficking.

Importantly, for the first time on a global level, this document provides the criminalisation of such acts as human trafficking, and calls upon all states to take steps to recognise it as a criminal offense (Art. 5).

Thus, universal international law reflects the following tendencies in the development of combating human trafficking:

1) special attention is given to the protection of universal human rights - individuals who have been trafficked;

2) special attention is paid to international legal protection of women and children who became victims of human trafficking;

3) human trafficking is recognised as transnational crime and enhanced responsibilities of the persons involved in such activities;

4) it is globally recognised that the crime of human trafficking is criminal and punishable, each state shall take all necessary measures to recognise it as such in the legislative level;

5) the development of international information programs to prevent human trafficking is initiated, the level of cooperation in preventing and combating this phenomenon is improving.

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Enforcement of competition rules and antitrust policies under the Association Agreement between the EU and Ukraine

This report is devoted to the review of innovative legal drafts into the anti-trust legislation of Ukraine. The paper reveals the damaging influence of undefined antitrust legislative norms which make the market competitiveness and business on the whole suffer. On the contrary, the paper provides a profound analysis of measures taken up in the course of fulfillment of the Ukraine - EU Association Agreement. Certain draft laws on calculation of fines for violation of antitrust legislation, the control over economic concentrations and transparency in the activity of the Antimonopoly Committee of Ukraine are expected to uniform the legal practices of governmental bodies and improve the business climate of Ukraine in general.

As a part of Ukraine - EU Association Agreement, the Antimonopoly Committee of Ukraine has committed to bring into compliance competition law with the European standards [1]. Certain legislative drafts regarding matters of control over concentrations, imposition of financial sanctions on business entities, improvement of transparency in the activity of the Antimonopoly Committee have been recently submitted to the parliament. Below we provide an overview of the legal changes which are expected to improve business climate, fight against corruption and facilitate the implementation of the Ukraine - EU Association Agreement.

The draft law on amendments to the legislation "On protection of economic competition" regarding calculation of fines for violation of legislation on protection of economic competition No. 2431 is aimed at creation of legal framework for transparent and public fines and implements certain provisions of article 255 of Ukraine - EU Association Agreement [6].

At this juncture, Ukrainian legislation on protection of economic competition does not contain a policy which defines the system, methods and principles of fine calculation by the Antimonopoly Committee of Ukraine. Under the draft law on amendments to the legislation on protection of economic competition regarding calculation of fines for violation of legislation on protection of economic competition No. 2431 the laws on "Protection of economic competition" and "On protection from unfair competition" are amended with the provisions on Methodology of calculation of fine limits by the Antimonopoly Committee of Ukraine [2].

The draft law sets the principles of proportionality, legal security, non-discrimination and reasonableness in practice of AMCU. Currently, AMCU determines the amount of fine in each case based on its internal methodology, which is not available to the public and often reflects selective approach of AMCU to imposition of fines. The adoption of the Draft Law No. 2431 should allow business to make estimates of fine amounts beforehand and to think over the strategy for mitigation of such amounts in advance [4].

There is no doubt that every kind of violation constitutes a separate segment, which requires a specific approach to identifying key criteria. Therefore, the following criteria are recommended to be taken into account by AMCU for calculation of fine limits:

- the net income (revenue)of the market participant in the year preceding the imposition of fine;
- the result, consequences and impact of violation on competition at the territory of Ukraine;
- the frequency of violations of legislation on protection of economic competition by the market participant in particular segment;
- the competitive position of a market participant at a particular market;
- the duration and repetition of violation;
- extenuating and aggravating circumstances;
- the severity of violation [6].

The other legislative initiative is the provision of the draft law stipulating the right of a market participant to appeal against the decision of AMCU on imposition of fine or imposition of an obligation to eliminate the effects of violation of legislation. The court is obliged to use the above-mentioned Methodology on calculation of fines while considering an appeal. Hence, this provision guarantees market participants the right to a fair trial.

Finally, the law creates conditions to control the activities of AMCU and brings antitrust regulation into conformity with the best European standards which will definitely lead to improvement of competition policy and business environment in Ukraine in general [8].

The other legislative initiative is related to control over concentrations in Ukraine. One of the most urgent issues is the financial thresholds, in excess of which transactions require prior authorization for concentration by the Antimonopoly Committee of Ukraine. The law on Amendments to the Law of Ukraine "On Protection of Economic Competition" (regarding the improvement of the effectiveness of the control over economic concentrations) dated June 25, 2015 envisages the following legislative changes [5]:

- raised thresholds for the aggregate asset value or the aggregate sales turnover of concentration participants that preconditions necessity for concentration clearance by the AMCU or the Administrative Collegium of the AMCU from 12 million Euros to 30 million Euros, thresholds for assets value or sales turnover in Ukraine of parties to concentration from 1 million euro to 4 million euro, sales turnover in Ukraine of at least one of the parties to concentration to 8 million euro, and goods turnover including turnover abroad of the other party to concentration to 100 million euro;
- limits of total period of consideration of applications and cases of granting permission for concentration, including the time to collect

additional information necessary for a decision in the case to 180 days;

- introduction of the norm, according to which, if during the period of the examination of concentration application set by the Law of Ukraine "On Protection of Economic Competition" (30 days), the Antimonopoly Committee of Ukraine has not started the proceedings regarding concentration, the decision on granting permission for concentration shall be deemed as adopted;
- introduction of reduced concentration assessment procedures;
- reduction of the amount of information provided to the AMCU, which is not necessary to assess the impact of the concentration on competition in Ukraine;

Antimonopoly Committee is also considering introducing a bi-level system of control in which the amount of national and global trade will be considered separately, creating national and transnational financial thresholds to concentration. However, an increase in thresholds alone may be insufficient to effectively improve the concentration regime. It is also important to bring the practices of AMCU on control over concentrations in conformity with the EU regime [3].

Perhaps the greatest changes to the activity of the AMCU are brought by the draft law “On amendments to some legislative acts regarding ensuring of transparency in the activity of the Antimonopoly Committee of Ukraine” No. 2102 dated February 11, 2015.

Prior to this draft law was adopted in November 2015, the AMCU was not obliged to publish its resolutions, which created the opportunity to apply differing approaches in similar cases and ultimately violated the principle of legal certainty and significantly restricted the rights of companies in the legal practice of the AMCU [7].

The law “On amendments to some legislative acts regarding ensuring of transparency in the activity of the Antimonopoly Committee of Ukraine” provided for mandatory publication of all resolutions of the AMCU and its agencies:

- applications and cases regarding granting permission for concentration;
- applications and cases regarding granting permission for concerted action;
- cases of violation of legislation on economic competition protection;
- cases of unfair competition

The mandatory publication of resolutions has to be conducted within 30 days from adoption of resolution. The law stipulates that the classified information provided to the AMCU, shall have precise description and justification for the confidentiality of such documents. At the same time, the applicant shall provide the AMCU with non-confidential version of such documents by removing, altering or crossing out the information submitted as confidential [8]. By this the market participants are bound to prepare "reasoned explanation" of the confidentiality of information, and the Antimonopoly Committee is bound to check the validity of such claims and if such justification seems insufficient the AMCU has to disclose relevant information against the will of its owner.

The requirement of mandatory publication of the resolutions makes the enforcement practice and approaches of the AMCU accessible to market participants, promotes transparency and public awareness. Undoubtedly, the draft law will positively affect both the current work of the AMCU and the Ukrainian competition agencies in general.

Conclusions

To sum up, the above-mentioned legal initiatives should bring clarity and certainty to the regulatory environment for business, as currently Ukrainian competition law is opaque and often arbitrary. The criteria previously applied by the Antimonopoly Committee of Ukraine in fine imposition were blurred and could have been easily falsified regardless of such factors as severity of violation, its systematic character or scale. The transparent fine calculation system is expected to prevent cases of unauthorized fine imposition and will become a clear guideline for business entities. Likewise mandatory publication of AMCU's resolutions is of great value for market practitioners due to the possibility to cite the judgement of AMCU in case of litigation or rely on a proper source of information. At the same time, it should be noted that each of the legislative drafts put under the consideration is a step forward to the European standards of fair trade and market competition.

Therefore, the implementation of EU competition rules with respect to such matters as calculation and imposition of fines, control over concentrations and mandatory publication of resolutions of AMCU will raise the transparency and accountability of AMCU activity, which in turn should facilitate improvement and attractiveness of the overall business environment.

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Facebook as a platform for counteraction to plagiarism

Examples of using Facebook as a platform for explanation of the term "plagiarism", preventing its occurrence and resistance of outlined phenomenon, are analyzed in the article.

The stormy development of the Internet (perceived as "no one's" territory or, on the contrary, the territory of "all for all"), new and social media has provided access to the huge array of information (content production and consumption) for all. This caused the problem of plagiarism in all spheres of human activity to a new level in general and in social communications in particular. We can see features of plagiarism in all areas of the branch - academic, professional, educational. It causes threats to property and moral rights of copyright holders, and leads to leveling the prestige of scientific research, the decline of scientific ethics, transformation and distortion of scientific and professional values (value), reduced quality of education.

In this context, Facebook, like other social media, is "a giant warehouse of personal information" [13, p. 85], can be (and is), on the one hand, the platform of spreading the plagiarism (such as abuse republication - repeated promulgation, usually in other online media, and in this case, many accounts of someone else's article on the true byline and referring to the source of the comments the account holder, but often without them), and the other - communicative space in which there are an explanation of the problem of plagiarism, attempts to prevent the phenomenon and published materials to combat it.

Understanding of the problem should include understanding the concept of plagiarism, its characteristics and types, knowledge of the tools to combat and prevent it.

If we talk about definition of the concept, for instance, the Law of Ukraine "On Copyright and Related Rights" defines plagiarism as "promulgation (publication), in whole or in part, of another's work signed by the name of a person who is not the author of the work" [14]. Explanatory Dictionary gives the following interpretation: "Plagiarism [Lat. plagiatus - stolen]. Appropriation or borrowing of text from another literary or scientific work without consent of the author and without specifying sources "[17, p. 676]. Yuri Kovaliv in the "Literary Theoretical Encyclopedia" emphasizes that plagiarism is "deliberate appropriation of another's authorship of literature, painting, music, science work or part of it without the indication of source" [6, p. 220]. P. Repeshko said: "Plagiarism is the presentation of other people's work as your, using of other people's ideas or phrases without specifying the sources, and providing incorrect information about the source from which information is taken [16, p. 84]. Internet Dictionary of Miriam Webster (Merriam-Webster online dictionary) classifies plagiarism as following: 1) steal and pass off someone else’s ideas and words as your own; 2) use other people's material without reference to the source; 3) to do literary theft; 4) to present as new and original ideas or products taken from existing sources. That plagiarism is an act of fraud (fraud) covering stealing someone else's work and other fraud concerning this work. [7]. The glossary of the site contains the following definition: "Plagiarism is the reproduction or appropriation of other people's work without reference to the source; impersonating someone else's work for his own "[8]. However, today most comprehensive study of the problem presented in defended doctoral dissertation of G. Ulyanova "Methodological problems of civil Intellectual Property Rights Protection against plagiarism" [18].

If we talk about counteraction to plagiarism, we should mention example of the Ukrainian sociological research within the project "Academic Culture of Ukrainian Students: Key Factors in the Formation and Development" made by East- Ukrainian Foundation of Social Research with the support of the "Vidrodzhenya" in the period from December 2014 to July 2015. Electronic manual in the form of presentation "What you need to know about plagiarism: a guide to the academic literacy and ethics for 'dummies" (2015) [9] was created and concluded on this basis. By the way, will be useful also guide the same type of T. Pavlenko "Culture and ethics of scientific publications" (2016) [11]. As well it is necessary to note, that the materials of this survey were discussed during the conference "Academic honesty as a systemic problem of high school of Ukraine: university, teacher, student" July 16, 2015 in UKRINFORM [5].

As for the means of prevention, an important step, for example, will be the introduction of checking systems for plagiarism in diploma and dissertations in all Universities. (This, incidentally, requires a new Law of Ukraine "About Higher Education"). Their effectiveness is quite justified. Good experience in using the system of checking for plagiarism has, for example, the National Aviation University, where such a system of verification students' diploma and projects operates, according to the order of the rector, from 2010, and in 2016 (the order by the Acting Rector № 53/od from 23.02.2016) introduced a system of comparative analysis of electronic texts of abstracts and dissertations. We also need to abandon the system of reports, replacing them, for example, for essay. It is necessary to carry out explanatory work on plagiarism, because many of the students do not even suspect that they resorting to plagiarism. For such explanatory activities is suitable, for example, the course introduced in 2014 at NAU - "Modern Ukrainian media in dimension of values." This course intended, in addition to purely axiological aspects, to explain the essence of phenomenon of plagiarism, the type and shape and form stable values to the guideline "resort to plagiarism means to steal," and therefore plagiarists should be brought to administrative responsibility (a system of penalties) and subjected to moral condemnation. That is one way - to educate generations of appropriate values. Exactly on this way, the project for promotion of academic integrity, launched by the American Council for International Education in partnership with the MES of Ukraine (coordinator in Ukraine - T. Tymochko) [3, p. 8-9.].

How could Facebook help us to solve the outlined problem?

First of all, it is the discussion of the problem, promulgation of materials and specific cases of plagiarism detection. Examples of these discussions, in particular, are discussing of the record (from 21.03.2015) of doctor of philological sciences, professor of Taras Shevchenko National University of Kiev. Alla Boyko: "-All are lost! - I hope so will appeal those, who in his scientific (or rather pseudo-scientific) research is still safely using "incorrect borrowings", that is plagiarism "[1], - which she promulgated on her page in Facebook. Incidentally, A. Boyko tried to attract the attention of the scientific community to the problem of plagiarism: for example, look for her interview "How to prevent" professional suicide ?" [2]. Participants of the the discussion were a lot of scientists, including L. Vasylyk, A. Voyevodyna, S. Galata, Y. Ostapenko, N. Pahsar'yan, L. Filipovich, E. Shestakova and others.

As well as consistent statements of senior researcher of Institute of Mathematics of the NAS of Ukraine Iryna Yehorchenko about the problem of plagiarism in general and in high profile case concerning plagiarism identified in the doctoral thesis "Theoretical and methodological guidelines for the development of innovative culture of future culture experts in higher education" (defended October 15, 2015) Kirilenko Catherine, wife of Vice Premier Vyacheslav Kyrylenko [4].

Spreading in their profiles promulgated in various online media currently popular infographic regarding the problem. For example, PhD, associate professor of NAU Natalia Filyk that specializes in copyright law, regularly accommodate the materials on her own page. For example, June 27, 2016 she has distributed material "Academic plagiarism in Ukraine in numbers" [10], located on http://studway.com.ua/plagiat-2/.

Creating special communities. For example, the page "Project to Promote academic integrity in Ukraine - SAIUP» [15]. The American Councils for International Education launched the project in cooperation with MES of Ukraine.

Placing the materials with educational purpose in the pages of law firms. For example, it is interesting series of clips "patent attorney" (plagiarism directly related to three of them), commissioned by "Rivnepatentu" and posted on the "Patent Attorney of Ukraine Yuriy Trachuk" [12].

Conclusions. Thus, the problem of plagiarism is now one of the most critical faced by Ukrainian scientific community. The rapid spread of plagiarism leads to leveling the prestige of scientific research, the decline of scientific ethics, transformation and distortion of scientific and professional values (values), reducing the quality of education. In this context, Facebook, as well as other social media, is a platform for plagiarism spreading on the one hand, and the communicative space, where explanation of the problem of plagiarism is explained, steps to prevent the phenomenon are making and materials to combat with is published. In particular, the following tools are used: 1) discussion on general issues and specific cases of plagiarism detection; 2) distribution in user's accounts information on the issue from various online sources; 3) creation of the pages of communities, whose activities are aimed at preventing the spread of plagiarism and at eliminating the with it; 4) placing educational materials on the pages of law firms.

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Method of concealed search and collection of information as used by max winter, an Austrian originator and founder of investigative reporting

This Paper is devoted to a creative experience of Max Winter, a prominent Viennese journalist, and originator and founder of investigative reporting, whose heritage is a classic in European journalism, but who is still little known in the educational and media environment in Ukraine.

The students who study Best Practices in Journalism and explore the development of modern media practices must be familiarized with a European and global experience of people whose creative heritage has become a distinctive classic of the genre. Unlike curricula set for students who major in Ukrainian and World Literature, the personalities of distinguished figures who left a mark in reporting, interviewing, journalistic stories and causeries are not reviewed individually in curricula for journalists. However, studying the classics would acquaint the soon-to-be and actual journalists who are in pursue of creative ideas, with the highest professional achievements and internationally and historically reverberating op-ed pieces that once changed the social life and highlighted social problems, and that are still topical at present.

One of the most outstanding figures in European journalism is Max Winter (1870–1937) who is referred to in German-speaking countries as the pioneer and founder of investigative reporting. At the beginning of the 20th century, in Vienna, Max Winter published a series of articles about the poor, the unemployed, workers and vagrants after exploring drainage tunnels applying the method of a concealed search and collection of information that would be further successfully used by German writer Günter Wallraff in his undercover work at the second half of the 20th century. The Max Winter's staggering stories exposed horrible living conditions of numerous homeless people living in Vienna sewage tunnels and in the metro subway system of Vienna. To deeply investigate the topic, Max Winter began to work undercover disguising himself as his protagonists with a purpose of infiltrating into the hidden world of underground tunnels and create impressive descriptions of the *Black Heart of Vienna.*

Investigative (from Latin *investigare* "to track, to trace out") reporting became the key genre practiced by Max Winter – a talented and unique author who made an unmatched contribution to investigative journalism. This form of journalism deeply investigates topics that are of social interest, such as a political corruption, serious crimes, corporate wrongdoings, immoral manifestations in communities, social upheavals, etc.

Max Winter was born on the 9th of January, 1870, in Budapest, and his family moved later to Vienna. He obtained a secondary education and entered the University of Vienna but did not complete his studies. He began his career in journalism at the age of 23, for *Neue Wiener Journal*, a Vienna newspaper. In 1985, he received a new job in *Arbeiter-Zeitung*, a central media mouthpiece for the Social Democratic party. Max Winter worked for some time as a court reporter, and his articles featured a political focus and a desire to improve the living and working conditions of disadvantaged groups, in particular, prisoners, beggars and thousands of homeless people in Vienna. At that time Max Winter began to use the *disguise method* in his journalist investigations. For example, in 1902, he disguised himself as a homeless man and was taken to prison specifically for searching for and collecting of information about the lives of Vienna prisoners.

In 1905, Winter's first journalistic-style book named *In the Underground Vienna* was published as a result of multiple journalist investigations using the *disguise and impersonation method.* The book was devoted to a pressing problem of an underground existence of thousands of unemployed and homeless who were flowing to the capital of an agonizing Austro-Hungarian Empire from all regions. The huge city had very few shelters for the homeless, and public houses for the poor and migrant workers, so the number of dwellers at the heartbreaking, stinking and life-threatening underground tunnels raised at a rapid rate. At that time, the population of Vienne counted almost two million people, and the city was the fourth largest place in the world overtaken only by London, New York and Paris.

The whole segment of Vienna population that live underground, in sewage systems and subway tunnels, became a permanent topic in Max Winter's journalist stories and reviews. Not just he uses his articles to turn public attention to that decrepit side of the megalopolis, but he also offers to resolve that global social issue through humanistic actions. This is a great contribution of Max Winter that today, as over one hundred passed after Winter's stories were published, Vienna has been ranked highest in overall quality of living standards from among 221 cities all over the world, and for a few consecutive years, according to an international survey.

In 1911, Max Winter was elected Member of Austrian Parliament and served there until 1918. In 1918–1923, he was member of the Vienna Municipal Council, deputy city mayor (1919–1920), and advisor to the Social Security Department (1918–1920). He worked as an expert in social protection of the city population and was one of decision-makers for social policies, in particular these related to the construction of social housing for the poor which the today's Vienna so proud of.

The Max Winter's heritage includes about 1500 journalistic stories that exposed abusive practices in government, awoke a public conscience and forced authorities to apply measures to handle the problem of local vagrancy and beggary. In 1949, a district of Vienna, Leopoldstadt, was renamed to Max-Winter-Platz by grateful fellow countrymen. In Max-Winter Park named so in honor of the journalist, there is a monument and a gravestone with the words carved on it "His words stood for freedom and fairness…"

Max Winter could have advised to all his followers in investigative journalism to be brave in delving into all aspects of life, to try to see everything with their own eyes – "on roads, at factories and plants, in cafes and restaurants, in buildings, in flats, at stadiums and playgrounds, in court rooms, police stations, rescue stations, at hospitals, orphan asylums, prisons, church offices, etc." A journalist should penetrate everywhere, and know all secrets, thousands of mysteries in the city, all its prejudices, contradictions and sufferings. Only then will a journalist's pen serve people, and will a human-focused mission be performed, since the key principle in journalism was and is humanism.

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Transformation, prediction of development and expansion of an informative opportunities of the Ukraine broadcasting

In the article are examined and analyzed the special features of the development of the regional radio broadcasting and interrelations of creativity in the broadcasting with technical progress. The keywords: terrestrial, wire, satellite, internet, digital broadcasting, FM-station, radio-space, development, society.

At the beginning of the third millennium broadcasting remains one of the most influential media in modern society. In current article we try to study relationship over the time of broadcast journalism development with progress in broadcasting technologies. This subject, in particular in Ukraine, has not been properly studied.

As methodical base of this study was used the work of V. O. Artemenko, Y. D. Baranevych, O. J. Goyan, V. M. Vladimirov, V. V. Lyzanchuk, I. G. Maschenko, V. Y. Myronchenko, I. L. Penchuk, G. F. Rozhok, V. I. Semenenko, Y. G. Shapoval. Mentioned above works describe the way of Ukraine's radio broadcasting development. In particular, O. J. Goyan states, that advantages of the radio broadcasting used as mass-media gives technologies to journalism that, in certain circumstances, allow the radio broadcasting be much more effective source of information than the other media.

Taking into account the current needs, relevance and insignificant degree of existing research, we turned to the origins of radio broadcasting and its condition at the beginning of XXI century. We try to identify the main challenges and opportunities of radio journalism in the transition of the domestic broadcasting to a new stage of its technological development.

The first attempts in Ukraine to use a records and play recorded audio in the radio broadcasting were in the 30s of XX century, when applied for this purpose electromechanical recording to discs coated with a special varnish-like composition, and optical recording as in sound motion pictures. Electro-mechanical sound recording was being used in consumer grade products and not for archive recordings. In an audio broadcasting the usage of speech recording was limited. Because of the complexity of media processing optical recording method was not being used.

There were other physical principles of audio recording, including electrostatic, thermoplastic, etc. But since the mid of 40s among many engineering principles, the most prevalent for speech recording became tape recording, due to the many advantages of that method. First of all, it concerned the technology of recording and playback. After recording the phonograms was not being required any intermediate processing. Playback can be started immediately after or even simultaneously with recording.

Magnetic tape was being used repeatedly. After an easy erasing the recording medium was ready for be recorded again. Amount of repeated use was limited only by the physical deterioration of a recording media.

Appropriate quality of recording technology allowed its use in all phases of existing technology of broadcasting programs creation. Therefore, in the second half of the XX century, most broadcasts were aired from recorded media and were based on the reproduction of audio recordings, i.e. the so-called “mechanical” speech. The recording technology made it possible to reduce the cost of radio broadcasts compared to live performance.

Replication became possible. By using of copying method or rewriting were being made copies of phonograms taken from magnetic recording. The quality of copied mediums was close to the original. It was important that with proper storage conditions the quality of the tracks was not deteriorated for years.

However, this method of sound recording has some inherent drawbacks. Magnetic recording is not visible, which complicates the editing of tracks and determines the presence of specific distortions, sensitivity to the effects of extraneous magnetic fields, to temperature changes and to changes of relative humidity environment. But still, gramophone and tape recordings are important landmarks of the audio recording.

In 1978 tri-programs radio broadcasting gave its audience a choice among the First Program of All-Union Radio Broadcast or “Mayak” and “Promin” broadcasting stations. In same time the audience became able to consume stereo broadcasts. Since Ukraine independence, tri-programs broadcasting had ceased to exist.

In the beginning of the XXI century with the help of satellite radio the local broadcasters launched the local retransmission of programs produced by central network broadcasting. Satellite broadcasting promotes also the development of cable broadcasting. Local cable providers receive a TV signal from the satellite and in addition of offering its subscribers the agreements of satellite TV packages, also launch streaming of radio stations, because quality of transmitted by cable sound is sufficient enough and is effectively consumed by subscribers.

A promising direction that should contribute to the improvement of broadcasting stations, is the development of broadcasting networks and digital technologies. As beginning of the implementation of terrestrial digital audio broadcasting should be considered the signing by Ukraine in June 2006 regional frequency plan for digital broadcasting “Geneva-2006”. Transition period when analog radio resources had had the international protection, continued up to June 17, 2015. Delaying the introduction of digital broadcasting in the Ukraine could lead to a loss of radio frequency resources.

In November 2009, the Cabinet of Ministers of Ukraine established the Interagency Council on implementation of measures for the introduction of digital broadcasting. The Interagency Council became responsible of coordination of all stakeholders on the way to transition to digital broadcasting.

Wired broadcasting networks suffered heavy losses due to natural reasons as natural disasters (ice, hurricanes), also due to theft of wires and due to lack of necessary funding and absence of the desire to restore this type of broadcasting.

Between 1991 and 2000 the number of active fixed radio outlets in Ukraine decreased by half. This negative process continues.

Choice of receivers for receiving state radio programs is becoming less because the number of older receivers of domestic production, dedicated mainly for long (LW), medium (MW) and short (SW) with less degree of ultra-short (UW) due to physical wear. The new receivers are mostly ranges SW (denoted usually as AM or MW) and FM. They became the most common.

A major problem of the electronic media became the chain of economic crises, in the late of XX century and in 2008-2009 that had had negative impact on the potential of technical and technological growth of public broadcasting. As a result of chronic underfunding of public radio stations for nearly two decades, far behind the modern needs of their material base, reduced power transmitters, some of them have stopped working at all.

Due to the fact that the material base of broadcasting in Ukraine is extremely behind the modern needs, at the beginning of XXI century the priorities of technical modernization were considered in distributing radio programs via satellite network, preserving and development of cable broadcasting as one of the cheapest and biggest by mass coverage of public information influence, moving of the public broadcasting to the so-called FM-range radio in the Internet.

In 1998 year, two Ukrainian radio stations “Nashe Radio” and “Dovira-FM” abandoned imperfect terrestrial microwave links and began transferring its signal from Kyiv via satellite. The signal can be taken at individual satellite antennas. Others use the space exclusively for streaming its signal to correspondent point for further relay.

Expansion of the Internet in the national information space also affects the behavior of the audience. Listeners have possibility to choose a program to listen from the sites on Internet. The rapid development of the Internet forces the domestic media market participants to react quickly to changes in the needs of the consumer. In Ukraine are actively registering Internet radio stations, which focus on a narrower audience and broadcast only on the web. The advantages of this radio is that it may stream, in particular, whole day a certain music format. Thus the cost of opening such stations are minimal: no need of license, minimal initial investment. To launch its own radio on the web enough to install a few special applications.

In the first decade of the XXI century in Ukraine the Internet broadcasting stations are developed by on-line radio enthusiasts and mostly music lovers for whom income is not the purpose. The audience of such stations is small. Some of them are "pirates", working without any license for broadcasting, using unlicensed music, does not following the rules and specifics of the radio. In our view, Internet stations are interesting for the audience as a phenomenon in the field of new radio technologies.

Internet broadcast radio station increases the number of its listeners by young people who, sometimes with no time, opportunities, or the need to listen to the station with basic receiver seeks to acquire new technologies. Internet allows creating virtual fan-clubs of broadcast station. Listeners can communicate with each other and with staff of broadcast station. Broadcaster has the ability to maintain feedback from its audience.

At the end of 2009 there was not actually a domestic market for Internet radio. Over the last five years in Ukraine is gradually increasing the number of stations operating in this format. Internet radio stations are extremely important technological way to distribute their broadcast products in areas where radio signals cannot pass or is so expensive that it is not economically feasible.

Global computer network allows stations to broadcast their transmissions to any audience that has access to the Internet that is an interactive source of information. Therefore, a global computer network is an additional way to deliver information to broadcaster's audience. Any material that is transmitted through the airwaves, can be duplicated on the Internet site of the station. And listeners can open the website of the station with the ability to listen the interested message again. Internet radio is an additional way to save and make money. Radio broadcasters are opening their own sites that introduce potential audience of communications, advertising their leaders, hold contests, quizzes, polls of the audience.

In 2000, appeared a new technology of the individual internet podcasting that allow to download audio files automatically to mobile devices of consumers. The technology of podcasting is a fusion of functional features radio and the Internet. This is sort of a unique audio diary. All that is written in the sound can be in a separate files present on the Internet for anyone, anytime. Radio stations try to gain new access to the target audience through podcasting of their programs, making musical online stores using special programs and channels.

In same time Internet does not threaten the current state of modern radio because it is not absorbed broadcasting stations but provided an opportunity to distribute their services and establish an interactive relationship with the audience on the new technological and program basis. At the beginning of the XXI century Internet and radio are equal partners in the field of mass communication that complement each other, and in this their common perspective.

16 June 2003 16 broadcasters from 15 countries started digital broadcasting on medium-length waves totaling 195 hours daily. The beginning of the broadcasting devoted particularly significant event in the history of the International Telecommunication Union - World Radio Conference (WRC) WRC-2003, which was held in Geneva (Switzerland). In this city started digital broadcasting of "Radio France" in the medium wave length range at 1179 kHz by 2kW transmitter.

Digital broadcasting is a radio transmission method that is based on digital technology and, unlike analog transmission method, involves a principally new opportunities for innovative audio programs created transferring as a combination of multimedia information: textual, visual, graphical and actual sound. Therefore, it is not only about providing information to consumer, but also its perception as the service, that information is accompanied by certain services.

Text of music program that is shown on digital receiver's display, alongside with pictures and videos of artists can be considered as a multimedia submission of information. In addition to information about the station (frequency, language, genre) display of digital receiver can show information about program on air (song title, the text, authors and performers), and also a variety of information - news, exchange rates, weather and more. All this information can be recorded in the receiver. A user that listens radio in the background can return to records at any time.

Analog broadcasting is losing its ground in respect to digital broadcasting due to development of digital broadcasting technology worldwide and in particular Ukraine. On the one hand, analog broadcasting system in Ukraine generally exhausted its technical capabilities. This affects primarily the possibility of continuously receive high-quality signal, for example, while driving, as well as in areas of unobstructed receiving of analog AM and FM signals that are overcrowded and radio spectrum do not have sufficient capacity to increase the number of broadcasting frequencies.

However, analog broadcasting provided important and high enough, particularly in the FM-range transmission quality that was not dependent on the weather, geographic and industrial noise. Therefore, the transition from one system to another occurs when, despite satisfactory quality of broadcasting, new functionality is required, which is very important for the national radio market.

Digital transmitters with optimal access to the audience comparable with analog transmission require much less power and allow using radio spectrum more effectively. Digital transmitters can be integrated with computers and mobile devices that promotes of much quicker perception of broadcast programs by listeners.

Conclusions. Broadcasting as well as other electronic mass communications methods, on the verge of centuries due to further development conducts technological and semantic converting to digital era. Transition to digital broadcasting standards is primarily due to the limited frequency resources, the need to improve the technical quality of radio programs, the introduction of advanced technologies, and the lack of government support of Broadcasting, Radio-communications & Television Concern (BRT).

However, at current stage, the major industry players do not ready to a radical change in technology transfer and reception neither technically nor financially nor mentally. The development of broadcasting in Ukraine inhibits absence of decision at the state level about what kind of broadcasting should be a priority or they are currently equally important. In addition there are complexities with the uncertainty with the basic digital format, and hence with new ways of broadcasting development, some of which are used in various countries, including Ukraine. Digital formats fundamentally change opportunities of broadcasting.

Undoubtedly, the introduction of digital methods of signal processing into broadcasting systems will facilitate the integration of the national broadcasting media into the global information space.

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Social media as a tool of manipulating public opinion: issues of astroturfing and sock puppet

Social media has the strength to influence on individual and public opinion. For example some of political and commercial institutions use the fake accounts for hiding the real public opinion, spreading false information etc. This research deals with the issues of astroturfing and sockpuppet as methods of information influence in cyberspace.

Today social networks are not only online pages for interpersonal communication, they grew into a tool of political influence and PR, marketing tool, instrument of construction hyperreality. There are many modern techniques of information influence in social media that are used to change or distortion public opinion: astroturfing, sockpuppet (sockpuppetry), impression management, false-consensus effect, social proof, social construction of a social phenomenon ets. Most of these techniques are used by politicians to lobby their interests in the international information space, promote their ideas, create an attractive image, find and mobilize a sympathetic public. However, some state governments use the same methods.

Astroturfing can be interpreted as the attempt to create an impression of widespread grassroots support for a policy, individual, or product, where little such support exists [2]. Any "artificial" public opinion is presented as real, using the method of astroturfing politicians try to persuade the audience that certain reforms or laws really supported by the public. The advantage of using social networks is that they allow contacting with the large audience without temporal and spatial communication barriers. Astroturfing is the use of fake grassroots efforts that primarily focus on influencing public opinion and typically are funded by corporations and governmental entities to form opinions [1]. The term astroturfing is derived from AstroTurf, a brand of synthetic carpeting designed to resemble natural grass, as a play on the word "grassroots".

Astroturfing closely linked to the spiral of silence, theory proposed by E. Noelle-Neumann. German political scientist explains that the media can easily manipulate public opinion and opinion of the minority positioned as the majority opinion, because individuals have a fear of isolation, if they think that their own vision of a particular issue is not like the majority vision. As already mentioned, today astroturfing is frequently used as a tool of political manipulation. For example, this technology of information influence (state-sponsored Internet propaganda) is used in China, USA, Russia, Israel and some other countries. Astroturfing could be used on international informational arena too; states with a better developed information infrastructure could exert influence on the third world countries. Multiple online identities and fake pressure groups are used to mislead the public into believing that the position of the astroturfer is the commonly held view [2]. Pragmatic potential of astroturfing consists in the correction of decision-making processes, ensuring international public support for certain political actions.

Using of astroturfing as manipulative technology and component of political PR has several advantages:

- eWoM (electronic word of mouth) – users share information via the Internet (e.g., web sites, social networks) about a product, company, politicians or political parties;
- a large number of Internet users;
- absence of time and space barriers between the "supplier" and recipient of information;
- maintaining content (information provided earlier is always visible);
- audience targeting;
- quick feedback from the audience;
- non-advertisement format of information;
- using of multimedia;
- etc.

Sock puppetry is another manipulative technology that is close to astroturfing. A sock puppet, in the context of online communications, is a fake identity created to promote someone or something through blogs, wikis, forums or social networking sites such as Facebook or Twitter [3]. Today many countries use armies of sockpuppets for manipulating public opinion, but sock puppetry is unethical and sometimes illegal technology. One of the most famous armies of sockpuppets is 50 Cent Party; this is the term for Internet commentators hired by Chinese government in an attempt to manipulate public opinion to the benefit of the Chinese Communist Party. Guardian Liberty Voice notifies that the number of the 50 Cent Party reaches 2 million internet users that comment different articles, blogs, and social media [4]. The history of the 50 Cent Party began in 2005, Chinese Ministry of Education began to hire commentators for the bulletin board systems of various universities. An Internet Water Army is a also a name of a group of Chinese internet ghostwriters paid to post online comments with particular content.

Counterfeit internet agents of influence are the part of astroturfing too. Most commonly they serve the interests of a foreign power and hold considerable credibility among the target audience. Politicians, journalists, bloggers, community activists, religious leaders, volunteers can act as agents of influence on the Internet.

The idea, which imposed on society, may be submitted to the audience not only as author comments, but in the form of jokes, catchphrases, viral videos or memes. Public relations specialists, for example, use Internet memes to create interest in politicians or political parties before elections.

State-sponsored internet sockpuppetry can be used to:

- implementation certain idea in society with the aim of lobbying interests of power in some spheres of social life (education, medicine, agriculture, etc.);
- rigging voting results;
- blocking negative public attitude to power:
- reducing of social tensions;
- blocking social activity of citizens or online activity of netizens;

- concealment of corruption;
- creating distrust in society to the opposition parties and media;
- etc.

Classic Lazarsfeld investigation in the 1940s have shown that voting decisions are not usually based on one-step communication, more necessary is two-step communication, which includes conversation with opinion leaders, colleagues, friends and acquaintances who can either consolidate or weaken the voter's opinion. Sock puppetry is the kind of two-step communication; sockpuppets can influence on users of social networks and change their opinions. Of course today astroturfing is a popular method of influence on public opinion, but it is not always effective. Public relations specialists should pay attention to the following indicators: the importance of information and its credibility; speed of it distribution; dominant attitudes in society; subjectivity of recipients; ease of remembering of information; consequences of dissemination of information, etc.

Conclusions. Astroturfing and sock puppetry are modern tools of marketing, political influence and PR. They are used on the international information arena as an instrument of influence on foreign audiences and decision-making processes. Today governments want to influence on public opinion, so they fight for dominance in the Internet, information wars and media interventions became a commonplace. For Ukraine it is important to explore cyberspace and to be able to withstand powerful external information influences. However, if the Ukrainian politicians ignore the latest communication technologies, the information security of citizens will be absent.

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Nominations of the leaders of the parties in the Ukrainian media

The range of lexical units which operate as components of names of heads of Ukrainian parties that are used in today's media discourse was delineated. Their etymology and donor conceptualization area were considered. The performance was determined. Connotation specificity was traced.

The subject-object structure of one or another segment of human activity is reflected in every discourse. The naming of members of this activity is an important component of structuring semiotic space of this discourse. The political sphere is reflected in political texts (including programs, speeches, advocacy leaflets) and media texts also [8, p. 126]. The political sphere is formed by the available political parties. The parliamentary parties that are presented in the highest legislative body of the respective factions are headed on this process. Each party has appropriate structure. Supreme leader and center parties are in charge of: «taking the important decisions; concentrating all the information about the activities of political parties in their hands; manipulating the behavior of parties masses [10]. Researchers have noted that «recently the role of the individual political leader have been increased, their business and moral qualities, the popularity level» [7].

In today's media discourse the highest leaders of political organizations are named differently. We will consider these nominative units.

Leader. Since many parties have pronounced different leadership nature, media often use the lexeme «leader». Meanwhile it's characterized by great popularity not only in political but also in other types of discourses («team leader», «group leader «, «sales leader», «rating leader», «hit-parade leader» etc.). Dictionary gives this nominative unit as: a) «the one who stands at the head of a political partie or other social-political organization; chief (2 terms.), director»; b) «a person or group of people who is first in any competition» (http://sum.in.ua/s/Lider). This is the English word (leader) etymologically means «the one who leads». So, leader is the one who goes ahead and entails other. Information about Yulia Tymoshenko at the «Batkivschyna» website has the same title – «Leader» (http://www.batkivschyna-kievobl.com.ua/ru/text/Leader). In the media in various combinations with the name of parties it's frequently called by this word: *Лідер партії «Батьківщина»* Юлія Тимошенко та голова держкомпанії «Укргазвидобування» Олег Прохоренко сперечались про справедливу ціну на газ, витрати Укргазвидобування, український видобуток, ціну російського газу для України та зарплату Прохоренка (http://www.epravda.com.ua/cdn/cd1/2016/06/gaz-chek2/page4.html); На думку *лідера «Батьківщини»*, ці рішення є незаконними й антисоціальними (http://www.pravda.com.ua/news/2016/06/23/7112660/); Червонозаводський райсуд Харкова задовольнив клопотання прокурора про проведення спеціального судового провадження стосовно екс-співробітника Качанівської виправної колонії Євгена Зимогляда, підозрюваного в застосуванні сили до *лідера ВО «Батьківщина»* Юлії Тимошенко під час її примусового транспортування в ЦКЛ №5. (http://www.pravda.com.ua/news/2016/06/13/7111683/).

In the same way lexeme «leader» is widely used in the nominations of directors of other structures: У *партії «УКРОП»* – новий *лідер*. Позафракційний народний депута Тарас Батенко очолив партію «УКРОП» (http://www.depo.ua/ukr/politics/stalo-vidomo-yakiy-nardep-ocholiv-partiyu-ukrop--13052016172900); *Лідер партії «Самопоміч»*, мер Львова Андрій Садовий займає 50-те місце у списку (http://www.pravda.com.ua/news/2014/09/12/7037580/).

Sometimes lexeme «leader» can be transformed by adding a feminine suffix -**k**-: Такий пафосний спіч українського політика дещо дисонував із буденними реаліями, так як партійні функціонери з ВО «Батьківщина», які організовували прес-конференцію своєї *лідерки*, категорично відмовлялися впускати на цей захід депутата Ковельської міської ради Володимира Косцьов'ята та спеціального кореспондента волинськоїгазети «Вільна думка» Миколу Силюка (http://kowel. com.ua/News/Article/5063).

Lexeme «leader» is used in combination with components of periphrastic (connotative) nature – unofficial names of parties: З вимогою створити слідчу комісію щодо офшорів президента виступив також *лідер «радикалів»* Олег Ляшко (http://www.pravda.com.ua/news/2016/05/10/7107970/); «Ці закони загрожують суверенітету, цілісності України і фактично є актом капітуляції. Вони неприпустимі, вкрай небезпечні», – впевнена *лідер білосердечних* Юлія Тимошенко (http://ts.petrovo.net/9687/1149-krok-vpered-dva-nazad-evrointegratsiyu- vidkladeno.html).

The word leader in this context is absolute synonym to the word «head»: «У партії «Батьківщина» є *голова, лідер*» – заявила вона на прес-конференції у відповідь на запитання, чи не планує Савченко очолити партію «Батьківщина» (http://www.pravda.com.ua/news/2016/05/27/7109898/).

Head. Lexeme «head» – is a unit full of meaning. One of its meanings – "the head of institutions, associations, companies, organizations and their departments» (http://sum.in.ua/s/gholova). It developed as a result of metaphorical transfer. Now lexeme acts as a traditional name of executive positions: *Голова партії «Батьківщина»* Юлія Тимошенко 21 травня перебувала в Рівному, де триває конфлікт навколо посади голови обласної ради (http://www.radiosvoboda.org/a/news/27749382.html); Мер Києва Віталій Кличко написав заяву про складання повноважень *голови партії БПП* (http://www.pravda.com.ua/news/2016/05/26/7109738/); Відкритий лист Громадської організації «Всеукраїнська Люстрація» до *голови партії Об'єднання «Самопоміч»* Андрія Садового та голови однойменної фракції у Верховній Раді Олега Березюка (http://antikor.com.ua/articles/22296-vidkritij_list_govseukrajinsjka_ljustratsija_do_golovi_partiji_objednannja_samopomich); Журналісти з'ясували, що пов'язує нового *голову партії УКРОП* та скандального екс-нардепа від Партії регіонів Олега Царьова (http://firstsocial.info/news/noviy-lider-ukropu-viyavivsya-pomichnikom-tsarova).

Голова комітету Верховної Ради з питань податкової та митної політики Ніна Южаніна і *голова фракції «Батьківщина»* Юлія Тимошенко посварилися під час обговорення законодавства щодо деофшоризації (http://www.pravda.com.ua/news/2016/04/25/7106675/).

Boss. Lexeme with a clear etymology «boss» and «helmsman» are frequently used less. The boss – «is one who directed somebody something; manager» (http://sum.in.ua/f/ochiljnyk): Партія «Батьківщина» не підтримує кандидатуру голову фракції БПП Юрія Луценка на посаду генерального прокурора України. Про це заявила *очільник партії* Юлія Тимошенко (http://espreso.tv/news/2016/05/10/quotbatkivschynaquot_proty_ pryznachennya_ lucenka_genprokurorom). The top of word-formative nests for «helmsman» is the word «helm» – «a) a lever or wheel controlling the rudder of a ship for steering; broadly; b) a position of control» (http://www.merriam-webster.com/dictionary/helm). There is a semantic affinity with the word «helmet».

Ruler. Expressive lexical unit «ruler» means: a) a person who rules a country, area, group; b) a worker or a machine that rules paper, and acts as a synonym for the word «boss» (http://www.merriam-webster.com/dictionary/ruler). General semantics of this lexeme is also reduced to the definition of «leader»: Згодом, перед журналістами *керманич «Батьківщини»* висловила розуміння стурбованості лідерів європейських країн щодо корупції в Україні та затримки в реформуванні держави (http://kowel.com.ua/News/Article/5063).

Chief. This word at one time (in Soviet propaganda) had the same «nominative rights» as the rest of the names («chief of the world proletariat»). In the dictionary it registered with values: a) «leader of the army, of the tribe»; b) «the ideological and political leader of social movements, parties, classes; helmsman» (http://sum.in.ua/s/vozhdj). But over time, its meaning began to move into the negative connotations. Now it's used in that aspect: Демонстративний вихід із коаліції, жорстка критика президентських ініціатив, у тому числі з мирного врегулювання на Донбасі, організація потішного «комунального майдану» під Кабміном – усе вказувало на те, що *вождь «радикалів»* розглядає місцеві вибори як прелюдію до парламентських (http://hgraf.com.ua/index.php/ar/explore/extenstions/item/2496-lyashko-zilletsya-z-ukropom). Often it is used for the category with a negative connotation, and also heads of the regional parties offices: *Місцевий багаторічний "вождь" "Батьківщини"* Василь Деревляний, який до того відверто "завалив" кілька попередніх місцевих виборчих кампаній, був шокований таким несподіваним щастям (http://nova.te.ua/statti/ternopilska-oblrada-kurs-na-oderevlyaninnya/)

Honcho. This lexeme appeared in the English vocabulary in the context of the Japanese mafia. It is used to describe the criminal leader or a mentor with a criminal history: А мова йшла про те, що «загальноміська» насправді зробилася геббельсівським рупором однієї лише політсили – *Партії регіонів*, переназваної після втечі з країни її *"пахана"* Януковича на ОпоБлок (у народі – "жопоблок") (http://krivbas24.com.ua/ivan-najdenko-liky-vid-kuryachoyi-slipoty-video/). It is a person in charge of some group or of some function, usually a male person. A Japanese word, often mistakenly thought to be of Spanish origin. In Japanese it's a term for a small-time yakuza gangster in charge of just a few underlings, but the underworld flavour has mostly been lost as the word has been adopted into English. (http://www.urbandictionary.com/define.php?term=honcho). That connotation is emphasized not only the criminal past of the former president, but also his criminal activities.

The conclusions

So, in the Ukrainian media discourse for the naming of leaders of political parties we use many lexemes such as: leader, head, boss, helmsman, ruler, chief, manager, mentor and honcho. The unit «leader» is a one of the most popular in the political sphere as well as in many others; it has many other image settings. Lexeme «head» is the traditional formal connotation. Less productive are words «ruler» and «helmsman». Lexeme «chief» positions the dentate as a negative «character». Unit «honcho» has negative and criminal intertextual loads.

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Pragmatic functions of the punctuation symbol "quotations" in media texts

The concept of "nonscheduled punctuation" was analyzed. A tendency to use punctuation based on semantic principle (along with structural) was shown. The pragmatic aspect of the graphical tools functions was identified. The "pragmatic shift" that emerged to use quotes in modern media texts was shown.

Punctuation is a well-organized system of graphic signs, the use of which is intended to facilitate the perception of the written text and to submit this text presented by the author's opinion as closely as possible. Punctuation is "a unique non-verbal semiotic system which is capable of induction and transmition of communicative-pragmatic meaning and prosody-intonation nuances of the written text" [7, p. 36]. However, researchers often confirm the appearance of the phenomenon, which is called "*nonscheduled* punctuation" in written language. At the first sight it seems that the "punctuation, which is not regulated by the rules, now is not exposed to a particular interpretation. It can be assumed that the use of punctuation marks becomes more spontaneous. Meanwhile, various texts analysis allows to find out that some kind of rate is settled behind which certain regularities are hidden» [11, p. 62]. Mouthy this is related to publicistic and literary texts, which because of their stylistic specificity of most common use of punctuation, are based primarily on the semantic principle (along with structural) [1, p. 39]. Speaking of pragmatic aspect of graphical tools functions, it should be noted that they perform a range of functions: a) intensification (lexeme with a minimum emotive value becomes more semantic expressive because of visual effect); b) signaling (focusing on visual markers which allow reader to have the opportunity to decode the author's intention better, that assists in establishing of cooperative relations between the parties of the communication); c) emphatic (allows you to make the logical and intonation accents, to reveal the implication prosodic aspect of the text message); d) authentication function (marking provides of other people`s words to create the effect of authenticity message) [13, p. 137].

In this article we will focus on "pragmatic shift" of use quotations. Quotations are paired excretory punctuation mark [2, p. 268]. They are used for marking: a) citations; b) words that are not considered to their own or used with a touch of ironic or contemptuous assessment of a strange expression and those, which are used for the first time or, conversely, are outdated used and unusual shade; c) registration of individual factories, businesses, organizations, clubs, ships, scientific works literary works, films, magazines, newspapers and others titles. [9, .p 151-152]. The use of quotes marked by the bright pragmatism, since this method is the attitude of the speaker to the message and shows his desire to signal the recipient of the special nature of the fragment notification which is marked with quotations. Speaker gets an opportunity to properly control the content, trying to reach right perception and understanding. It has ability to protect the information from an incorrect interpretation of its recipient, focusing on extra meanings, which often demonstrate an ironic attitude to the subject or person. Most clearly graphic character analyzed punctuation is manifested when quotations transmit some or other characteristics statements that cannot be expressed at all or not clearly expressed in oral communication. Lexical units, which are marked with quotations, in a certain sense are controlled by the communicator, who is seeking to achieve some adequate perception, provides correct interpretation, focuses on the presence of certain related values [4, p. 84-85].

The use of quotations creates a special context, realizes its intertextuality, implies those meanings which provides quotations bulleted snippet of its sender. Available material allows for the allocation of the following methods unregulated use of quotation marks: Available material allows for the allocation of the following methods unregulated use of quotation marks:

a) euphemisation: Лавров ледь стримав *"слово з 4 літер"* із приводу зламу пошти демократів (http://www.pravda.com.ua/news/2016/07/26/7115923/);

b) periphrasis, within which the process of diverse semantic modifications starts. Detected cases with the implement of the model «Adj + N» (Апеляційний суд відмовився відпустити *"бурштинового" прокурора* (http://www.pravda.com.ua/news/2016/07/19/7115298/); Порошенко назвав *"піратські ролики"* внеском у протидію інформвійні (http://www.pravda.com.ua/news/2016/07/24/7115767/); Суд не зміг ознайомитися з оригіналами *"чорної бухгалтерії"* ПР (http://www.pravda.com.ua/news/2016/07/20/7115450/); *"Мюнхенський стрілок"* планував теракт протягом року (http://www.eurointegration.com.ua/news/2016/07/24/7052553/); НАБУ затримало чергового фігуранта розкрадання "кіотських" коштів (http://www.epravda.com.ua/news/2016/07/12/598930/); Москаль каже, що "народні патрулі" самі контрабандою займаються (http://www.pravda.com.ua/news/2016/07/11/7114434/); Геращенко: *"Нормандська четвірка"* має дотиснути бойовиків, щоб вони звільнили заручників (http://www.pravda.com.ua/news/2016/07/13/7114670/), as well as models «N + N_{gen}» (РФ ініціює спрощене провадження проти заперечень України щодо *"боргу Януковича"* (http://www.epravda.com.ua/news/2016/07/15/599318/); У *"день тиші"* на Луганщині агітують ксерокопіями 100 і 200 гривень (http://www.pravda.com.ua/news/2016/07/16/7114994/); У НАТО стурбовані порушеннями *"режиму тиші"* на Донбасі (http://www.pravda.com.ua/news/2016/07/10/7114327/);

c) marking of foreign words which are in the process of borrowing: Гройсман вимагає доповісти, хто *"кришує"* зловживання на ремонті доріг (http://www.pravda.com.ua/news/2016/07/25/7115880/); Поліція розслідує *"злив"* відео закладення вибухівки під авто Шеремета (http://www.pravda.com.ua/news/2016/07/24/7115797/);

d) introduction of the stranger speech (mini-quote): Гройсман оголосив про *"початок кінця корупції"* в Україні (http://www.pravda.com.ua/news/2016/07/21/7115546/); Матіос каже, що не захищає Кулика і *"має сумніви"* (http://www.pravda.com.ua/news/2016/07/14/7114755/);

e) the development of polysemy (providing values of occasional words): У Фірташа звинуватили інвестклімат у *"провалі"* продажу ОПЗ (http://www.epravda.com.ua/news/2016/07/19/599702/); Через нові *"замінування"* на Херсонщині відкрили провадження (http://www.pravda.com.ua/news/2016/07/17/7115084/); *"Мінування"* збило явку в Херсоні (http://www.pravda.com.ua/news/2016/07/17/7115077/); У Болгарії *"застрягли"* 150 українців. Авіаперевізнику обіцяють "жорсткі заходи" (http://www.pravda.com.ua/news/2016/07/16/7114990/); Медики: у Медведька і Поліщука безліч травм після *"допиту"* (http://www.pravda.com.ua/news/2016/07/13/7114652/); Трамп офіційно назвав ім'я *"свого"* віце-президента (http://www.pravda.com.ua/news/2016/07/16/7115003/);

f) marking simulacral: СБУ і МВС моніторять ситуацію навколо "хресної ходи" – Геращенко (http://www.pravda.com.ua/news/2016/07/11/7114440/); СБУ затримала розчаровану *"екс-депутата ЛНР»* (http://www.pravda.com.ua/news/2016/07/15/7114897/); 18% жителів окупованої Донеччини вважають себе *"громадянами ДНР"* (http://www.pravda.com.ua/news/2016/07/14/7114758/);

g) meaning distinction: Апеляційний суд відпустив з-під варти *"айдарівця"* Радченка (http://www.pravda.com.ua/news/2016/07/11/7114458/); Міносвіти скасує *"спеціалістів"* і *"кандидатів наук"* (http://life.pravda.com.ua/technology/2016/07/11/215073/);

h) slang options: На Чернігівщині на хабарі впіймали *мера-"радикала"* (http://www.pravda.com.ua/news/2016/07/14/7114770/); В українки Каліни забрали *"бронзу"* ОІ через допінг (http://www.champion.com.ua/weightlifting/2016/07/13/657233/)

The conclusions

Even the most advanced graphic system cannot remain immutable for a long time, because of language development is a permanent process. Reflecting its verbal option, the graphics system is looking for the ways and methods of approximation sender`s thoughts to the recipient as much as possible.

Media texts are the result of these processes, they are a "testing ground" for a variety of speech innovations that affect, even such, seemingly, conservative subsystem as punctuation.

The researchers are talking about the "unregulated punctuation." In this way there is formation of new ways for the realization of all infinite palette of author intentions that arise in the communication process.

The use of quotation marks allows communicator "to control" marked punctuation linguistic units, to reach their accurate interpretation, to ensure their correct perception, to accent them on relevant accompanying values.

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Local government of Ukraine in within the context of the experience of European Union countries

The proposed paper aims to show organizational and legal mechanisms of functioning of local government of Ukraine. The problems in the field of local government which keep a check on the transformation of Ukrainian local government into authoritative, autonomous institutions, able to decide urgent issues of local life in democratic state, taking into account all European traditions, are analyzed.

According to European standards, at least, to one of the existing variants in Western European countries, this law solves the problem of power authority distribution between executive representative local self-governing institutions on the level village-town-city. The mechanism of functional authorities' distribution has remained traditional. It is stable and looks like follows ing: the executive committee accountable to a council, and a chairman heads a council and an executive committee electorial system that have approximated local government in Ukraine to civilized European standards.

However, in the making local government in Ukraine came across numerous serious problem. Among them it is necessary to point out such problems as the preservation of certain contradictions in local self-governing legislative basis, which require its subsequent improvement: the brining of legislature to conformity with international law standards, in the first place, with the demands of European local self-governing Charter and established of the civilized democratic countries of the European council. This problem should be specially emphasized in the financial and budget sphere of Ukrainian local governing activity, in the sphere of its material and financial security, in which the problem of efficient, just finance distribution is still open. However, the problem of clear-cut distribution of state and local budgets is closely connected with one more still unsolved problem - the clear-cut differentiation of power between state power bodies and local government, the differentiation of authority between different power rates and in the final analysis the interaction between local government and state power bodies. The problem of inadequate correlation between administrative territorial units and local councils requires urgent solution. The number of local councils (12000) is twice and a half as less as the number of populated areas (over 30000).

This complex of problems hampers a great deal the transformation of local government of Ukraine into really authoritative, autonomous and financially capable institution, which is able to solve effectively the local life actual problems of the democratic state in accordance with European traditions.

The process of local self-governing institutions has approximated to European standards as much as possible. In contrast to Soviet period, when the elections to the different councils of all levels were formal, the deputy staff was constantly and diligently regulated by party structures. They were the structures which sent the so called "rate", a good example to which is the experience of local councils' deputies' staff formation of the eighteenth convocation. In this way, the number of local councils' members in the party authorities' motions was 34,2%, farmers - 38,6%, non-party people - 56,2%, women - 49,2%, members of the komsomol - 21,1 %, young deputies (under 30-30%), the deputies elected for the first time - 36,3% (1), and the results of local councils elections in 1982 were accordingly 34,2%, 38,40/0, 56,2%, 49,2%, 21,1 %, 32,9%, 38,20/0 (1). Thus, the party authorities' motions of Ukraine about the basic points of candidate staff coincided with the results of the elections to local councils almost in full.

We think that it proves convincingly enough that in the 80-ies local councils in the Ukrainian Soviet Socialistic Republic performed the function of decoration, "cover" in the process of the power authority implementations by party structures.

The local power bodies were formed and regulated by the Communist party only, which thought it impossible for any opposition to exist. Besides, the very term "local deputies", let alone its content as a form of territory communities self-organizing, was taken out of use in Soviet period of Ukrainian history. In the Ukrainian constitution of 1978 people's deputies' councils were only declared as state power and local self-governing authorities.

Certain practical steps in the direction of democratization in local power authorities' forming, and by this, practical renovation, local self-governing making in Ukraine, were made in March of 1990, when the elections of deputies to Supreme Rada and local Ukrainian Republic councils took place.

Legal regulation of local self-governing organizing and functioning in Ukraine during the 90-ies of XX century was ensured by a series' of legislative documents. Apart from the above mentioned, we want to point out the Law of Ukrainian Republic December 7, 1990 on Local People's Deputies' Councils In Ukrainian Republic And Local Government; the Law February, 24, 1994 on the Elections of Deputies and Chairmen to Village, Town, District, City, Regional Councils, the Law February, 3, 1994 on Local Power and Self-governing Authorities' Forming"; the Law June 17, 1994 on the Changes and Supplement to the Law on the Elections ofDeputies Chairmen to Village, Town, District, City, Regional Councils, the Law June 28, 1994 on the Changes and Supplement to the Law on Local Power and Self-governing authorities' forming; the Ukrainian President Edict December 30, 1995 on State Executive Power Authorities' Delegation To Chairmen and The Executive Communities of Village, Town and City Local Councils Headed by them, the Law on Local State Administrations (1999) and others (1).

The Law on the Elections of Local Councils Deputies And Village, Town And City Chairmen should be pointed out among the valid normative documents which regulate the local self-governing organizing problems in Ukraine. It is thelaw which considerably approached the process of local self-governing organizing to European standards, despite that the majority system under which elections take place in one-mandate districts, was assumed as its basis and neither the proportional one, under which local self-governing authorities are formed according to party lists, nor the mixed system of self-governing bodies forming.

By the way, European local self-governing Charter does not demand that the elections to local government bodies should take place according to party lists or mixed system only. And the local elections results in 1998 proved that the party membership of local council deputies is not the main characteristic for voters. Thus for instance, 482 of 6268 deputies of Zaporizhzhya district local councils are members of political parties (2). The authority, grounding and political literacy of elected representatives of the people are the most significant features for our voters. In this connection the statistic data, which are indicative of the fact, that the educational and health protection institutions have become the second significant and influential group almost in all the regional local councils, are of noticeable importance: there are about 20% of doctors and teachers in the regional local councils.

Significant quantitative changes in local council staff have taken place in comparison with the staff of deputy corps of the previous (1994-1998) convocation. The educational level of local council deputies has considerably increased: more than 25% of village council deputies have a higher education. The member of town council deputies with a higher education is more than 50%, and district, city and regional council deputies' corps consists of 75% of the deputies with a higher education. Also the significant renovation of deputy corps in all the branches of local self-governing has taken place. The council staff has renovated average 80,4% (3). The local council staff changes of this kind took place both in regions and in Ukraine on the whole. 67% of the deputies, who had never been council deputies of such a level, were elected to local councils of Ukraine in March 1998. Besides, one thirds of the elected 11 thousand of village, town and city chairmen did not fill this position during the previous convocation.

Thus, certain conclusions can be drawn on the grounds of comprehensive comparative analysis of local Ukrainian and European countries organizing and functioning, their legislative security. First of all the process of Ukrainian local self-governing renovation and formation during 90-ies of XX century basically took place on the lane of the local self-governingdevelopment tendencies of European countries and at the same time with the regard for the specific peculiarities and his historic traditions of public politic life in Ukraine. A well- grounded proof for this is the fact that almost all the main principles and rules, European civilized legislative standards, which regulate the organizing and activity problems of local government found the embodiment in the Constitution, in the Law on Local Government in Ukraine and other legislative acts (3).

Mostly due to this local government in Ukraine gradually turns into an important public power institution. It also takes place due to radical, real forming system transformation of self- governing representative bodies - local councils of all the rates. Elections in practice have turned into real citizens' will in comparison with Soviet period. The authors are deeply convinced that it is precisely the changes in the sphere of elections' system that brings the local self-governing of Ukraine nearer to the level of civilized European standard.

All this complex of problems restrains the changing of the Ukrainian self-governing into a really authoritative, autonomous and financially capable institution, which is able to decide actual questions of local life in a democratic state, taking into consideration all European traditions.

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The local self-governing in Ukraine

The proposed paper aims to show organizational and legal mechanisms of functioning of local government of Ukraine. The problems in the field of local government which keep a check on the transformation of Ukrainian local government into authoritative, autonomous institutions, able to decide urgent issues of local life in democratic state.

The need in defining the most reasonable ways of state organization development, and in solving the problem of increasing the efficiency of the executive power, organs especially of the local ones, has grown sharply under conditions of Ukraine independence. On the same plane the study and generalization of the practical work experience of local self-governing institution in Ukraine during the 90-ies of the XX century, when this process was factually in the making, acquire the great importance. The timely generalization and scientific realization of the comprehensive practice of local self-governing institutions will allow to some extent mistakes and errors of Ukrainian self-governing institutions structure organization and then activities, hence to approach their functioning to European standard.

Local government is local self-governing authorities, right and real opportunity to regulate the considerable part of governmental affairs and to manage them acting according to the law, in the interests of local population. Local self-governing is the juridical person of the state law, which is ruled by the elective body, empowered on a certain territory.

The European Charter of local government adopted by the European Council in 1985 serves as a basis of organization and activities of local government in modem Europe. This document determined the general development principles of local Government as a main factor, characterizing any democratic formation.

Implementation of these principles provides effective governing which is at the same time close to the citizens.

Local government in Ukraine began to renovate only in the 90ies of the XX century. The adoption of the Constitution in 1996 was of great importance for the process of local self-governing development. This Constitution for the first time in the history of the home constitutional law assigned the status and garantees of local self-governing bodies, activities. Thus article 7 in section General Statute says that "local self-governing is recognized and guaranteed”.

This evidently positive fact was given concrete expression in Articles 140, 146 XI of the separate special section "Local Self-Governing". As mentioned in article 140 in particular, "local government is the right of local community citizens of a village, town or city to solve questions of local importance independently within the limits of Constitution and the laws of Ukraine..."

Local government is carried out by the territorial community according to the law. It can be carried out directly or through the local self-governing bodies: village, town, city councils and their executive bodies. City self-governing bodies, presenting common interests of territorial communities, villages, towns and cities, are district and regional Councils. The controlling organization matters of districts in cities belong to the competence of city councils. Village, town and city councils can allow organizing house, street, block and other bodies of population self-organizing of citizens, initiative empower them with a part of own competence, finance, property" (article 140). Thus Ukrainian Constitution has clearly defined the system of local self-governing bodies to which village; town, city, district and regional councils are referred. But, this article of Ukrainian Constitution has still preserved certain touch and traditions of Soviet times. Owing to this it does not fully coincide with the principles and standards, generally acknowledged by democratic Europe, which define local government as non-state or autonomous citizens' self-governing institution. This disparity and unconformity can be easily traced if we compare the norms of part I of article 140 of Ukrainian Constitution and part I of article 3 of the European Charter about local government. In the latter it is pointed out that government is understood as local self- governing authorities' right and real opportunity to regulate the considerable part of local affairs and rule them, acting according to the law, on their own responsibility and in the interests of local population. As it is seen from the texts of both documents (Constitution and Charter), such an important point that gives local government in the country "real opportunity" to solve local affairs "on their own responsibility and in the interests of local population" is missing from the Basic Law of Ukraine. Thus, the standard of international right, the right of local government to its autonomous of state budget and its taxes takings, has factually remained unsealed in the constitution. More than that, articles 95 and 142, which deal with the budget system of the country, do not legally state that the budget system consists of state and local budgets, which are autonomous of state ones. Thus, even after Supreme Rada had adopted the new Constitution, local government in Ukraine remained without financial autonomy, which undoubtedly hampered its development in accordance with European standards.

The problems of local self-governing ability to use its power fully in accordance with the standards of European right are reflected in the Law on Local Government in Ukraine", which has been acting since May, 1997. According to this legislative document, local self-governing authorities act within their power limits by themselves, as the autonomy and are not subordinated to each other. That is, the councils do not create the general single vertical line of power, and it fully coincides with the demands of European local self- governing charter and radically differs them from the structural system of the state power and local governing of the Soviet period. Besides, the Law on Local Government in Ukraine finally stopped the artificial (to our mind) division into a base and representative levels, according to the Law of Ukraine on Local Councils of People's Deputies and Local and Regional Government edited on March 26, 1992.

In accordance with this law district and regional councils were not acknowledged to be local self-governing authorities. And according to the Ukrainian Law on Local Government in Ukraine local and district councils are local self-governing institutions.

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Strategic priorities of aviation services market's competitiveness growth in Ukraine within globalization

The basic strategic priorities of aviation services market's competiveness growth in Ukraine within globalization terms are defined in the article. The special attention is given to the prospects of improving, security and achieving correspondence of national aviation services market's standards with international ones under the terms of Ukraine's joining Common aviation space with EU and rules of 'common aviation area'. The main priorities of aviation branch in Ukraine are defined concerning its competitiveness growth.

Under the terms of crisis economic situation directly linked to the loss of traditional outlets for national goods and services Ukraine has been searching for new trends and niches for further economic development. The important place in this process is taken by aviation services market development which is closely connected with innovations, high tech growth, domestic and foreign trade maintenance and passenger traffic. The set of aviation services draws closely related branches to its sphere development such as highway engineering and all kinds of transportation (including their repairs), infrastructure objects, machine building, hotel and restaurant business, trade etc. Thus, aviation services market development forms multiplicative effect of economic growth that positively impacts on creation of additional workplaces and national production capacity growth. In this way the issue of finding strategic priorities of aviation services market's competitiveness growth is of actual importance for Ukraine concerning the globalization challenges and aggravation of competitiveness in this business segment in the world.

In 2015 Ukraine was in agreements on air communication with 68 world countries including the following ones:

- providing no restrictions as for number of airlines and flights from Ukraine with 11 countries;
- providing some restrictions as for number of flights, control over departure and arrival airports with 48 countries, 8 of which gave permission just only for one airline carrier;
- providing restrictions as for having just one Ukrainian airline with 9 countries [1].

These data are evidence of institutional and organizational obstacles in free air communication between Ukraine and world countries.

Among the main problems hampering the Ukrainian aircraft industry development and aviation services market development it should be mentioned the following: crisis of domestic civil aviation market related to lack of investments into national airlines to update and modernize the set of aircraft in service; reduction of civil aircraft export; underdevelopment of loan tools to finance manufacturing and realization of state aeronautical engineering, unavailability of financial leasing; lack of tax and other incentives for local and foreign financial groups to invest into Ukrainian aircraft industry etc. Among the factors obstructing drawing investments into national aircraft industry the following ones are defined: organizational dissociation of its structures; decrease in scientific, intellectual potential and worsening personnel potential in design engineering departments, institutes and enterprises engaged in designing and producing aircraft; competitiveness aggravation concerning laws of property in the aircraft manufacturing sphere; toughening the world organizations' requirements concerning control over keeping quality and safety standards in the sphere of aircraft manufacturing and air transportation [2].

In 2015 Ukrainian register included 915 objects of air industry, among them there were 352 objects of general purpose aviation, 72 aircraft in service, 32 aircraft manufacturers, 39 aeronautic engineering designers [1]. Unfortunately, for the last years our state has lost competitive position in the aeronautic engineering market, air transportation and air services market. Though, in spite of all the drawbacks, Ukraine has saved powerful competitive potential in the sphere of transport and regional passenger aviation. It possesses full circle (macro technology) of aeronautical engineering creation. Considering the level of development, aircraft construction in Ukraine is a member of the "club" of top world countries applying high avia tech. So aircraft industry is both one of the most profitable and one of the most capital-intensive spheres of machine building.

In 2015 Ukrainian aircraft industry numbered more than 60 enterprises producing aeronautic engineering, including 5 large enterprises – public corporation 'Motor-Sich', Kharkiv aircraft plant, Antonov Aeronautical Scientific-Technical Complex (Antonov ASTC), Kyiv plant 'Aviant' which employed nearly 25 % of labor force engaged in the sphere of machine building. Aircraft industry potential un Ukraine is oriented towards designing and producing regional passenger and transport aircraft (including medium aircraft segment); aviation engines and aggregations; on-board radio electric equipment aimed at using satellite communications, navigation and surveillance; helicopters and small aircraft, particularly, pilotless vehicles etc. The following aircraft are of the most perspective and competitive designs in Ukrainian aircraft industry: An-38, An-70, An-74, An-124, An-140, An-148, An-158 and their modifications; engine production chain D-27, D-18T of fourth series, AI-450, AI-222-25, ВК-2500; helicopter; pilotless vehicles [1].

The examples of interstate contracts made proves the existence of powerful competitive potential of Ukraine in the aeronautic engineering world market which allowed to broaden cooperation and international integration to aviation sphere, promoted aviation complex development in the state. For instance, Ukrainian aircraft An-124 "Ruslan" was chosen for military and transport traffic in 12 NATO countries (including EU countries and Canada). Its competitive advantage compared to Americal aircraft C-17 "Globe-master" was lower price and greater weight-carrying ability. In particular, French military forces used aircraft An-124 "Ruslan" made in Ukraine to transport military technique and property to Mali for the operation Serval.

On April 18, 2002 Brasil and Ukraine signed the protocol on the Alcantara Cyclone Space project which was to give Brazil and Ukraine access to the global commercial launch market for satellites in low and medium Earth orbit, with the possibility of launching very light telecommunications satellites into geostationary orbit. The project provided drawing costs from state budget as well as from commercial investors.

China is a prospective foreign trade partner of Ukraine and the main consumer of Ukrainian export in Asian-Pacific region. The powerful domestic air traffic market guarantees demand for Ukrainian planes. In particular, the negotiations are in force concerning Ukraine's participation in China state program on Chinese western regions development which provides wide-scale infrastructure objects building, including ones in aviation sphere. The Comac ARJ21 Xiangfeng, a twin-engined regional jet, manufactured by Chinese aerospace company Comac, features an all-new supercritical wing having a sweepback of 25 degrees and designed by Ukraine's Antonov Design Bureau. It is fitted with winglets to improve aerodynamic performance. Antonov also assisted the project with geometrical determination and integral analysis of the construction strength of ARJ21.

The special attention is given to the cooperation in the sphere of aircraft building and air traffic development with EU countries. On March 12, 2013 inter-governmental agreement on air traffic was signed between Ukraine and Poland. It defines the procedure of aircraft enterprises inspecting aimed at evaluation of its correspondence to quality standards of the International Civil Aviation Organization (ICAO), specialized agency of the United Nations which codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth. This procedure allows to transfer to the process of fare monitoring and restricting the intrusion of air traffic administration into the process of fare setting, permitting aircraft enterprises to make commercial agreements on air traffic using common accepted codes etc [3].

Ukraine is realizing the twinning project " Support to the implementation of European standards in air traffic management and air navigation" aimed at supporting the sustainable development of civil aviation in Ukraine; harmonising regulations and working practices to comply with international standards (ICAO) and international best practices; preparing for the implementation of international and EU standards.

Institutional and legislative basis of Ukraine's cooperation with EU countries in the sphere of air transport development is formed with realization of Air Law which was adopted by Verkhovna Rada in May, 2011 [5]. It regulates the legal fundamentals of activity in the sphere of air transport, defines priorities of air branch state regulation, normalizes terms and standards of air space use considering aviation and air traffic safety guarantees, provides state interests and national security in air traffic. Air traffic security is one of the main conditions for competitiveness in EU countries as well as in the world.

Among the priorities of air traffic security Air Law mentions the following: implementation of international organizations' requirements to Ukrainian legislature, especially concerning air navigation security and passengers' protection (both in civil commercial aviation, general-purpose aviation and state aviation);

normalization of the way of passengers' damages done by flight delays and/or route changes; standardization of the cross-bordering terms by air vehicles; precise definition of state authorities responsible for air transport functioning etc. [5]. Air Law of Ukraine provides executing requirements of air transport international organization such as the Joint Aviation Authorities, or JAA, an associated body of the ECAC representing the civil aviation regulatory authorities of a number of European States, the European Civil Aviation Conference (ECAC), an intergovernmental organization which was established by the International Civil Aviation Organization (ICAO) and the Council of Europe, the European Organisation for the Safety of Air Navigation, commonly known as Eurocontrol, an international organisation working to achieve safe and seamless air traffic management across Europe, and considering conclusions and recommendation of the International Civil Aviation Organization (ICAO). Compliance with Air Law norms will promote international standards implementation and satisfaction of the requirements concerning the structure, quality and safety of air vehicles use, pilots' qualifications, state and capacity of air services providing buy airport service, creation of Common aviation area between Ukraine and EU countries. European Common Aviation Area (ECAA is defined by bilateral agreements between European countries about a single market in aviation services. The ECAA in effect would liberalize the air transport industry by allowing any company from an ECAA member state to fly between any ECAA member states airports (including the possibility for a "foreign" company to provide domestic flights). Ukraine's joining ECAA opens the new air services markets for the country covering 500 mln.people.

Conclusions

Aviation services market's competitiveness growth in Ukraine within globalization is closely connected with intensification of integration processes and Ukraine's joining European Common Aviation Area. The agreements between this country and EU define strategic priorities of aviation complex reformation and Ukrainian air services market's competitiveness growth emphasizing on quality improving, safety guaranteeing, corresponding of national standards of aviation complex development with the one of developed countries.

Among the basic priorities of aviation services market's competitiveness growth in Ukraine there are harmonization of Ukrainian legislation to EU legislation in the sphere of flight security and air navigation management. Such security standards concern planes' technical standards; qualification level of air carrier and traffic controller service; qualification level of air inspectors; accurate compliance with flight schedule; guaranteed way of passengers' damages done by flight delays, flight cancellation and flight postponing etc. Mutual access of the countries to the national air services market is of important trend of air traffic market's competitiveness growth in Ukraine, including air traffic market, producing and maintenance of air vehicles, air specialists' training etc. Uniting of air markets is beneficial for Ukrainian air industry mainly for the following reason: air production of Ukrainian origin and aviation services will go through corresponding certification and develop competitiveness in European and world markets. This process will positively affect national air complex development, aviation services market's competitiveness growth and Ukrainian economic growth in general.

To take competitive advantage of Ukrainian air complex it is reasonable to create favorable conditions for drawing investments, technological base updating, international air consortium creating with the participation of leading transnational world corporations; provide organization of joint ventures and long-term production and marketing cooperation; guarantee state support to aviation complex in Ukraine. Creation of air hubs and consolidation of air enterprises within powerful diversified developed world countries' air complexes is also perspective in Ukraine.

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Features and trends in the market of consulting services in the aviation industry of Ukraine

This article investigates the condition of the consulting market in the aviation industry of Ukraine. The structural configuration of the Ukrainian consulting market on functional grounds, with the customer's branch, as well as geographically were analyzed. The characteristic of the main causes of instability of consulting activities in Ukraine and outlined its development trends. The reasons of unstable development of the consulting activity in Ukraine are studied. Trends of consulting market development has been defined.

Today the term "consulting" is becoming more common for Ukrainian aviation. But trust your company outside consultants ready yet every director, because they have to spend money on something that seems at least strange - because my own experience, unfortunately, not enough.

The main purpose of consulting is to improve the quality of management, improve the efficiency of the company and increase individual productivity of each employee. Potential consumers of consulting services to serve any organization that face management challenges as consulting producers of the product is determined to offer consulting market is a consulting firm, product manufacturing activity is consulting services.

Today in Ukraine there are over 350 national consulting firms, of which 42% are engaged exclusively in providing services on management consulting, public offices leading consulting firms that are leaders in consulting business.

In the management consulting market offer:

- Consulting multinational corporations (big five: Deloitte & Touch Tohmatsu int., Arthur Andersen & CoSC, McKinsey & Co, PriceWaterhouseCoopers, Ernst & Young,), with an extensive network of regional offices, united only corporate strategy and culture;
- Large multifunctional company, which has about hundreds of professional consultants who specialize in serving large companies and offer a full range of management services and solve complex problems. Typically, these firms also engaged in research activities, allowing them to continually improve the product offered;
- Highly specialized firms that typically provide consulting services to small and medium-sized companies and offer their services in limited areas of management consulting, enabling them to achieve a high quality of service. As always, they are trying to work in a particular territorial space;
- Universities, training centers that are conducting extensive training of specialists can carry out training, initiating learners, compliance consulting and knowledge to further the provision of various aspects of business;

- Some independent consultants - highly qualified specialists with experience and tend to act as experts or for any problems or permanent consultants of small firms.

Generally, in the world, as well as Ukraine, the market is clearly segmented consulting services, and competition between sellers of consulting products is within its segment.

Analysis of Regions consulting services (Fig. 1) shows that the bulk of the accounts for the central region (35%).

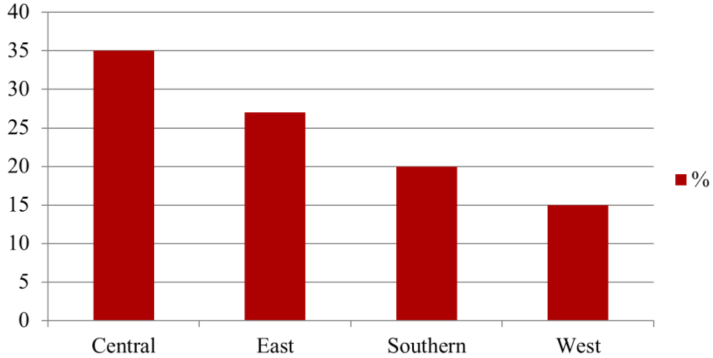

Fig. 1 Consulting services market in regions Ukraine

Analyzing offer consulting services in Ukraine, you can identify the most common types of consulting services provided (Fig. 2).

Types of consulting:

IT- consulting	Security organizations	Human resource consulting
Engineering	Advertising and PR-consulting	Auditing
Financial consulting	Strategic consulting	Equity consulting
Investment consulting	Marketing consulting	Advice consulting

Fig. 2 Types of consulting

The main services of consulting services in aviation are post-privatization support of enterprises, market research and marketing organization in enterprises, developing business development strategies, search for partners and investors, the formation of public relations, advertising.

Also, the analysis of available information sources in this area can be noted that the market of consulting services Ukraine there is the whole range of consulting services that the quantitative composition can be displayed as follows (*Table 1*)..

Table 1.

The range of consulting services

Consulting services	Number of companies
Training	34
Strategic management	30
Marketing and Advertising	26
Quality system	6
Promotion	19
Control	4

Thus, the table can conclude that among the entire spectrum of consulting services most widespread in Ukraine is training, management consulting and consulting in the field of strategic management.

Also, the analysis of available sources of information in the field of aviation can be noted that the market of consulting services Ukraine there is the whole range of consulting services.

Among the companies surveyed 68% of companies provide training services and 60% of companies of strategic management and management consulting. However, none of these companies specialize in only one of these services. The portfolio of services provided by them, there are other consulting services.

In such services as consulting in finance (52%), consulting in marketing (44%) and HR-consulting (44%) are more precise specialization companies. Service on Reengineering business - processes (40%) are very popular in Ukraine. Currently there are no consulting companies that would specialize only in providing this service. Most often, reengineering business processes accompanied by such services as IT-consulting (36%) and consulting Quality (18%). At this stage of market development consulting services can confidently noted that very promising all kinds of consulting.

It should be noted that currently Ukrainian consulting firms compete with up to Western, particularly in activities such as: restructuring and organization of business processes, quality control, engineering, information technology, marketing, auditing, management consulting and training. In addition, methodological developments in activities such as active learning methods, learning in action, engineering and auditing more developed than their foreign counterparts.

As is clear from the survey results, the Ukrainian market management consulting is far from being called mature. Much of the leaders have no clear idea of who the management consultants and what they do. This means that the market is almost not familiar with this type of service. The positive is the fact that the respondents agree with the statement that foreign assistance in solving management problems still necessary and positive impact on the company. Therefore, it is hoped that there is great potential for the development of the market of consulting services in Ukraine.

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Prospects and problems of the airline industry in Ukraine

Air transport is a key element of the national transport system which affects the economy and international relations. Prospects for the airline industry in Ukraine were highlighted in the context of Ukraine's accession to the CAP. The benefits and threats for key members of the aviation market were noted in the article. It was mentioned about the main problems of the airline industry and the reasons for their occurrence.

Air transport as part of an integrated transport system of Ukraine solves the problem concerning the organization of international transport links, the needs of the economy and the population in the air transportation. The current situation of the aviation industry of Ukraine points to a number of problems, which should be solved.

The current situation and trends of the national aviation complex indicated that Ukraine in recent years had made the clear steps towards integration into the global aviation environment. Thus, in December 2008 Ukraine joined the Montreal Convention for the Unification of Certain Rules for International Carriage by Air, it was a step transition to a leading edge aircraft market. The Convention defines modern legal framework for the implementation of air traffic and meets modern international practice of international air transport.

For another thing, one of the country's priority is an agreement between Ukraine and the EU about Common Aviation Area (Open Sky), because it is a prerequisite for the implementation of domestic companies air flights to any European country. Integration of aviation market is favorable for Ukrainian aviation industry, because Ukrainian aviation products – including aircrafts and spare parts to them - will be certified and can be sold in the EU countries.

In Ukraine, the Agreement is beneficial primarily for consumers of aviation services. According to the Agreement passengers will be guaranteed not only the safety of the flight but much larger choice of airlines at reasonable prices and convenient flight schedules. But Ukrainian airlines and airports joining the CAP will test its survival and stability. The biggest Ukrainian airline companies, including "UIA" are not in the best position to compete actively with European carriers. Moreover, no airline of Ukraine is part of international airline alliance like Star Alliance, Oneworld, Sky Team. This fact worsens the situation of airline in case of joining, since currently they carry out their flights on the basis of bilateral agreements.

Table 1.

The Consequences of Ukraine's Accession to the Common Aviation Area with the EU

Object	Risks	Benefits
Airlines	- increasing price-related competition in the market; - Reducing airline profits through lower airline tickets prices; - defeat in the competition.	– the possibility to carry out air travel to all EU countries without restrictions; - the possibility of competing airlines in Europe.
Airports	– flight delays due to the limited capacity of their service; - increasement of waiting time at passport control point; - reduced level of safety of baggage.	- incentive to upgrade and build new terminals of airports; - increasing the role of Ukraine as a transit country; - updating of regional airports to be used by budget charter flights.
Passengers	- reduction of guarantees to support aviation infrastructure unprofitable for airlines directions	- ensuring the safety of European standards; - providing the European level of passenger service; - increasing the number of flights and routes; - expanding priced band of airline services.

In aviation there are many factors that reduce the air traffic. The main ones are the low competitiveness of Ukrainian airlines due to the state fleet and its physical obsolescence. In addition, there is a discrepancy of aircraft and international standards, and it does not allow Ukrainian carriers to operate international flights.

Dynamics of passenger transport in Ukraine shows that a steady rise has performed since 2010 to 2013. Then, during the 2014-2015 there was a sharp decline in passenger traffic by 21.2% on average. First of all, this is due to political instability and crisis in the economy of Ukraine for 2014-2015 which had an impact on the aviation industry in general.

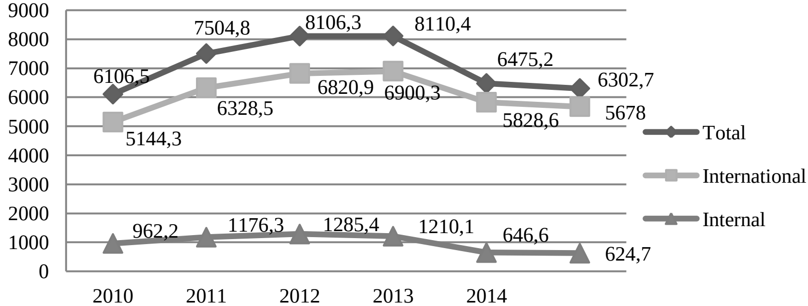

Fig.1. Dynamics of passenger air transportation in Ukraine (thousands people).

Graphical display of the relationship between the volume of air passengers and GDP per capita in Ukraine is shown in Fig.2. Correlation and regression analysis were used for processing the data results as the primary method of establishing relationships between selected parameters.

Data set analysis confirm the direct and stable relationship between demand for air transportation on GDP per capita. The coefficient of determination for dependence is R^2 = 0,84 and this dependence has a very close correlation R = 0,91.

Studies show that there is demand for air transportation when the cost of air services does not exceed 15% of the revenue. Thus increasing competition in the air transportation market does not have an impact on air traffic volumes increase without welfare increase.

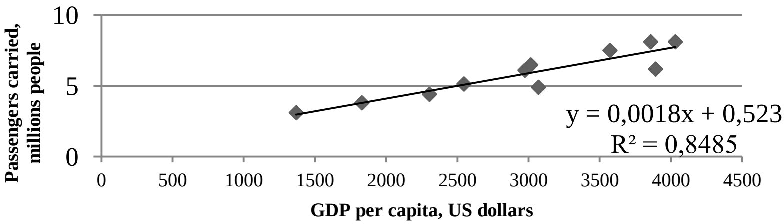

Fig.2. The relationship of the volume of air passenger traffic and GDP per capita in Ukraine.

A large number of airline companies are showing significant dispersion of Ukrainian market and low efficiency of aviation operations/ Current situation in terms of this study can represent the main problems of Ukrainian aviation industry:

- low competitiveness of national airlines as compared with foreign ones;
- a large number of formalities in international air transportation;
- expansion and conquest of national airlines by foreign ones;
- fragmentation of capital and capacity of domestic airlines limiting their competitive capabilities;
- reduction of aircraft fleet and its low technical level;
- a significant part of aircraft owned by Ukrainian air carriers is often and physically obsolete, and this fact affects flight safety;
- the negative impact of the global financial crisis, which amplified the negative dynamics of key macroeconomic indicators;
- inconsistency between technical capabilities of airports and modern international requirements;
- lack of financial resources for the development of airports.

Thus, this study allows expressing the idea that infrastructure of Ukrainian aviation market is developing too slowly and unsystematically, which on the one hand, hampers the country’s integration in the international space, and on the other - threatens to loss the control over this important sector of economy.

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UDC: 339.9

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The development of business aviation in the world

In the article it is dwelled upon the features of the global business aviation market, the analysis of the market of manufacturers of business jets in the world is carried out, rating of the countries by the number of planes of business aviation and regional distribution of business jets in the conditions of globalization changes is performed.

In conditions of global transformations new conditions are created to increase competition in the global aviation market that causes impact on the market of aviation services. Accordingly, aviation market interacts and influences through the competition mechanisms the development of the global economy. Business aviation is one of the most important components of the global transport system that provides workplaces and stimulates economic growth. Business aviation market is an integral part of civil aviation.

In the global world economy it is necessary to develop business aviation strategy for the business development and effective country functioning, which requires not only the study of practical international experience of its functioning but the development of a number of scientific problems as well both theoretical and applied.

Together with deepening of globalization and economic integration processes the needs and attractiveness of business aviation services is growing. Perspective trend of business transportation development becomes the purchase of transport aircraft with the crew by some large corporations. Such changes in the business aviation services market, having very rapidly developed recently, require finding new methods aimed at analyzing its structure and estimation of trends. Therefore research of the current state of business aviation services market is relevant.

Recently the popularity of business aviation has increased around the world especially the economy of the Western countries has an important influence on the industry. The rapid development of the business aviation market in the US and Europe has transformed the business jets in one of the most important air transport vehicles after regular aircraft types and the annual turnover of the relevant market exceeds military aviation market.

Global business aviation market has experienced a big boom period, a disastrous fall and stopped in front of the new realities. 2014 has been the most successful since the collapse of the business aviation market in 2008. Activity of business aviation market largely depends on the self-conception of customers both private individuals and companies. Despite some fluctuations on major world stock markets during 2014 in total stock indexes increased which contributed to increase of consumer activity. The growth of demand on new aircraft and the aircraft of the secondary market increased as well [6].

The changes which occurred in the business aviation market in 2014 affected the intensity of flights and the secondary market and forecasts and the balance of power among manufacturers of business jets. Serial production of business jets is a large part of the global business aviation industry its «locomotive» and the main indicator of the market. Since 2008 the rate of production of aircraft for private flights has been steadily falling. Thus in 2008, 1313 of business class aircraft were produced and in 2012 their number decreased to 670. This is primarily due to the demand which fell sharply for medium and small aircraft while the demand for large business jets did not change significantly. In 2013 the number of produced aircrafts was 678 of business jets [1].

According to the General Aviation Manufacturers Association in 2014 deliveries of business jets stabilized after a four-year decline 708 jet aircraft were transferred to customers which is by 30 more than in 2013. But despite this difference in the number of produced aircrafts the cost of supplies in 2014 was huge - 21$ billion [5].

In the future, expect production growth by 2020, when in the market will be launched 1166 cars. Overall, it is expected that for the period from 2013 to 2022 will be built from 9250 to 9575 new business jets worth more than 230$ billion [3].

Large transnational business that receives large and long-classes aircrafts has more immune to falling economy, while medium and even small businesses are the main buyers of small business jets they are more dependent on the economic situation and available financing terms surgery. Thus, during the four-year recession long-range aircrafts have had the most stable demand, which cost starts from 40-50$ millions. Accordingly, gains were producers who have a lot of machines in the model number [6].

According to Aviation International News the largest producers of business jets, such as Textron Aviation (parent company structure Cessna)which increased the rate of deliveries by 12% transferred to clients 159 aircraft and Citation Gulfstream which referred to clients 150 aircraft, which is 4% more than in 2013. However, Dassault Aviation has reduced the number of aircraft delivered in 2014 to 66, which is 14% less than the previous year.15% of all orders accounted for clients from BRIC countries (Brazil, Russia, India, China), [5].

The Brazilian aircraft company Embraer in 2014 delivered to customers 208 aircraft, including 116 business jets. As a result, in the manufacturing sector the rearrangement of forces began. Previously there were a "big six" leaders in the format "5 + 1" (Bombardier Aerospace, Gulfstream Aerospace, Cessna Aircraft, Dassault Aviation, Hawker Beechcraft and a young but promising Embraer), now the Brazilian group Embraer strengthened its position, surpass bankrupt American Hawker Beechcraft and catches another US company - Cessna [1].

Among the top 10 countries by the number of business jets in exploitation USA is leader their the number of registered aircraft is the largest in the world it is 67% of business jets and 63% of the world fleet [2].

According to Gama General Aviation Statistical Data Book and Industry Outlook 2014 business aviation annual fee in the US economy is 150$ billion. and 1.2 million jobs annually. A contribution to the economies of the European business aviation is 20$ bln.

The map of supplies business jets map was changed in 2014. Despite the negative effects of the crisis the USA share is 52.4% of the world number of passed jets to customers. Europe is the next with 15.6%, Asia - 12% of business jets, the share of Latin America has 11.1%, and the Middle East and Africa have 9% [7].

In recent years, gradually increasing activity of China and India, but the number of transactions with customers in the region can not be compared with the number of transactions in the US.

According to «Bombardier Business Aircraft Market Forecast 2014-2033» Forecast of business jets supply by region of the world in 2023 will be such [8].

Thus, the greatest number of supply forecast to US (3975 business jets). Next comes Europe - 1550 and China and Latin America 950 and 940 business jets.

The study of the global business aviation market has allowed identifying a number of characteristic features and fundamental differences functioning.

Business aviation is very important factor in accelerating the development of the economy. There are thousands of new jobs, high-tech and government revenue. Business aviation contributes to developing international market. But the development and distribution of business aviation in the world is not even enough.

Thus business aviation market is growing worldwide with high speed. Each country is associated with this activity. In 2014 the market for business aviation stabilized and even had positive dynamics, the growth of flight activity is 4%. A leader in the development of business aviation in the world is the United States. Their part in 2014 is about 52% because of the US economic recovery and growth of world economy [1].

Most international analysts believe that the business aviation market expects further growth over the next 10 years. The main factors that actively influence the current development of business aviation in the world is the growth of corporate profits, integration and globalization of business, economic development market. There has been progress in the development of equity ownership program aircraft that make using of business jets more affordable.

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Brand as an effective management tool of the air-transport business

The definition of the brand air-transport business is formulated, its shape are given. The problems of national air-transport business are outlined. Components of effective development of air-transport business brand: back- and front-office of the airlines, its architecture, distribution and brand-communications of the brand air-transport services and companies are analyzed.

The brand as a feature of a highly competitive air-transport company has become an integral characteristic of the globalized world. It is perceived as the bearer of unique quality and attractiveness that form the modern philosophy to provide air-transport services and their consumption. The peculiarity of this phenomenon is that despite attempts branding these services and company not all achieve the desired success.

Creating a brand aiva-transport business in Ukraine is hampered, primarily, by weak competition and the lack of due state support of the country's aviation industry, which has to become the flagship of the national economy, because the presence of the full production cycle of the passenger and freight planes from engineering to assembly, their uniqueness and price competitiveness single out our country in a TOP-ten aviation country of the world. Quality of service of the national aviation companies did not complies international standards, questionable is correlation between quality and price of services.

With the brand is associated not only economic results of its creators; it is associated with certain emotions, is the spiritual and mental satisfaction to consumers, creates a positive perception of services, air-transport company that provides them, and through them - appropriate perception of the country, which represents air-transport company, ie brands of air-transport services and company responsible for strategic promotion and development of the country in general, being point of connection country with the outside world.

Determine the brand of the air-transport business as its effective management tool by which establishing a connection between the subject of branding and consumers (passengers) that achieves the goals of the owner thanks satisfaction consumer expectations through the mechanism sustainable associative perception totality of its values. The object of branding act as air-transport services and itself air-transport company, for which a set of values must be united, clear and permanent.

Formation of an effective brand ensured by the harmonious development of back-office (the internal part) and front-office (external component) of the company, sustainable conformity the service quality to declared values, systematic approach to brand development, which assumes necessity of union organizational efforts of brand management in commodity and communicative space by creating a constant architecture brand, comprehensive approach to creating the optimal structure of the distribution services, and effective set of brand-communications that ensure long-term viability of the brand of the air-transport business.

Architecture of brand of the air-transport services reflects the geography of transport links with the outside world, and for the air-transport company - the geography of its offices-representative in the country.

The modern structure of distribution of the services air-transport company based on urban network ticket offices and a network promoting electronic bookings, purchase of tickets with subsequent checking. The density of these networks, quality of service in them, that provides speed and effective communication, clear interfaces and availability of electronic sources of feedback for consumers contribute to the emergence of loyalty among consumers, ensuring economic efficiency of air-transport companies and distribution networks.

The exact choice of brand-communications ensures the formation of consumer perception of brand air-transport services and the company, distinguishes and highlights their competitive advantages in the system realize their identity, indirectly affects on the creation of a positive image of air-transport company and optimally defined a combination of individual instruments, their frequency, time and nature of that support systemic broadcast information necessary impact on consumer guarantees the quality of this influence.

Brand air-transport company exists wherever there is contact between it and its own staff who are involved in the process of providing air-transport services and their promotion, ie where there is *Employer brand*, because the first person to whom the company "sells" a product is its own employee whose faith and belief in what they do, depends on the quality services installed communications and final financial result, which allows you to define brand as the market perception of quality branded internal production management processes and standards, unique added value [1, p.69-70].

Back-office of brand air-transport company is based on the traditional scenario: analyzes its internal environment, establishing its compliance with the goals and objectives of the company; being developed low of corporate practices and policies, which set the direction of development of the company, its organizational structure; are regulates and declares the relationship between all departments, contractors and with consumers; provides measures to prevent conflicts; obligations to protect the natural environment; special attention is paid staff motivation system that forms the staff loyalty to the company.

Department of Human Resources (HR) plays a special role in creating an employer brand, its responsibilities include: offering an effective strategy for employment; analysis of competitors and the strengths of their own; primary planning of labor and overcome its turnover; organization of the working environment and adaptation of new employees; formulation motivation system, training and re-certification; employee engagement in the development of the vision and mission of the company; construction of public relations and company image creation [2].

Ignoring of each component of the above mentioned can lead to disconnection with the audience, to dissonance back-office and front-office of brand company as an important realization of the declared advantages. Thus, the formation of the back-office is a significant concept of the air-transport company that envisages communication between employees, employers and applicants in the labor market rather complicated process, system messages and promises of the company implementation of which contributes to its image in the market, which in turn, helps attract the best employees and ahead of the competition in development. Each audience sees of brand through the prism of the communications, culture and business-processes, and this prism that forms the front-office of brand company must be indivisible and equal for the perception of the audience, both internal and external, as shown in Fig.1.:

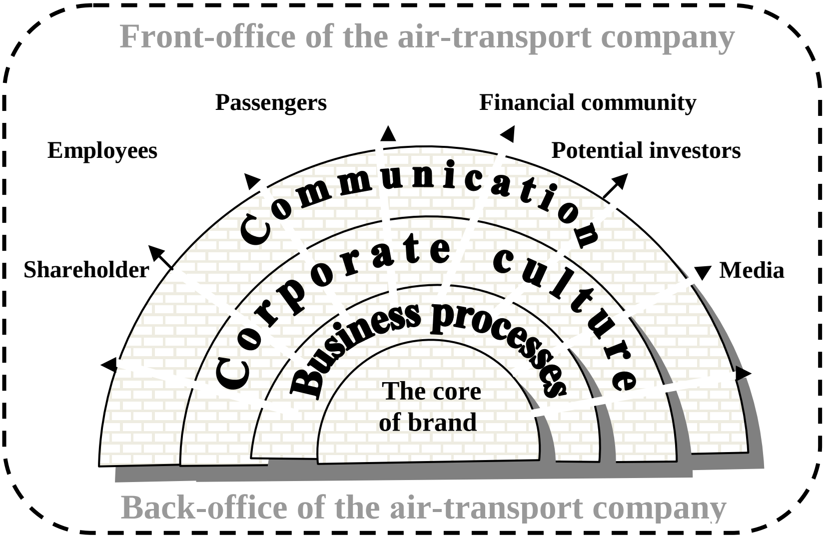

Fig. 1. **The scheme forming the front-office of brand of air-transport company**

Source: compiled for [3]

Front-office of brand company formed under the influence of the three components: business-processes, corporate culture and brand-communications system. Well-established business-processes and declared the current corporate policy and culture of the company, clear, accurate communication with its own staff and the environment determine and support the core of brand that allows purposefully, consistently manage the perception of audiences, both internal and external. J. Gregory reasonably recommends constantly monitor the development and condition of the company of brand through the measurement and evaluation of the company core of brand based on the calculation of return on investment in its development [3]. It will trace a condition employer of brand at the time and make the necessary adjustments in the management of the back-office.

It is important to remember about the mutual influence of back-office and front-office of air-transport company brand that every action causes an equal force counteracting domestic and foreign components of the company of brand, which is shown in Figure 2. Changing the core of the company brand requires adequate changes in brand-communications, culture and behavior of employees, reorganization of business-processes that together forces to change the company's strategy in the market, because the changing values and makes adjustments to perception of the company consumers. The process has the opposite effect, namely the change in strategy will certainly adequate changes in business- processes, communications, company culture, which results in a corresponding change in of the core brand company.

The increase of the company prices and improve the financial return of the business directly dependent on indicators of benefits and awareness of the company, raising them improve the brand image of the company. Correctly organized business-processes, cultural and behavioral aspects of communication are forming the awareness and benefits of air-transport company.

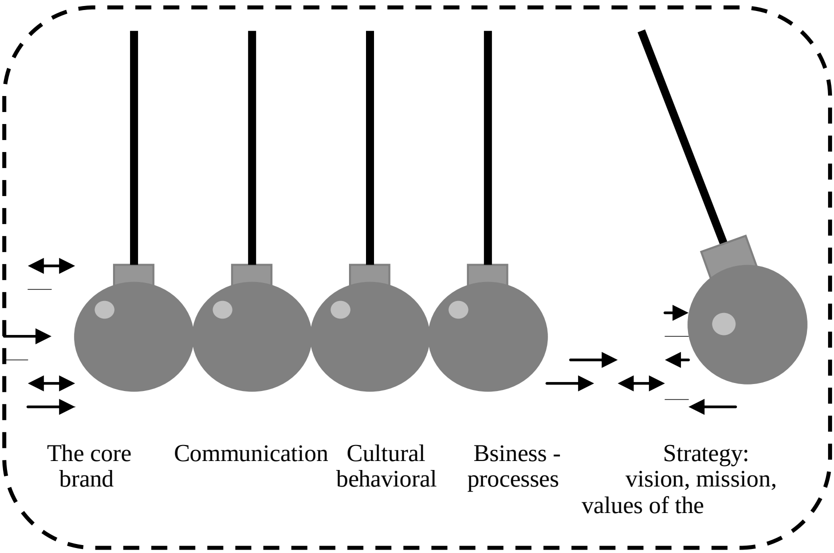

Fig.2. **The scheme of interaction between back-office and front-office of airtransport company**

Source: compiled by author for [3]

Conclusions:

Brand air-transport business gives it the following advantages:

1. Audience loyalty and reduce marketing costs;
2. Simplification of development strategy of the air transport of the company;
3. Certain protection of the company and consumer;
5. Strengthening corporate image, simplifying promotion the ideas to market.
6. The increase in total capitalization and stock price.

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UDC 629.735

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Forming of competitive edges leaders of market of aircraft building

Tendencies are considered in strengthening of competition in the world market of aircraft building between the companies of countries “G7" and BRIK. Actuality of application of marketing instruments is reasonable “4p" in the achievement of competitive edges in a fight for a consumer. Importance of the state is underline in advancement of products, both to the internal and on external market.

Prologue. In the Kyiv polytechnic institute a question comes into question about an appropriation to him to the name of Igor Sikorsky. KPI is an alma mater of the known aircraft designer. Here he studied in 1907-1911. I. Sikorsky is the creator of first in the world: four-engine airplane the "Russian knight" (Russia, 1913), heavy four-engine bomber and passenger airplane "Ilya Muromets" (Russia, 1914), transatlantic hydro-aeroplane, serial helicopter (the USA, 1942).

I. Sikorsky it is been proud of, first of all, in four states:

- now on Ukraine, where he was (Kyiv) born, studied (KPI), designed airplanes and helicopters of own construction;
- in Russia, where he created airplanes "Grandee" (Russian knight), "Ilya Muromets" (Petersburg, 1912-1918);
- in France (Paris, 1918-1919), where an aircraft designer was offer services to the military department in building of airplanes-bombers;
- are the USA, where he created many types of airplanes and helicopters (1919-1972).

Rising of task. The aim of this publication consists in research of progress of world aircraft building trends, exposure of competitive edges of market leaders. Among basic tasks the decision of that allows to execute the put aim of research, we will mark the following: to analyze the competitive edges of participants of market of aircraft building; to consider the role of marketing complex in the achievement of competitive edges of firms-producers of aerotechics; to study the problems of development of industry of aircraft building, in the countries related to the name I. Sikorsky (Ukraine, Russia, France, USA).

From a duopoly to the oligopoly: A (Airbus) + B (Boeing) + C (COMAC) + other? On the estimations of PwC in 2050 84% world GDPS will be on 32 the industrially developed countries. Group of first 15 economies of the world conditionally can be divided into 3 sub-groups. In the first sub-group China, USA and India, is included with the expected GDP (PPP) accordingly in 61, 42 and a 41 $ milliard (in permanent prices 2014 year). Entered the second sub-group of countries is Japan, Germany, Russia with GDP (PPP) accordingly – 12, 8 and 7 $ milliards. To the third sub-group 9 countries are attributed. To them behave: Brazil, France, Indonesia, Great Britain, Mexico, Italy, South Korea, Saudi Arabia, and Canada. GDP (PPP) these 9 countries will make accordingly from 7 to 4 $ milliards.

Development of aviation industry the small amount of countries can carry out only. The developed base of engineer, provides national safety, economic stability of the state her aviation industry, promotes prestige of country on a world arena. Aircraft building assists development of engineering education, science and technique, increases the profits of the state from a satiation the products of internal market and expansion of export deliveries.

Basic companies at the market of products of aviation industry are Airbus S.A.S and Boeing Company (USA). On their stake is more 90% world market of passenger airplanes. The market of passenger liners in the near time substantially will broaden due to the air producers of Canada (Bombardier Inc.), Brazil (Embraer – Empresa Brasileirade Aeronautica), Japan (Mitsubishi Aircraft Corporation), Russia (IAC), India (Hindustan Aeronautics), some other countries. "By a player" №3 on the world arena of aircraft building soon China will become with his company COMAC (Commercial Aircraft Corporation of China).

Demand determines suggestion. Suggestion from the side of producers of aerotechics can increase only on condition of growth of demand on the made products. On the prognoses of company Boeing, 2033 to 36 770 main airliners will be produced. Their global park will increase from 20 910 machines in 2013 to 42 180 in 2033. Cost produced during 2013-2033 25 680 machines will make $5, 2 trillion. Almost 70% from the indicated amount will make "main airplanes with one passage-way" (Boeing 737, A320, MC-21 and C919). Regional airplanes 2490 things will be produced. Their cost will make near a $100 milliard (less than 2%).

On the prognoses of company Airbus a common amount of the produced new liners is in 2034 expected in an amount 32 585 machines ($4, 9 trillion). It won 12% below, than on prognoses at Boeing. 22 927 machines will be produced with one passage-way for passengers (on a cost – 55%).

Airbus forecasts that demand on large airplanes (A380 and Boeing 747) will make 1550 machines. Boeing supposes that customers intend to purchase 620 units only. Such distinction is explained that the greatest and modern airplane of A380 is produced exactly Airbus. Boeing here does a rate on native modernization of Boeing 747. On the prognoses of Airbus to 2034 the amount of large airports in the world will grow from present 47 to 91 [1].

Boeing Company. The plants of company are located in 67 countries. A company supplies with the products in 145 countries of the world. Boeing cooperates with more than 5200 suppliers in 100 countries. Five unique internals of Boeing are fixed in basis of politics of advancement. They provide to the customers competitive edges and guarantee success. In the number of these internals: 1) devotion to business (willingness to render support to the customers and their business); 2) competences are in planning, exchange by productive and technical experience; 3) revolutionary technologies (research developments are provided by safety, reliability and economy of air ships); 4) support during all life cycle (from the moment of acquisition of airplanes and during all term of exploitation, including realization of current technical service, modernization and renewal, and also transmission of air ship to other user); 5) unsurpassed complex of services, allowing maximally to promote efficiency of park and operations, and also profitability of airline.

Airbus S.A.S. Competitive edges of Airbus:

1) introduction of front-rank technologies on all levels: development (design); production (use of more perfect and safe materials); management (innovative systems of controlling of flights, for example, system of fly-by-wire); legation sale support (use of ICT, e-Solutions);

2) introduction of innovations: conception – eco-efficiency); less "dirty" and energy expense production; low level of noise; minimization of extras of CO2 and passing to the prospect on "a green" fuel;

3) successful marketing strategy: A380 did a rate not on distance of flights, and on the size of ship (problems with placing in airports); enhance able attention to the necessities of passengers: air-buses more spacious, less noisy, are maximally automated;

4) the special attention is spared to the human factor, organizational culture, to bringing in to work of the best specialists in corresponding areas (designers, engineers, managers);

5) presence of considerable financial resources (capitals of a few largest European companies, profits from stock trade at the market. governmental subsidies).

Embraer. Basic support by a company at first was done on the sector of small and local airplanes. After the transmission of company from state in a peculiar she took a course on development of near main aviation. Such strategic decision is explained by the increase of demand on this type of airplanes. The new models of passenger airplanes of series of ERJ were worked out. They became very popular both in Brazil and at the market of Latin America, other regions. Producing of series of more big-tickets of E followed after it - Jet, and also producing of models of business-class.

The not insignificant factor of development of company is state support. The products of company became priority at purchases aeromechanics for the needs of the Brazilian civil airlines and army. All production capacities are in Brazil, that allows saving on current outlays. As a result of carefully thought out politics of company, customers get modern airplanes with quality, to the answering world standards, at moderate enough price and in necessary amounts.

IAC (Incorporated aircraft building corporation, Russia). In a soviet period aviation industry was the developed enough and powerful industry. The airplanes of any complication were built – from small (An-2) to giant Il-86. Annually in a country made airplanes for a civil aviation within the limits of 437 (1975) – 152 (1990). On the aviation plants of Russia producing of airplanes made within the limits of 218 (1975) – 84 (1990) units. In 1991 66 airplanes were made. In subsequent years the production of airplanes went down sharply. In recent year their producing made: 2010 – 13, 2011 – 19, 2012 – 22, 2013 – 32, 2014 – 37 units [2]. Stake of Russia in world aircraft building in 2005 only 2-2,5% made. This index is incommensurable not only with Airbus and Boeing but also by the producers of aerotechics in Canada and Brazil. The import of the used airliners of production of Boeing and Airbus was encouraged, other companies instead of rendering support of domestic aviation industry.

Russia does certain steps in modernization of operating park of civil fleet. Producing of airplanes of Sukhoi Superjet 100 is grown, or SSJ-100. They came on changing of Tu-134. In a prospect (2034) the stake of SSJ at the market must make 14% (364 units). They successfully data are exploited by the Mexican airline of Interjet. In Russia the airplanes of SSJ-100 use such airlines, as "Aeroflot", "Yakutia", Red Wings, UTair et al.

Development of main airplane of MC21 is completed. MC- 21 will be equipped by an analogical A320neo engine. The far of the newest innovative systems is inculcated in the construction of airplane. MC-21 will become the first airliner with a composite (black) wing.

To the competitive edges of Russian aviation industry it is possible to take: presence of powerful productive base put right system of training of personnel's. Among threats to development of aviation industry: weak protectionism politics of the state, instability of co-operation connections from political and economic approvals from the side of foreign countries, insufficient politics of advancement of products to the foreign markets.

Ukrainian aircraft building corporation. Ukraine behaves to 9 countries of the world, that have an own production of airplanes of complete cycle. Powerful aviation industry that in the days of the USSR built to 242 (1980) airplanes (An-24, An-26, An-32, An-124, Tu-134, An-72, An-74 An-70, An-124 "Ruslan" and An-225 "Dream") annually was reached Ukraine. In 1991, when independence was proclaimed, 114 airplanes were produced in Ukraine. In 1992 124 airplanes were yet made again. Then the volumes of output sharply went on a decrease: 1993 – 45, 1994 – 32, 1995 are 19 airplanes. During all subsequent years the volumes of output hesitated within the limits of 3-8 airplanes in a year [3].

Last years in Ukraine annually produced 1-3 regional airplanes of An-148 and An-158. The priority markets of the Ukrainian production distribution it is been countries the CIS, India, Iraq, Iran, Libya, Egypt of and other

In opinion of analysts of agency there is "Credit-rating", the state of aviation industry of Ukraine is characterized by the presence of the system problems related to adaptation to the market conditions of ménage, by a hard competition in the world market on a background subzero demand at the internal market, by the substantial deficit of turnover means et cetera.

COMAC. History of Chinese aircraft building takes beginning with 1909. The new era of civil aircraft building of China begins in 100. She is constrained, foremost, with development of near main passenger airplane of COMAC C919. China positions C919 as a main competitor European Airbus A320 and American Boeing 737. China becomes one of three leaders of market of civil aviation in the world. A liner of C919 is the model program within the framework of project on creation of the state of innovative type.

During the nearest 20 a company COMAC intends to produce 2500 C919. Already preliminary orders acted on 517 airplanes from a 21 domestic and foreign company. In development and organization of production of airplane several hundred thousands of workers of industry took part with more than 200 enterprises from 22 provinces of country. A corporation COMAC offered the new national model of development of passenger aviation is "mobilization of all forces of country, concentration of intellect of the whole world".

COMAC attracted on the line of co-operation 16 large multinational corporations as suppliers of the side systems of C919. It promoted the level of air technologies and productive possibilities of Chinese air industry considerably, assisted development of integration of state, private and foreign capitals in the productive chain let of making of airplane.

As compared to by existent airs an expense of fuel C919 will have below on a 13%-15%, wind age – below on 3%, noises in the salon of airplane will go down on 3-5 decibels. A corporation COMAC plans on the basis of standard good to work out the series of foods in reply to suggestions of clients: the extended or shortened variant, model with megascopic distance of flight, air-freighter, liner of business-class of and other [5].

Conclusions

1. Front-rank positions at the market of aviation industry are promoted by prestige of the state on a world political arena, assists development of education, science and technique strengthens economic potential of country, her safety.
2. A keen competition in a fight for a consumer strengthens positions at the market of not only traditional leaders of aircraft building (Airbus and Boeing) but also assists expansion of influence on him new "players" (COMAC).
3. At the market of aircraft building in a prospect (to 2050), strengthening of positions of airlines of countries of BRIK is traced in relation to the group of countries "G7".
4. In the increases of competitive edges at the market the special role must be spared to the effective use of marketing-mix "4P" (product, price, place, promotion).
5. In research the necessity of strengthening of support of the state is underlined in the period of restructuring of aviation industry, and also in activation of advancement of products to the consumer.

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Research experience the world of formation integrated structures in the aviation industry in the case of Boeing Company

The article is devoted the study of world experience of realization of strategy of confluence and absorption in industry of aircraft building and determination of possibilities of introduction of such strategy in Ukraine.

Aircraft industry is one of the most important tool for achieving social, economic, and foreign policy goals and a part of the country's image in the world. Internationally necessitates of air companies develop civil aviation, establish economic ties between countries and regions, support the processes of cooperation and integration companies. In addition, as a result of globalization, the global aerospace market is feeling the economic, political, social, energy, environmental and other conflicts.

Increasingly, global trends in the world economy are - economic, cultural, social and scientific changes - with far-reaching consequences. These trends have greatly effect in the activities of companies and the activities of individuals. We can identify global and industry trends among these trends that affect aviation sector states(table 1).

Table 1

Global trends of the global economy and their impact on the aviation industry

Trend	The impact on the aviation industry
Changes in economic power from West to East	It is expected that the Group of Seven economies will double by 2050, this will stimulate demand increased for aviation and a boom in commercial aerospace. However, , the Asia-Pacific region plan to take delivery of nearly the same number of aircraft as North America and Europe together over the next two decades, global market of civil aviation is projected to grow more than 30% compared to current levels of production and attract new members from among developing countries.
Demographic changes	The percentage of older than 60 years people, is projected to increase from 8 to 21% by 2050. Therefore, the key challenge for aerospace companies will search of talented professionals that lead the reform of education, migration law and greater use of outsourcing and offshoring.
Urbanization accelerating	The population of citizens is projected to increase from 50 to 72% by 2050 will require an additional infrastructure and improve public safety. Urbanization is also a driver of demand for aviation products.

Continuation of table 1

Resource shortage	In terms of resource depletion demand for innovation to commercial aviation will increase. There will be necessity in new aircraft designs, new materials, new systems, air traffic control, using biofuels, ect.
Rapid technological progress	Aviation industry probably has the longest cycle of production to other sectors. However, the airline will have to evolve and respond technological progress much faster.

Note. Compiled by the author according to the Aerospace & Defense megatrends. [Electronic resource]. - Access mode: www.pwc.com. [9]

Thus, given trends in Table 1, companies operating in the aviation industry to meet new global challenges and new opportunities for development.

It is also important to note the specific trends in the aviation market, namely low interest rates, lower operating costs for transportation (due to falling crude oil prices), increased demand for emerging markets, improve the world's largest economies. Thus, for quickly respond to a surge of orders, aircraft manufacturers should consider like changes in the global economy and industry trends

Analysis of the trends of modern aviation market led to the appearance of the characteristic features of this market - namely, the formation of integrated structures as a result of international cooperation for development, production and servicing of aircraft. Cooperation today - the only way to effective implementation of the appropriate timing of various projects with minimal investments, as well as minimized technical and financial risks.

Among the leaders present include aircraft combined structures such as Airbus, Boeing, EADS et al., realizing the full range of measures for the creation, production and ensure the operation of aircraft. The most famous integrated structures that lead the world market air engine - are General Electric, Pratt & Whitney, Snecma, Rolls-royce and the others. Their long experience indicates that international cooperation combines scientific and production potential in applications of new technologies is justified, because development and batch production of modern aircraft is a complex process that based on work more than 30 fields of science and technology. [5]

Foreign experience also shows that the creation of large integrated structures in aircraft carried out for a long time based on various strategies. In some cases, large construction company is "below" naturally on the initiative of management or business owners as a result of acquisitions of smaller companies or accession; others - the state actively participated in the creation of large associations. Thus the impact of integration on the basis of different strategies and differentiated significantly affected by many factors. [2] Thus, to select the optimal strategy for the creation of effective market associations of enterprises in the aviation industry of Ukraine important to study foreign experience.

The US Boeing company is one of the world's largest manufacturers of aviation, space and defense technology. Using a strategy of mergers and acquisitions, the company has made considerable progress. Mergers and acquisitions in this company began in 1927 when it was acquired by Gorst's Pacific Air Transport for sake of eliminating its main competitor. The following mergers and acquisitions were aimed to diversification and consolidation of the company on the market. In 1997, when the merger of Boeing and McDonnell Douglas, and had called The Boeing Company. [3] In 2015 the company was absorbed by Peters Software, which developed software for training pilots. In 2016 it was announced that The Boeing Company intends to acquire the Mercury Systems company. Boeing is considering purchasing vendor digital signal and image processing systems for the aerospace and defense industry, which will allow the company to reduce costs and increase its presence in the aerospace industry and access MRCY microprocessor business, which can be used in unmanned aerial vehicles. [9]

Thus, analyzing the history of transactions of mergers and acquisitions Boeing Company, it can be concluded that the strategy of capital consolidation allowed the company these following advantages:

- receive the highest profits in the industry (Boeing ranked first in terms of sales among the leading aerospace companies in the world today);
- eliminate its main competitors (Gorst's Pacific Air Transport and McDonnell Douglas acquisitions, etc.);
- to enter new markets and become a leader for them;
- implement its diversification activities successfully (construction of helicopter, developments in the sector of defense and aerospace sector);
- actively conduct research and implement innovations in production;
- be cost-effective, competitive company, even during the economic crisis in the world and the country.

In 2015 the company had set a record field - 762 aircraft for civil aviation, and the profits amounted to 66 billion dollars. USA (Figure 1):

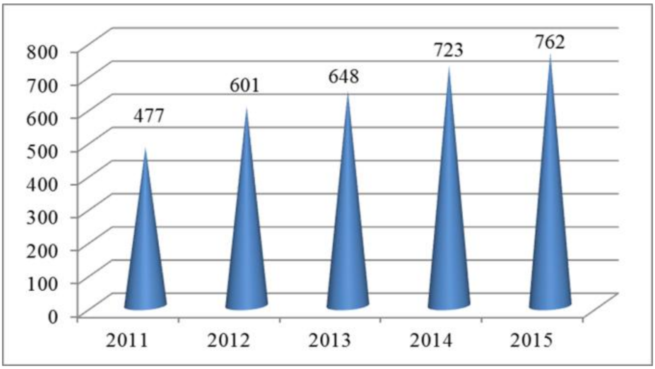

Fig.1. The volume of commercial aircraft Boeing Company, (pc).
Note. Constructed by the author according to the official website of Boeing [6].

In addition, these figure show that the number of aircraft produced growing , for example in 2011 it produced 477 airplanes and in 2015 this figure had rosen to 37.4%.

Aviation company also made significant progress in the field of military - in 2015 186 military aircraft, 15,787 weapons systems and 4 satellites were delivered. The company has signed 768 new contracts for the supply of commercial aircraft. [6]

Today, the State Aircraft Building Concern "Antonov" (formed by the Cabinet of Ministers №1014 of 30.10.2008). is the major domestic aircraft building industry. There are some of the following companies: "Antonov" (in 2010 had the SE "Serial Plant" Antonov "- formerly" Kyiv Aviation Plant "Aviant") State Enterprise "Plant №410 of Civil Aviation", Kharkiv State Aircraft production company. [7]

Creating a concern "Antonov" was intended to promote cooperation companies engaged in aircraft building and more favorable environment for the sale of aircraft of domestic production.

However, according to data of the State Aviation Service, the number of aircrafts of "AN" used in the world decreased from 1,128 units in 2005 to 900 units in 2015 total for the period 2002 to 2015 based on the group produced about 50 aircraft, including AN-140 (5 pieces); AN-124 (2 pcs); AN-140-100 (5 pieces); An-148-100 (1 pc); An-74 (6 pieces); An-32 (10 pieces); An-32P (6 pieces); An-74-T-200A (1 pc); AN-74 TK-200 (1 unit); An-32B (1 pc); AN-148 (6 pieces); AN-158 (5 pieces); AN-178 (1 unit). [8]

So, analyze given information, it is difficult to speak about the efficiency and profitability of the aircraft building industry of Ukraine. According to experts, to improve the profitability of domestic aircraft must produce at least 20 aircraft per year, but in order to enter the international market and compete with world leaders - about 350-600 units per year. However, this result can not be achieved without addressing many important issues.

First, you need to determine the ownership of the concern "Antonov" because state ownership is not attractive for international cooperation and attract investment. Competitive advantage leading aircraft building companies in the world providing a transnational form of organization of production, which was largely achieved through mergers and acquisitions. However, the first step to restore the aviation industry of Ukraine should be government support in the form of preferential loans and direct investment in the development of the group and others. It is also necessary to identify niche Ukraine in the global aircraft industry market, defend or re-develop it. [1]

For the success the international market group should ensure that the package of measures that would support the credibility of the brand name "Antonov" helped shape the company's image as a modern manufacturer and supplier of high quality aircraft and reliable business partner.

Conclusions

The civilian aircraft industry in the economic structure of any country belongs to the strategically important industries, whose provides development employment numerical number of employees and a positive impact on the economy of the country.

Importantly, that the specifics of Aircraft companies in the market creates competition, which is global in nature. In addition, the technological complexity of the industry require significant investment in development and production. As a result, the intensity of the integration process increases, including using a strategy of mergers and acquisitions in the industry.

Ukraine - one of the few countries that has a closed cycle of aviation. The high level of scientific and technological developments to ensure aviation production process shows that Ukraine continues to retain the status, scientific, technical, technological and human resources which allows air to create competitive products. But it is important to note that the main Ukrainian aviation competitors plants are Russian, Canadian and Brazilian producers. In addition, the regional transport market, which is rapidly developing in recent years, promotes active players actions, which may well join Ukraine. However, to compete in this market domestic aircraft building enterprises should reconsider the prospects of its development, implementing the strategy of mergers and acquisitions.

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Aviation transport enterprises management as a factor of activisation of globalization processes in economy

Abstract. *In this thesis it is described, actually processes of globalization. Globalization is not unification, this is union of humanity in whole world. In thesis it is defined, that effective management of different enterprises intensifies globalization processes in the world. In this thesis we can say, that globalization is developed with activization of flexible system of management of avia-transport enterprises.*

On the beginning of new millennium the globalization of world market called in the majority of developed countries the profound economic crisis, which was happened after a period of long-term increase. For the struggle with the crisis the governments of European countries, and USA, and Japan set in motion all types of instruments of anti-crisis policy beginning with budget and ending of money and credit [1].

We must say that global economy is historical social process, contents of which is increasing relationship and correlation of national economies, union of national markets in indivisible world market.

Globalization is not unification (Americanization), this is state, process, perspective of human society development, union of humanity in whole world. The philosophy of globalization, its cognition and regulation is complicated of national, religion, state-political components.

As is known, advantages of globalization are not realized automaticly. Not all countries feel equally. Interests of near of people make their actions as foreseeing. Today the subjects of economic interests, which state behind of modern globalization, are not persons, but corporations.

Globalization is objective unturned process which we can’t stop. However, this process can be regulated. In the global economic system the possibilities for spontaneous market relations between countries did not remain.

We have any questions: Haw does state national economy maintain in the globally functional world industrial mechanism? Haw will biggest European market, formed on the West, and union of markets of Asia, America, Near East influence on the economy of our country?

We need emphasize, that global environment is an encirclement, external system of components, which influences on the elements of world system from the outside.

The international market is a totality of national markets.

The world market [3, p.29] is the kind of firm commodity-money relations between the countries that are constructed on international division of labor and other factor of production.

It should be noted that the world market which is considered in the context of the world economy is the infrastructure of the latter one. When we speak about the world economy we understand two aspects:

1. The real sector of the world economy;
2. The market sector of the world economy.

The global economy is distinguished from the world economy by the quality of ties. So the global economy is universal all-round, full and general. The world economy is unification of different subjects of international economic relations at different levels and in different forms of these ties, the quantitative characteristics correspond to this unification, including universal production, world demand and supply, development of market infrastructure and etc. The global economy foresees that the relations which form it develop on the basis of such conformity to natural law, namely:

a) The dialectical unity of separated economies, which protect their own interests, enter, get certain international economic relations under the influence of development of trends of economic ties internationalization;
b) The inequality of countries development as the cause-end-effect relation between the increase of concentration, productive monopolization and aggravation of contradictions;
c) Deepening the international division of labor is caused by a new stage of science-technical progress. This division of labor is a factor of improving productive forces by the material contents. Also it is a factor of social labor productivity increase. And by the social form, it is a method of forming international dependence, inequality of rights of different countries;
d) The main subjects in a system of the world economic ties are TNC and TNB, but the importance of small and middle businesses in international economic relations increases;
e) The effort of state influence on the world economy ties;
f) The effort of a subjective factor implementation in the global economic linkages, when destinies of many-sided subjects of international economic reaction depend on human economic behavior.

The global economy is the economy, quantitative indicators of which turn into qualitative on the basis of the fore-mentioned conformities to natural law.

Effective management of different enterprises intensifies globalization processes in the world. Aviation transport enterprises have special system of management. And main aspect of this system is organization-economic changes. Accordingly to content of management of organization-economic changes and it taking into consideration the peculiarities of activity of aviation enterprises we can define the category "organization-economic changes" as changes, which are caused by state of avia-enterprise and are directed to ensuring of its development in long-term period; functional-structure transformation of avia-transport enterprise and own law-organization form. Today the changes must be based on new paradigm of management. This new paradigm foresees using of system and situation approaches to management. Main aspects of conception of complex management of organization-economic changes in avia-transport enterprises are [2]:

1) Management system is totality of procedures of decision acceptance, which is formed as a influence of external environment;
2) Organization mechanisms must constantly watch on changes of external and internal environment of enterprises, must be preparatory to revealing of new problems;
3) Type of management structure must be chosen in such manner as ensuring of maximum flexibility and adaptation of enterprise;
4) Procedures of decision acceptance, processes of planning and control must be acted accordingly to adaptation and planning management;
5) Organization development of avia-transport enterprise happen owing to functional and fundamental changes in management;
6) Logic and speed of changes of functional and fundamental elements must be chosen by head in dependence on the stage of own product life cycle;
7) Must be exist complex of management of organization-economic changes;
8) For successful realization of changes it is necessary to elaborate the system of support of changes;
9) Projects of reorganization of avia-transport enterprise must correspond to legislation of Ukraine.

Conclusions. So, we can say, that globalization is developed with activization of flexible system of management of avia-transport enterprises. For example, Avia-company "Ukrainian International Airlines" inculcated a new system of humanities transport, when company takes on the side 2-3 persons or babies with especial requirements. Human management is the future of globalization system.

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The Relation between Turkish Tourism Industry and Air Transportation

There are many studies about the relationship between tourism and air transportation. Almost half of the international tourist use airway in the world. This share is much more in Turkey to the world average. The aim of the paper is review the relationship between tourism and air transportation in Turkey.

Introduction

Tourism is closely related with air transportation industries. Without airports and airlines, tourism industry especially medium and long haul destination tourism could not be this size. The tourism and air transportation industries dependent each other. The availably of air transport is one of the most important factor of development of tourism. Air transportation is important factor for international tourist flow and enable tourism activities smoothly and easily.

Air Transportation Industry in Turkey

Turkish air transportation industry started 1933 for domestic flights and international flights started in 1947. There was two milestones for Turkish Air Transportation Industry. First was, in 1980's given permission for private enterprises for the air transportation industry. After these date some new airline companies (especially charter airlines) and airport operator's founded. Second, 2002 the domestic routes open for private airline companies without any restrictions.

Figure 1 shows the number of international and domestic passenger number in Turkey in 1960-2014. After 80's the number of international passenger number began growing and after 2003 the domestic passenger number was growing rapidly. And first time in 2013 the domestic number of passenger exceed international passenger number. The period 1983-2014 the international passenger number was from 2, 5 million to 80, 3 million. And the period 2002-2014 the number of domestic passenger number growing 8, 7 to 85, 4 million. (http://www.tuik.gov.tr)

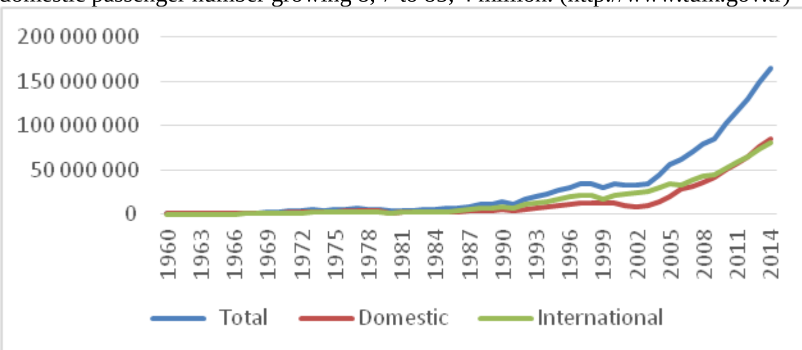


Figure 1. Number of Domestic and International passengers in Turkey 1960-2014

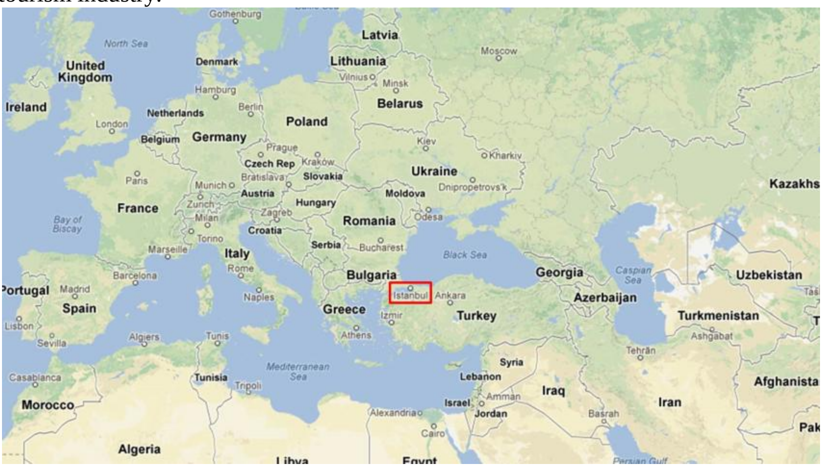
Number of airplane and workforce growing 2003-2015 period, 162 to 489 and, 65 thousand to 190 thousand. (http://web.shgm.gov.tr) Turkish air transportation industry after these two deregulation in 1982 and 2002 became the one of biggest in Europe.

Foreigner's transportation mode to visit Turkey

First half of the 2016 69, 4% of the foreigners who visit Turkey use airway, roadway 26, 8% and seaway 3, 7% respectively. The first four entering points are Istanbul, Antalya, Edirne and Artvin within 52 city. (http://www.airporthaber.com) Edirne and Artvin are border cities of Turkey which use mostly daily shopping and working mostly not for tourism. As a WTO defines international tourist as a person who visits another country than the one which is their usual residence for any other reason than for working. (Biegera and Wittmerb, 2006) It means roadways share much lower for tourism activities. The seaway share is cruise line tourist share which use mostly Aegean port of Turkey.

In one of the survey made in 2015 shows that 7, 2 million foreigners visited via roadway which almost 70% which is around 5, 2 million from neighbor countries (Iran, Iraq, Greece, Bulgaria and Georgia). This survey also shows how air transportation is important for tourism industry in Turkey. (http://yigm.kulturturizm.gov.tr)

According to state data, foreigner's transportation mode to visit Turkey the airway share is around 70 % but the real number for the tourism industry 10-15 % more around 80-85 %. It shows that how air transportation important for the Turkish tourism industry.



Picture 1. Turkey and Neighbor Countries

The air transportation share for the countries has some differences. Islands States like Japan and Australia air transport's share is around 100%. Tourism countries like Greece, Thailand and Egypt air transportation share is around 76-80 %.

Country	Air Transport's share of arrivals %
Japan	100
Taiwan	100
Australia	99
Korea	95
Thailand	80
Greece	79
Egypt	76

Table 1. Air Transport's share of arrivals
Source: Biegera and Wittmerb, 2006

Tourism Industry in Turkey

Turkish tourism industry started growth after 1980's, government of Turkey give priority for the industry and the industry get bigger day by day. Tourism revenues share to GDP is just 0.1 % in 1963 this reached 6.2 in 2015. Figure 2 shows the % of Tourism revenues to GDP in Turkey. (http://www.tursab.org.tr)

After three decades later, Turkey become the one of the biggest tourist destination in the world more than 36 million tourist visit and spent more than 34 billion USD in 2014. (http://www.aktob.org.tr)

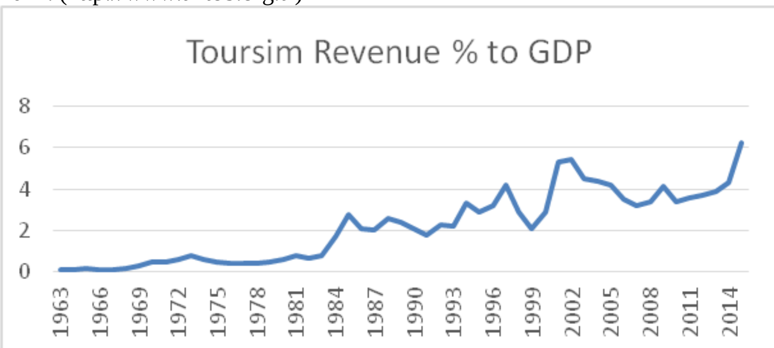


Figure 2. Tourism Revenue % to GDP in Turkey 1963-2014

German, Russian and English tourists is the top three countries visited in Turkey in 2015. (http://yigm.kulturturizm.gov.tr/) Almost half of the tourist visited Turkey via "Packet Tour". Charter airlines carried more than 11 million tourist which more than 8 million tourist to Antalya in 2013. (http://yigm.kulturturizm.gov.tr)

Number of beds from 1966 to 40 thousand to 1, 1 million in 2014. Especially, after 1980's the growing rate for the number of beds much more than before. (http://www.tursab.org.tr)

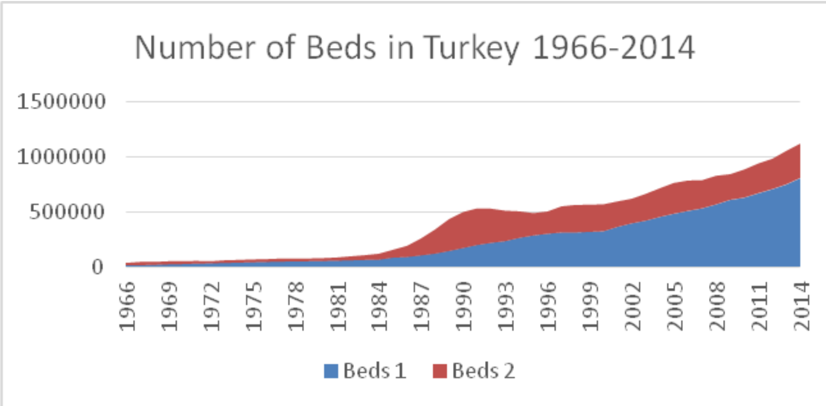


Figure 3. Number of beds in Turkey 1966-2014

Conclusion

The geographic location of Turkey and the range of international market from Turkey make air transportation more important for Turkish tourism industry. More than 80% tourist visit Turkey via air. The most transportation mode for Turkish tourism improvement is air way. Because of this air transportation is highly important for Turkish tourism. To improve air transportation and growth of city pairs markets will effect tourism industry positively. To improve air transportation to enlarge existing airports or make new one is essential for sustainable tourism in Turkey. Invest for new hotels for accommodation is meaningfully only with growing number of international tourist and with air transportation only.
There is close relationship with tourism and air transportation in Turkey. The growing number of tourist and international passenger number is similar. To sustain tourism growth new airport and airport terminal construction project should be done. And to sustainable tourism could only together with sustainable air transportation.

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Formation of quasi-integrative aircraft construction structure in Ukrainian defense system in terms of small-scale aircraft production (on example of SE "Antonov")

Conceptual basis for the formation of quasi-integrative aircraft construction structure on the basis of domestic aircraft construction enterprises headed by leading aircraft enterprise SE "Antonov" are presented.

An important component of defense industry of Ukraine that has high defence, economic and scientific importance is production and scientific-technical potential of the enterpeises of military and civil aircraft construction sector. Needs of accelerated development of a competitive defense industry of Ukraine require scientific substantiation advanced forms of economic integration of aircraft construction enterprises in the form of quasi-integrative aircraft construction structure, which is a single, flexible integrated system of high-tech production technology and modern design.

Integration of material and informational resources in the world's leading aircraft building companies as one of the main factors of competitiveness of integrated supply chains and experience of forming inter-organizational and inter-sectoral cooperation and competition models are presented in the works [3,4,5,6]. Issues of system integration as one of the manifestations of business networks nature is confirmed by scientific opinions [1,3]. However, in terms of new integrative challenges in high-tech field issues of the possibility of building flexible quasi-integrative structures, particularly in the defense system, as new aircraft construction units in an open industry and object-oriented model of aircraft construction.

The purpose of the article is analysis of the processes of quasi-integration in the science-intensive sphere and formulating foundations for creation within a system of defense industry a mobile quasi-integrative aircraft construction structure oriented on small-scale aircraft production.

Formation of a single global scientific, technical and technological space, increased organizational flexibility of enterprises through segmentation or the dissolution of large enterprises and cooperatives of small and medium-sized enterprises through the development of new flexible forms of quasi-integration ("quasi" from the Latin “quasi” - "almost", "close") is characteristical for the current stage of development of the international division of labor in the high tech field.

Quasi-integration in contrast to the classical integration does not assume full control over the property and management of the combined assets, and provides only control over the behavior of formally independent participants in the absence of legal control over their property. System-inherent feature of quasi-integration - is an organized coordinated activity of partner organizations seeking to reach their goals through participation in joint projects, implementation of which aims at integrating their resources and core competencies, and is supported by modern information technology. Result of quasi-integration is creation of flexible integrative structure, involving in the agreed financial, industrial, technological, commercial activities many manufacturing, engineering, service, R&D-centers. Features of quasi-intgrative structure are operational inclusion of the required additional participants and possibility of participating in several high-tech projects; ease of entry/leaving of integration structure; high motivation of enterprises in a sustainable concerted action. In a more specific sense quasi-integrative structure is interpreted as "artificially formed" or "imaginary, that does not exist in the real physical space" [2], but which, in our opinion, can be regarded as an economic unit newest integrative organizational form.

Practical embodiment of quasi-integration used in high-tech sectors of the economy, in particular in the aircraft industry, is *system integration*, which is characterized by a chain from the ODM (original design manufacturer – developer of the product and/or design) to the OEM (original equipment manufacturer – manufacturer of the product having the trademark or brand) and then to the CEM (contract equipment manufacturer – contract manufacturer of products, operating under the trade mark of the customer, OEM). In this chain, the OEM-enterprise when creating a new product uses services of other organizations and practically performs only final assembly of the product and gets the most profit, whereas the production of components (parts and assemblies) and most of the actual production is transferred to contract manufacturer. In this case created quasi-integrative structure is based on the identification by the OEM-company it's strongest sides (so-called core competencies) and conducting independent work only within the framework of this competencies. Outside the structure OEM-company uses outsourcing. OEM-company promotes use of new information technologies for the integration of joint activities.

In our opinion the relevance of decentralization as a natural measure to increase the flexibility of management and response to complications of the basic functions of a high-tech corporation (R&D, manufacturing, marketing, sales, planning and accounting, investment), is determined by variability of the environment above all, especially in the field of high-tech production, so high-tech corporation with a closed production cycle does not have time to adapt to new conditions, which ultimately leads to lower efficiency.

In our view, as a possible variant of development of domestic aircraft building enterprises in the system of defense industry can be considered a transition to a new model of manufacturing aircraft corporation, which provides for the purchase of structural elements of the highest quality from specialized suppliers, uniform design and manufacturing and service enterprises, and utilization of aircraft corporation capacity only for assembly work. This will help to reduce the duration of the production cycle and design cycle, decrease necessary amount of working capital and transaction costs, and thus lead to significant cost savings and reducing the cost on production of structural elements, etc.

Quasi-integrative aircraft structure as a mobile economic unit in the creation of a particular agreed product implies close relationship of trust between counterparties to minimize the cost of coordination and reduce information uncertainty among individual companies, thus, reducing transaction costs and more efficient use of resources.

However we should underline that main core of quasi-integration is the presence of monitoring over the behavior of independent companies - subcontractors for the lack of control over their property performed by active enterprise of the quasi-integrative aircraft construction structure. As an active company and OEM-company of quasi-integrative aircraft construction structures can serve SE "Antonov" (at present is part of the SC "Ukrboronprom") because it has distinct character of leadership and plays leading role in the production of aircraft. Yes, SE "Antonov" in accordance with the Regulation "On the general designer for creating technology for defense and security" N 1010 from 31.08.2011 coordinates research, experimental design, research and technological works and production by the companies - and provides scientific-technical and organizational support of creating products and technologies of the world level. SE "Antonov" is the legal owner of the intellectual property rights on their researches, including the registered trademarks "Antonov", "ANTONOV", "RUSLAN", "AH", "AN", certificates of civil aircraft types and has the exclusive right to permit and prohibit the use of rights in production, sales, repairs, maintenance of products manufactured on the basis of its reserches. As well as aviation technology developer and the owner of the certificate type SE "Antonov" during all the time of development and production provides architectural support of production.

Thus, the range of SE "Antonov" functionsis is very wide and significant, which can be added with the right to control quality of products and services provided, require the fulfillment of license agreements and implementation of measures to address the deficiencies and copyright of aircraft maintenance etc.

It should be noted that with the transfer of design documentation and technology of manufacturing new aircraft to serial and repair facilities SE "Antonov" actually invests own intellectual capital in these enterprises, contributing to the development and introducing new technologies (including information) in factories, training professionals, job creation and most importantly - capitalization of serial companies. Taking into account reasonable transfer of functions and rights it can be said about feasibility of giving to SE "Antonov" status of active company in quasi-integraitve aircraft construction structure to enter a new round of international relations and contracts.

Content guidelines for the development of quasi-integrative aircraft construction structure on base of leading aircraft construction enterprise of Ukraine SE "Antonov" are shown on fig. 1. In our own view during creation and functioning of quasi-integrative structure as a mobile economic unit in course of manufacturing certain agreed product additional coordination possibilities based on trust between aircraft construction enterprises can be implemented in following variants:

1) *quasi-internalizational relations format.* General aircraft construction company - final system integrator pursues its monopoly power through universal control mechanism of collective behavior in relation to supplier-companies and

subcontractors (range of vertical restraints), while maintaining legal status of partners. In the structure of market exchanges are viewed items of hierarchical coordination, long-term relationships of integrative type "principal-agent" are established.

2) *externalizational relations format.* Consolidated aircraft construction company which is forced to respond quickly to rapidly changing conditions in the external environment, transfers number of internal business functions to outside performers on contract basis. This externalizational format of relations can be realized in two basic forms:

- quasi-externalization which involves preserving of main system integrator control over the assets within the network relations and hierarchy of all structural elements of the system based on market coordination;

- vertical disintegration through outsourcing. Decentralization of system integrators' power happens at each stage of technological process, leading to the full withdrawal of assets owned by integrated company. This process entails the appearance of legally and economically independent system integrators and forming of long-term intercompany relations.

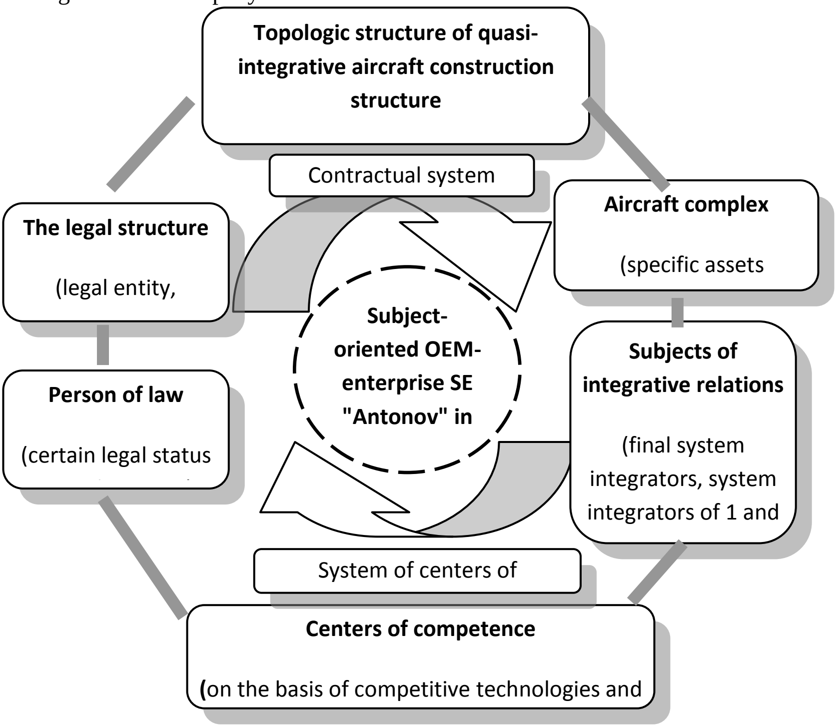

Fig. 1. Conceptual guidelines of forming quasi-integrative aircraft construction structure *Source:* developed by author

Therefore, the dual model of "integration-disintegration" expanded to three-tier chain "integration-quasi-integration-disintegration" and quasi-integrative aircraft construction structure is defined as a perspective open mobile business unit, which consists of legally independent but economically (technologically) related specialized high-tech enterprises (competence centers and system integrators) that within quasi-integration based on multi quasi-integrational connections include joint involvement of specific assets in commercial projects, high degree of confidence, information openness and mobility, achieving certain economic benefits of participants agreed in manufacturing of the product.

Thus, in our view, very important question of quasi-integrative aircraft construction structure's balance arises that's based on: resource complementarity of the uniting entities (which implies intragroup comprehensive utilization of labor, scientific, technical, industrial and financial resources); selecting participants for the economic feasibility of common effective functioning, sectoral affiliation, specialization, as well as enterprises location and related co-productions; extent of concentration of ownership, which determines strategy of quasi-integration initiators' in the distribution of rights management in accordance with capital's share. We should emphasize in this context that theoretical and methodological basis for system integration as justification of formation of quasi-integrative aircraft construction structure on basis of SE "Antonov" as an open mobile entity of subject-oriented aircraft production in the system of military defense of Ukraine, is just the latest form of economic integration - quasi-integration. Wherein goal of balancing elements of newly created quasi-intgrative aircraft construction structure is to achieve long-term sustainable multifaceted competitive advantages and economic efficiency, which is essential for embedding defence military complex in the global defense complex.

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Algorithm of forming the estimating method of total logistic costs based on artificial neural networks

It was considered one of the algorithms of forming the estimating method of total logistic costs based on the usage of mathematical apparatus of neural networks as a tool for the development of modern approaches to the definition of total logistic costs, based on logistic principles which are focused on optimization of logistical costs.

Algorithm of forming the estimating method of total logistic costs based on artificial neural network

Many countries place the great importance to the analysis of logistics in their countries, producing an annual report about the logistics status [1-4]. These studies are conducted by special labs that allows more fully and deeply to examine all processes which are related to logistics.

Except reports which are held by countries about the status of their internal logistics, The World Bank publishes an annual report about the level of its development in the world (LPI - Code [5].

Data about the level of logistics in the country and LPI are freely available and can be used by investors to assess possible risks connected with logistics, to develop the strategy of transport and logistics complex of countries [6, 7]. In Ukraine such scientific research is not systematic and permanent. At the same time, the country needs a comprehensive strategy for infrastructure development.

For the development of this strategy it should be done the calculation of real economic indicators. One of the components for evaluation and development of infrastructure strategy is logistic costs.

By neural networks are meant computing structures that simulate simple biological processes which are usually associated with the processes of the human brain. They are constituted as distributed and parallel systems that are capable for adaptive learning through the analysis of positive and negative impacts. Elementary transducer in these networks is an artificial neuron or neuron which is named by the analogy with biological prototype. In Haykin's book is found another definition of neural networks [8]: "A neural network is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use". The neural network is similar with the brain by two points of view [9]:

- Knowledge is entered into the neural network from the environment and is used in learning process.

- For the accumulation of knowledge are used connections between neurons, called synaptic weights.

The main advantages of artificial neural networks are: firstly, the parallelization of information processing and, secondly, the capacity for self-education.

In this regard, in recent years are increasingly used artificial neural networks. This approach has a high speed in comparison with other models.

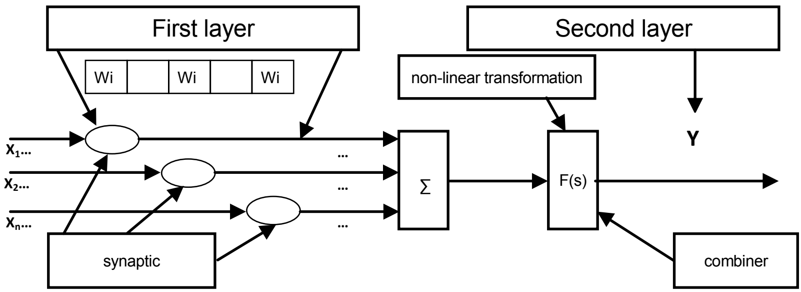
Neuron consists of three types of elements: multipliers (synapses), adders and non-linear function generator. Synapses are connected between neurons, multiplied the input signal with a number, which characterizes the strength of connection (synaptic weight). Adders are held signals combining which are received by synaptic connections to other neurons, and external input neurons. Non-linear function generator is realized a non-linear function of one argument - the output of the adder. This function is called activation function or transfer function of the neuron:

$$S = \sum_{i=1}^{n}(w_i * x_i + b_i) \quad (1)$$

$$y = f(s), \quad (2)$$

- W_i - synaptic weight, i = 1...n; b - offset value; s - result of summing; x_i - component of entry vector (incoming signal), i = 1....n, y - number of neuron inputs; f(s) - non-linear transformation (activation function).

Let us consider the elements of presented bilayer neural network. Input layer consists of n input elements, hidden layer of k neurons and output layer of j output values (figure 1).



x_i – i-st incoming signal;
W_i – synaptic weights of i-st neuron;
S – linear combination of incoming impacts;
f(S) – activation function (non-linear function generator);
y – outcoming neuron signal.

Fig. 1. The structure of the neural network that consists of a single neuron.

Neural networks have classification and characteristics. Depending on the functions which are performed by neural networks, three types can be distinguished:

1. Input neurons for which vectors are submitted that are encoded the input image or the impact of the environment; they are usually not carried out computational procedures, and information is transferred from input to output by changing their activation;
2. Output neurons and output values which are represented the output of the neural network. Transformation in them is carried out by the formula (1) and (2).
3. Intermediate neurons that are formed the basis of neural networks, the transformation of which is performed also by the formula (1) and (2).

In terms of biology, there are three main types of neural networks:

4. Fully connected neural network. Each neuron transmits a signal to other neurons, including themselves. All input signals are fed to all neurons. Output signals can be all signals or only some of the output signals of neurons after several cycles of the network functioning.
5. Multilayer neural networks. They unite neurons in layers. Layers are contained a set of neurons with a single input signals. The number of neurons in the layer can be different and it does not depend on the number of neurons in other layers. The number of neurons in general variant is C2. However, in addition to the input and output layers, multilayer neural network has one or more hidden layer. An example of the multilayer neural network is presented in Fig. 2.
6. Loosely coupled neural networks. Its neurons are located at the nodes of a rectangular or hexagonal lattice. Each neuron is connected with four (The von Neumann neighbourhood), six (The Golay neighbourhood) or eight (The Moore neighbourhood) its closest neighbours.

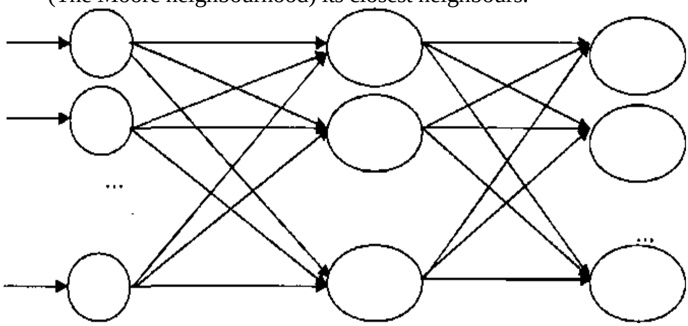


Fig. 2. Bilayer neural network

Also known neural networks can be divided by the type of neuron structures on homogeneous (consistent) and heterogeneous. There are binary and analogue networks. Another classification divides neural networks for synchronous and asynchronous. Networks can also be classified according to the number of layers.

One of the main elements of the neural network above is the ability of the network to learn. Learning is based on the following rules: error correction, learning from memory, Hebbian learning, competitive learning and others. The meaning of education is based on minimizing the error signal e (n).

$$E(n) = y(i) - d(i)? \tag{3}$$

где y(i) - neuron output signal value;

d(i) - actual output system signal.

The error signal is initiated by management mechanism, the objective of which is to use a sequence of adjustments in the synaptic weights of neuron k. These changes are aimed at recursive approximation of output signal y (i) to the desired d (i). This objective is achieved by minimizing the error function E (n):

$$E(n) - \frac{1}{2} * \ e_k^2(n) \tag{4}$$

On the basis of generalization of presented information we can formulate the algorithm for calculating the total logistic costs on the basis of artificial neural networks method (Figure 3).

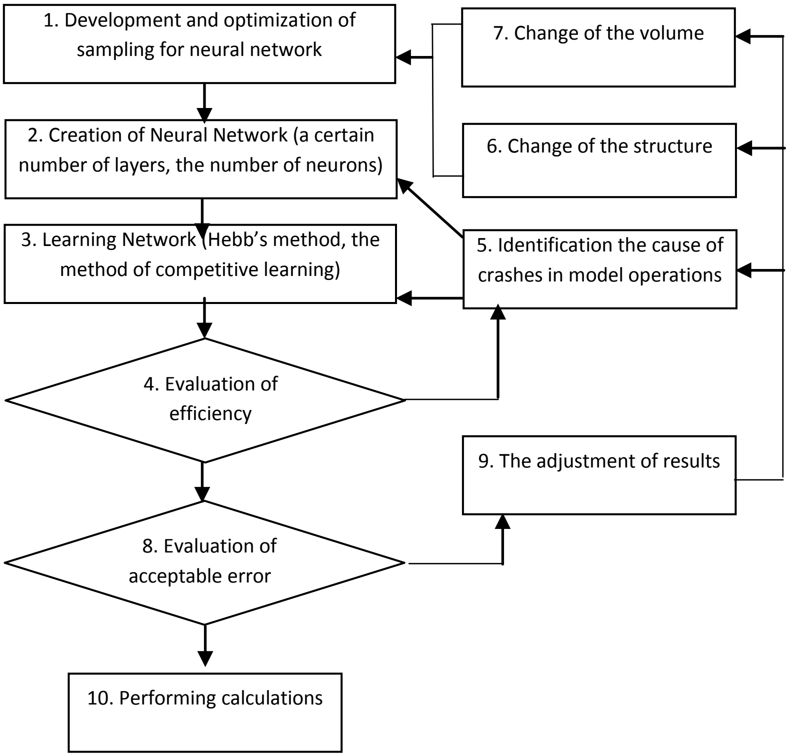


Fig. 3. Algorithm of forming the estimating method of operational systems based on neural networks.

For the analysis of logistical costs in Ukraine can be applied the current model. However, due to the number of limitations is arisen the question about the precision of estimate which is obtained by this method. Therefore, for more exact result is required a synthesis of models, in this case for the basis can be taken the method of neural networks.

Considered method for estimating total logistic costs which is based on the expert estimations allows you to calculate the desired rate if limitations are existed in statistical databases.

The formed algorithm of performing calculations allows to estimate the index of total logistic costs in Ukraine.

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Modelling of aviation vocabulary

The article deals with the problem of modeling of aviation vocabulary. The article describes the most significant features of the ideographic dictionaries, discloses the problem of the basic approaches to the modelling of vocabulary.

Quantitative and qualitative changes in the functioning of terminological systems, rapid co-sublanguages building of new science and technology lead to a number of problems which solution is of great practical significance. These problems are order, systematization and standardization of terminology, process optimization training to transfer scientific and technical literature and documentation, creation of terminology, etc.

Taking into consideration the fact that the rapid pace of development in all spheres of human activity leads to the expansion of contacts and professional communication processes of globalization should be stated that there is an urgent need for a comprehensive two – and multilingual terminological dictionaries because they allow to outline the common general terminology of the field boundaries of defined profession at several languages.

In other words, the lexicographical works are considered like an important step towards streamlining and standardization of vocabulary area of knowledge, because such a dictionary, as a result of lexicographical description of the defined terms is a step to a normative document, which includes the codified terms orienting users for their correct use.

This, in turn, will improve the contact and mutual understanding between professionals from different countries. That is why the analysis of the characteristics and principles building a bilingual terminological thesaurus is extremely important.

Taking mentioned above into consideration, the purpose of this article is to define the principles of modeling and the development processing technique of designing a bilingual vocabulary of professional language of aviation.

Background of such a dictionary has a long tradition: one of the oldest such as monuments thesaurus is created in II-III centuries BC Sanskrit dictionary "Amara-Kosa". Among the scientific papers of relevance of today, the best known thesauri are Dictionary of Roger for English, Buassera is for French, Dornzayfa is for German, Casares is for Spanish. Significant contribution to the development of the thesaurus issues have Ball, Shvedova, Morkovkin, Karaulov, Apresyan, Baranov. The computer network successfully operates and develop a thesaurus WordNet, a multilingual electronic linguistic database EuroWordNet, by analogy with it GermaNet base, BalkaNet, RusNet and many others [1].

In modern linguistics, thesaurus is a special kind of dictionary of general or specialized vocabulary, which indicates semantic relations (synonyms, antonyms, paronyms, etc.) between lexical units. Vocabularies in electronic format are one of the most effective tools for descriptions for individual subject areas and the creation of information retrieval systems.

Functional ideography as a way to describe the vocabulary suggests value-modeling organized conceptual areas of a language picture of the world and the definition of the nominative units, which are included in these areas.

A thesaurus is a type of the dictionary, which gives lexical semantic structure of different language series (notional headings) of varying degrees of generalization [1].

According to linguistic criteria thesauri are classified into:

1) monolingual focused on the structure of a language. To this type belong electronic Roget's Thesaurus, Merriam-Webster Online Thesaurus, Visual Thesaurus, CARMEN, RussNet etc.;

2) multi-language-oriented structure for multiple languages at the same time (international EuroWordNet type projects, BalkaNet, GEMET, etc.).

One of the main characteristics of the dictionary which defines its structure and volume is its thematic focus. According to the thematic focus of thesauri are divided into:

1) common language, representing the lexical composition of all the language and mainly very volumetric (electronic Roget's Thesaurus, Merriam-Webster Online Thesaurus, Visual Thesaurus, Euro WordNet);

2) special which represent specific field of science or simply combined words on the subject (e.g., NASA Thesaurus – Thesaurus NASA Aeronautics).

Common Language Thesaurus is different from specialized / terminological by a number of features:

1) specialized thesaurus often made only by nouns (words that part of the speech transposes in terminology), and in general linguistic presented words almost all parts of speech (noun, SPECIAL adjectives, verbs, adverbs, etc.) and stable combinations of words (idioms and proverbs).;

2) basis of a specialized thesaurus is based on a dominant concept, whereas the synoptic general linguistic thesaurus scheme is constructed under the influence of ideological and philosophical factors;

3) nature of the lexical material presented in these dictionaries, fundamentally different.

From mentioned above it follows that the reflection of the lexical systematization is predetermined by specialized t extra linguistic factors described by terminological system area and the Common Language Thesaurus simulates the lexical-semantic system.

The dictionary of bilingual terminological thesaurus of English professional language includes the following aircraft options:

1) language: English, Russian;

2) addressing: Aviation experts: designers, engineers, pilots, students, graduate students, teachers relevant training institutions and translators involved in literature on aviation subjects;

3) input: English units and Russian languages, as well as the identification number, with the provision of phonetic (accent), grammar (part of speech) and scientific information of definitions of the incoming word;

4) associative parameters: special tagging the semantic relationships between terms.

The practical value of the study of English aviation terminology cannot be overestimated in terms of flights security. According to the report of Interstate aviation committee the appearance of the airlines of the CIS countries in the international air routes led to a significant increase of accidents and disasters due to tolerance of flying staff to work on them without the corresponding present level of training. The main causes of aviation accidents are insufficient precise understanding in the process of conducting pilots with the radio control tower airport incorrect translation of aviation terms and their transmission on radio channels in the control room, and others.

Taking into consideration written above, the purpose of this article is to define the principles of modeling and the development processing technique of designing a bilingual thesaurus professional language of aviation.

Conclusion

Thus, the terminological thesaurus is not just a list of lexical units of a particular field of knowledge and a holistic linguistic model which facilitates the classification, storage and transmitting professional information. Modelling of thesaurus is particular field of knowledge.

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Communicative approach to aviation English teaching

The article outlines basic principles of communicative approach in teaching Aviation English to pilots and air traffic controllers.

As English is the language most widely used in common by the global aviation community, and the one which there is a requirement to provide (ICAO Language Proficiency Requirements), it is in improving levels of spoken English that the community's main focus currently lies. Despite the considerable attention of scientists to the problem of the use of communicative approach in lingodidactics, its use in teaching Aviation English to pilots and air traffic controllers remains an open question.

Main points of communicative linguistics (N. Arutiunova, F. Batsevych, T. Vynokur, H. Kolshanskyi, D. Baakke, J. Habermas, G. Leech, D.Wunderlich) can be summarized as follows: 1) in the process of communication as a special kind of human activity aimed at establishing and maintaining communication and applied to the transfer of information between people, two aspects interact – linguistic and social, as any statement produced in the particular situation of communication "has a fairly broad background of preconditions" [3] affecting its organization; 2) the language is used in regard to the situation of communication and the influence on verbal strategy of producer/recipient, i.e. taking into account the pragmatic effect, which eliminates the possibility of existence of isolated utterances produced out of the communicative context; 3) the unit of communication (and, accordingly, teaching) are certain actions or speech acts, such as requests, questions, apology, etc. Communicative importance of the structural elements of the communicative act (words, phrases, sentences) is revealed in cohered text (discourse), which determines their functions and relationships; 4) production of speech act is preceded by the formation of communicative intention of the speaker, which includes prior knowledge about the partner of communication, goal, object, place and time of utterance; 5) the most natural forms of verbal communication are listening and speaking, which often manifest themselves in dialogical form [1, p. 18].

Within several years since its emergence communicative approach to teaching has gained a leading position in the Western European and American methodology. The first wave of "communication revolution" was based on the idea of grouping bits of language according to communicative functions (in the USA called 'speech acts') like apologizing, requesting, and advising. It was not often for a direct relationship between function and language to be established because functions can be expressed by a vast range of expression and non-verbal cues; however, where a clear direct relationship could be found (e.g. *'my apologies'* for apologizing, *'do you mind if I' + Pr. Simple*, for asking permission), it was regarded as a matter of convention only, to be used for teaching purposes, not for authentic linguistic description; these 'bits' were called ‘exponents’ [5]. Due to this a number of ‘conventional exponents’, covering the range from formal to informal, could be related to each key function. Students were taught these exponents, often, misguidedly, at the expense of grammar. At this stage of the communicative approach no particular method of language teaching was suggested, exercises like "listen and repeat", "listen and extend," i.e. various "drills" were the main methods of teaching.

The second wave of "communicative revolution" took off by the early 80s of the XX century, radiating out from the UK. Its main principle was the separation of classroom work into ‘accuracy’ work and ‘fluency’ work. The aim of the first one was learning new units of language (grammar patterns, functional exponents, vocabulary, and so on), the second one focused on getting the students to speak freely (in discussions). The basic principle of all communication tasks of this phase was the "information gap" [5]. ‘Communicative drills’ (e.g. students interview each other about their daily routines to get controlled practice of Pr. Simple for routines) are the example of the accuracy-oriented information gap; free discussion, where the students discuss a real thing without interruption and the teacher takes notes of the mistakes and feeds these back afterwards, are the example of a fluency-oriented information gap.

Another kind of "communicative revolution" is the theory of language teaching, developed by American scientist S. Krashen. According to this theory, students learn (acquire) a foreign language if "fed a diet of genuine communication", i.e. learn a foreign language as children acquire their mother tongue. The researcher saw the main problem of second language teaching in the fact that students ‘*learn’* language being "fed a diet of classroom exercises" [4]. The result of this theory implementation was that many teachers started to believe that (unconscious) ‘acquisition’ was profounder, more real, and therefore better, than (conscious) ‘learning’. These teachers decided that the classroom had to become an immersive ‘bath’ of authentic communication. This attitude persists today in many classrooms, at the expense of conscious learning.

Since then, a number of mixed models based on "learning – acquiring" (among them models of M.H. Long, W. Rutherford) have appeared in foreign lingodidactics. This mixed model, according to Ch. Love, turns out to be the most popular at this time because the student continuously is involved into two processes – learning and acquiring, with each of them alternately prevailing [5]. In addition to that, western scholars believe that the teacher cannot influence the sequence and intensity with which these mechanisms are used by his students.

The first works of Soviet scholars of lingodidactics dedicated to new methodological paradigm – communicatively-oriented teaching of language are dated as belonging to the 70’s of the XX century. For more than a forty-year history the stated paradigm has been repeatedly modified: communicative approach has been supplemented by personality and activity-based (I. Zymniaia), culturological (Ye. Passov), cognitive (O. Mytrofanova, M. Pentyliuk) approaches. The communicative approach to language teaching enriched methodology with the development of the structure and content of various competencies (language, speech, communicative, social and cultural, etc.), related to the detection of levels required and sufficient to achieve the specified communication objectives; included in the scope of lingodidactics research of linguistics of the text, pragmatics of language, and a lot of the other studies, valuable in terms of authentic communication.

From the viewpoint of personality and communicative activity-based approach of teaching, pedagogical communication, according to scientists (A. Bohush, R. Martynova, M. Pentyliuk) should be implemented according to the scheme $S^1 \leftrightarrow S^2$, where S^1 is a teacher, a person who is genuinely interested in the subject of communication and can make the students get interested in it, in himself as a partner, an interesting interlocutor. S^2 is a pupil/student, communication with whom is regarded by a teacher/lecturer as cooperation in solving educational problems [2, p. 113-114].

Communicative approach (in any of its varieties) is aimed at strengthening the practical orientation of the language teaching, giving priority to the formation of students' skills to communicate in different spheres of public and professional life. The main task of the communicative approach is the formation of communicatively competent person, who is able to speak fluently and easily on any questions, showing a high level of linguistic culture, caring about the quality of speech (M. Pentyliuk).

In teaching Aviation English to pilots and air traffic controllers it is generally accepted that the closer the content matter of a course is to the actual situations, activities, functions and subjects encountered in the students' professional life, the more effective and motivating this courseware will be. Professional relevance is a combination of two factors: content and function. Content may include subjects such as approach, delays, bad weather conditions, sick passengers, a hydraulic failure and runway incursions. No less relevant for aviation professionals are the specific language functions required to deal with these situations, such as describing, requesting, clarifying and confirming.

By using materials and other resources commonly used during the flight training process, qualified language staff can, with input from the flight training department, develop a content-based Aviation English program, which incorporates standard radiotelephony practice, but includes all other linguistic aspects of flight training as well.

It is effective to use computer facilities for students' listening and viewing aviation CDs, DVDs and other computer based training. These materials can also function to enhance students listening comprehension and vocabulary skills in accordance with two of the ICAO holistic descriptors. By using a blended learning approach, with computer based training and classroom activities that are designed based on language functions, events, domains and tasks association with flight training, good learner progress can occur.

A large variety of commonly used resources should be utilized to ensure that the student has had a broader range of Aviation English exposure. This can include resources such as flight training manuals, checklists, aeronautical charts, aviation pictures in addition to activities such as total physical response, chair-flying, simulations based on actual instructor / student, dispatcher / student and mechanic / student interactions, interactions with a weather briefer, ATC communications, role-playing, attending safety seminars, etc. These resources and activities can all be extremely valuable language learning tools when introduced in a language learning scenario.

The primary objective of Aviation English training curricula for both ab-initio students and active operational professionals must be to build and enhance communicative skills and strategies of the trainees. Aviation English trainers should be able to use communicative approach methods to language learning that support their students in the most effective way to reach and sustain the required level of communicative proficiency. Among the examples of a consistently communicative approach to language training we can mention: interactive listening comprehension exercises which also elicit oral responses from learners; classroom information exchange and role-play activities in pairs; practice of vocabulary and grammar (structure) through oral use rather than reading and writing exercises; using graphic (scopes, instrument panels and charts) and numerical data (tables and displays) to elicit speech production to mirror pilots' and controllers' working environments and situation management; group problem resolution activities to develop interactivity and fluency skills.

Conclusion

Training pilots and air traffic controllers should have a communicative focus (communicative approach to language learning): a focus on successful communication as the goal, rather than pure grammatical correctness; learner-centred classrooms rather than teacher-centred; a lot of student talk; minimal teacher talk; minimal error correction; materials which attract learners' attention.

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Aviation terminology translation: dominant translation transformations in use

The article deals with aviation terminology translation and highlights the dominant translation transformations in the process of English-Ukrainian translation. The most common groups of aviation terminology have been analyzed.

It is undoubtedly true that the practical value of translation of English aviation terminology is growing. The safety of flights partially if not fully depends on the adequate and equivalent translation of aviation terminology. One of the main reasons of aviation catastrophes is the incorrect understanding in the process of radio communication between pilots and controllers and improper translation of aviation documentation. As far as the article deals with linguistic understanding of the problem, we find it crucial to define what a term is and what transformations can be applied in translating aviation terminology.

M. Glushko defines a term as a word or word combination used to express or define a notion having its semantic features and monosemy in meaning within a particular system [2, c. 79].

Scholars provide several definitions of the word «term» analyzing it from different aspects. Having studied a part of them we define the dominant characteristics of terms as follows:

- ✓ monosemy within a particular classification system;
- ✓ accuracy;
- ✓ consistency;
- ✓ independence from the context;
- ✓ relatedness to scientific notions;
- ✓ emotive neutrality.

Every epoch has its own notions, which circulate in a particular science. These notions are linguistically objectivized in form of terms. There are three types of them: 1) general; 2) interdisciplinary; 3) designed for specific tasks. Concerning aviation terms, the research has shown that more than 60% of aviation terms belong to the terms designed for specific tasks.

According to I. Asmukovych, English aviation terminology has been undergoing the formation for more than two hundred years and it reflects the complex process of aviation science development – starting from first hot air balloons to spacecraft [1, c. 112]. L. Tkachova claims, that aviation terminology system is the only system having borrowed many terms from other spheres which is explained by the fact that the field of aviation has been continuously using the developments and innovations from other fields of science. This is considered to be the reason for semantic variety of aviation terms [3, c. 28].

On the basis of the research carried out, we have found out that all aviation terms can be classified into the following groups:

1. **Airport.** Terms denoting the place of aircraft's landing, connected with airport, its parts and activities. Types of airports, airport services and parts of airports are also included.

2. **Aircraft.** This group includes terms characterizing the aircraft including types of aircraft, structural elements and its performance.

3. **Flights**. Group of terms which denote the planning and regulation of flights. It includes take-off and landing, type of flight, routes, airlines and aircompanies.

While rendering the terms belonging to the first group «airport» *calque* and *partial transcription* are considered to be the most widely used methods *(civil airport – цивільний аеропорт, airport of departure – аеропорт вильоту, airport of destination – аеропорт призначення, alternate airport – запасний аеропорт, customs airport – митний аеропорт, domestic airport – внутрішній аеропорт, freight airport – вантажний аеропорт, international airport – міжнародний аеропорт, local airport – місцевий аеропорт, transit airport – транзитний аеропорт, base airport – базовий аеропорт; aerodrome service – аеродромне обслуговування, fixed service – фіксована служба; meteorological service – метеорологічне обслуговування, radionavigation service – радіонавігаційна служба, customs service – митна служба, security check-point – контрольно-пропускний пункт* [4]). Along with calque and partial transcription *descriprive translation* can be used as well (*paved runway – злітно-посадкова змуга зі штучним покриттям, outlying airport – аеропорт, розміщений за межами населеного пункту, aerodrome control – служба управління рухом у зоні аеродрому, aeronautical fixed service – аеронавігаційна служба стандартних засобів зв'язку* [4]).

The second group «aircraft» includes terms which are also mostly rendered with the help of *calque and transcriprtion* (*all-cargo aircraft – (суто)вантажне ПС, all-metal aircarft – суцільнометалеве ПС, all-purpose aircraft – багатоцільове ПС, all-weather – всепогодне ПС, amphibian aircraft – літак-амфібія, balanced aircraft – збалансоване ПС, commuter size aircraft – ПС місцевих авіаліній, conventional take-off and landing aircraft – ПС звичайної схеми зльоту і посадки, departing aircraft – ПС, що відлітає, double-decker aircraft – двопалубне ПС, executive aircraft – адміністративне ПС, experimental aircraft – експериментальне ПС, heavier-than-air-aircraft – ПС, важче за повітря, jet aircraft – реактивне ПС, licensed aircraft – ліцензоване ПС, in-flight aircraft – ПС у польоті, in-coming aircraft – ПС на підході* [4]). *Descriptive translation* is also applied in translating the terms of the abovementioned group (*authorized aircraft – ПС, що має дозвіл на політ, cleared aircraft – ПС, що отримало (диспетчерський) дозвіл (на запит екіпажу), clean aircraft – ПС із прибраною механізацією крила, conflicting aircraft – літаки, що летять зустрічними курсами, making way aircraft – ПС у польоті, stealth aircraft – ПС з низьким рівнем демаскуючих ознак, літак-невидимка* [4]).

The third groups enumerates the least amount of terms which are mostly reproduced with the help of *calque and transcription* (*emergency landing – аварійна посадка, accuracy landing – точна посадка, automatic landing – автоматична посадка, off-runway landing – посадка за межами злітно-посадкової смуги, soft landing – м'яка посадка, advertising flight – рекламний політ, business flight –*

діловий політ [4]) but applying to *concretization and generalization* as well (*route license – ліцензія на експлуатацію маршруту, block-to-block time – повний польотний час, night landing – посадка у темний час доби, overshooting landing – посадка з викочуванням (за межі злітно-посадкової смуги), acrobatic flight – фігурний політ, box-pattern flight – політ «коробочкою»* [4]).

The research has shown that calque and transcription are considered to be the most widely used translation methods in the process of rendering aviation terminology. Descriptive translation, generalization and concretization are those translation transformations which are often used while rendering the terms which denote information concerning flights and routes.

Conclusions

Having taken into account the abovementioned examples we can claim that the most popular ways of translating aviation terms are calque and transcription. It is determined by the fact that Ukrainian terminology system is in the process of its development, it is easier for the translator to transcode or provide loan translation. Further researches can be carried out in the aspect of nominalization and standardization of English and Ukrainian aviation terminology.

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English as the official aviation language

English speaking countries dominate the manufacture and operation of aircrafts around the world, so the English language is used as the official aviation language. Aviation terminology is an important part of aviation sublanguage of the English language.

On the 1st of November, 1944 the government of the United States invited 55 allied and neutral States to meet in Chicago, in response to a British initiative. Out of the allied States invited 52 attended this meeting. The aim of this meeting was to discuss the international problems faced in Civil Aviation. The creation of the Chicago Convention on Civil Aviation and formation of International Civil Aviation Organization were the outcomes of the meeting.

The Chicago Convention saw the implementation of English as the official standardized language to be used in Aviation around the world. English speaking countries dominated the design, manufacture as well as operation of aircrafts, it thus made sense to have English as the standard language that would be used by all the countries involved in Aviation around the world. Having a standardized language aids in avoiding misunderstanding and confusion are the aspects which both have an effect on air safety.

Aviation is one of the youngest fields of technology. It is believed that the development of aviation began when the first kites appeared, but the history of modern aviation science has its roots in the 19th century, when the brothers Orville and Wilbur Wright made the first manned flight. Though it lasted only 12 seconds, this flight opened a new era in the history of world aviation and has become a landmark of rapid development of the aviation industry.

The pace of development of science and technology in modern process of globalization is growing every day, enhancing international relations and bringing international scientists and technologists together in international projects to demonstrate technological advances. The technological revolution has led to increased information and communication processes, resulting in a rapid increase in the number of scientific texts in different fields.

Aviation science that forms the basis of creation and use of aircraft is based on the achievements of aerodynamics, gas dynamics, thermodynamics, mechanics of flight, air navigation, automatic control theory, structural mechanics, materials, acoustics, ergonomics, meteorology, medicine, economics, military science.

Language plays an essential role in aviation safety. Thus, having a standard language with precise terminology that is used and understood by all operators in this industry is crucial.

Modern aviation vocabulary is subject to the general law of language: its formation is a complex of quantitative growth and qualitative change, it is a system in motion. It covers the names of aviation concepts that appeared before, derives from other languages those elements which it lacks, adding new, those that relate to concepts that have just emerged [2, p. 17].

Aviation sublanguage of the English language is rich and varied. First of all, this is due to the fact that this language was chosen as international language of aviation. A great part of the scientists' studies, recommendations to organizing interaction of aviation specialists, which are developed by international aviation organizations concern English language.

An important part of aviation sublanguage of English language is aviation terminology. I. Asmukovych noted that the formation of aviation terminology of English language has been in progress more than two centuries and reflects the complicated process of development of aviation science and technology, starting from the first balloons to spacecrafts' flights [1, p. 112]. The origin of aviation terms is the process caused by the factors of aeronautics development history. The origin and semantic structure of English aviation terms are determined by origin and development of appropriate objects, processes and phenomena of aeronautics. Thus, the semantic structure of aviation terms should be considered at the junction of two sciences – linguistics and aviation.

Semantic changes which took place in aviation terminology throughout the entire history of aviation term system can be divided into two basic types:

- semantic changes caused by new discoveries. An example is the term *aeronaut*, which original meaning is *"balloonist"*. With the appearance of machines heavier than air, it acquired the meaning "*pilot*" and after the space flight of a human its meaning is "*astronaut*";
- semantic changes caused by changes in objects and phenomena. Thus, the term *aeroplane* does not have the meaning, which it had at the beginning of the XX century, when the plane was a construction of wooden uprights and canvas. Today, the term *aeroplane* denotes a perfect machine with complex construction, which facade does not remind aircrafts of early XX century. Thus, the meaning filled up with new content as it is associated with the real object, not with the concept.

English aviation terminology was formed on the Francophone borrowings and own language material. Among the terms of French origin we note such terms, as: *aeroplane, aerobatics, aileron, avion, biplane, fuselage, hangar, hydroplane; longeron, monoplane, nacelle, pique, quadriplane, virage.*

At the beginning of the 20th century together with the appearance of the terms borrowed from French and German, creation of the new terms by own means of English language occurs because of the active development of aviation in Britain and the United States. As main parts of the aircraft had been already determined, in A. Shloman's aviation dictionary1910 p. were registered such aviation terms as: *balancers, body, cabin, deck, fin, nose, spar, tail* [3, p. 337]. The terms from the field of peripherals equipment and servicing of aircrafts were also widely used, e.g.: *aeroplane shed, aircrew, airfield, airman, airway* [3, p. 337].

As in the Ukrainian language, basic ways of aviation terms creation in the English language are the following: lexical and semantic, morphological, lexical and synthetic. Due to lexical and semantic terms creation the term system includes units from reinterpreted meaning (*jacket, jar, to load);* morphological way of terms creation gave aviation terminology derivative terms (*bear-ing, circl-ing, controll-er safe-ty);* word composition gave terms (*accident-free, air-crqft, aiito-throttle, gyro-plane*), using prepositions in the structure of terms is specific to the English language (*leveling-off, check-in, circle-to-land, lock-on, noising-over take-off),* two or more componential terminological units are created with the help of lexical and synthetic method (*radio communication equipment, snow clearing equipment* etc.). Some terms are formed by combination of several ways of terms creation.

Thus, componential analysis of English aviation terminology showed the presence of single-component and multi-component units. The analysis leads to the conclusion that the aviation sublanguage of English language is well developed. It covers terminological macro field "radio communication of Civil Aviation", which at present stage is absent in the Ukrainian language, and also rich aviation term system. By means of terms creation Ukrainian and English terms are similar, new terminological units occurs in both languages on the basis of lexical and semantic, morphological and lexical and synthetic ways of terms creation. In the initial stages of aviation term systems both languages borrowed terminological units from other languages (mainly from French, because French-speaking countries had been a leader in the development of aviation technology for a considerable period of time). At the beginning of the 20th century this situation changed, so today the leaders are English-speaking countries because English aviation terms are created from source language material, while the Ukrainian language continues to borrow them, mostly from English, and in this or that way adapt to the norms of the Ukrainian language.

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Language collisions of the globalized world in a modern aviation

The article reveals the main features of the modern era, outlines the distinctive features of modern globalization and the role of English as a means of global communication, and analyzes major language contradictions of the modern globalized world in aviation.

In recent decades, a question of the relationship of globalization and the language attracts more and more attention of scientists. As rapid, dynamic integration processes in economics, technology, culture, etc. have revealed significant problems in various fields of human life, including the communication; clarified a radical transformation of fundamental values and geopolitical structures of the modern information-oriented society. No wonder at the end of the last century, the American researcher Martin Carnoy emphasized the comprehensive revolutionary nature of the changes taking place in every sphere of human life due to globalization, noting: «Globalization together with new information technology and the innovative processes they foment are driving a revolution in the organization of work, the production of goods and services, relations among nations, and even local culture. No community is immune from the effects of this revolution. It is changing the very fundamentals of human relations and social life» [1, p.14]. Actually, these revolutionary changes are so deep, powerful and extensive that today, at this stage, we can confidently claim total globalization as a new era in human history, notable features of which is the emergence of a global society, global languages, global culture in a single global financial, economic and information space. Although the defined essential features of the modern era are being closely studied by many scientists, some features of this global language phenomenon have been characterized in the works of P. Braselmann, J. Brutt-Griffler, D. Crystal, A. De Swaan, G. Ferguson, D. Graddol, IN .Kachru, R. Phillipson, T. Skutnabb-Kangas and others., but they are still not thoroughly studied primarily due to the extreme complexity and contradictions of globalization. The aim of our research is to analyze the main language collisions of the modern world in the aviation.

The era of globalization, which is determined by the deep international integration, Transnationalism of the economic cooperation between two countries, namely the formation of transnational networks of finance, production, trade, communications, etc; high development of science, information, multimedia technology raises many issues that require an urgent search for answers. For now, humanity once again faces new challenges, and ignoring them can lead to it if not self-destruction, then at least degeneration. Actually it is the need to solve global problems that threaten not some separate ethnic group, but the whole planetary community. At the beginning of the XXI century a particular concern is paid to the gradual cultural and linguistic homogenization that can turn a rich and colorful world-wide cultural space in a uniform, globalization burnt-over desert. The probability of this scenario is confirmed by deploying highly disappointing forecasts of various modern scientists as to a linguistic diversity on our planet. For example, according to the "Atlas of the World's Languages Danger" by UNESCO in 2010 over 2 thousand languages today are doomed to extinction. According to the well-known Finnish researcher T. Skutnabb-Kangas by the end of the XXI century more than 90% of oral languages can disappear. According to the author of the work «Linguistic Genocide in Education – or World-wide Diversity and Human Rights?» (2000): «Languages are today being killed and linguistic diversity is disappearing at a much faster pace than ever before in human history, and relatively much faster than biodiversity» [2, p.5]. Other researchers point out that at least one language dies every fortnight [3, p.19]. The paradox of the modern era is that globalization gives each person, ethnicity, nation, country limitless possibilities to contribute to the enrichment of the cultural heritage of the mankind, opens a wide access for achievements of the international community in various fields of activity, helps to strengthen and develop cross-cultural, economic, political, trade relations and at the same time – causes the unification and standardization of the post-industrial society, causes a loss of ethnic and cultural identities, destroys the unique diversity of natural eco – and linguo-systems of the planet. Such ambiguity of globalization manifests itself in various collisions that are now becoming a sizeable aggravation. One of the major collisions of our time – the language collision that reveals extremely complex relationships between English as the international lingua franca (ELF) and the rest of the world's languages. The formation of a global economic, political, cultural and information-oriented space, a rapid growth of international contacts has contributed to the emergence of a "global language" phenomenon. It is significant that these concepts became active in the scientific revolution only recently – from the late 90's of the last century. Its distribution is associated primarily with the well-known scientific study «English as a Global Language» (1997) of the British scientist D. Crystals. It should be noted that for the expressiveness of The English language special status the scientists use such concepts as "language of universal communication", "language of international communication", "hyper-central language", "language-super-giant". Comprehending the reasons for the establishment of English as a global means of communication, scientists usually emphasize the decisive role of extra-linguistic factors. As D. Crystal rightly says: «A language becomes a world language for the one reason only – the power of the people who speak it. But power means different things: it can mean political (military) power, technological power, economic power, cultural power» [4, p.2]. A similar opinion is expressed by R. Phillipson stressing: «English is now entrenched worldwide, as a result of British colonialism, international interdependence, 'revolutions' in technology, transport, communications and commerce, and because English is the language of the USA, a major economic, political, and military force in the contemporary world» [5, p.23-24]. Remarkably, the author of «Linguistic Imperialism» (1992) points to the importance of transport and communications to establish a sole dominance of English in the world.

It is known that the active acquisition of the English international lingua franca status began primarily with branches of international maritime navigation and aviation. Actually, figuratively speaking, a triumphant march of this language around the world is outlined from the deep sea to the heaven. As the Russian researcher V. Smokotin noted:

"The first branch of international contacts, which recognized the need for a common language of communication has become international maritime navigation» [6, p.105]. However, the aviation due to its rapid development after World War II, which significantly increased its role in the international economics, trade, tourism, communications, etc., rather accelerated the establishment of English in the new status. And importantly, both branches were extremely favorable for perfection of English as a global language, free of cultural connotations ("simplified English"), or the so-called "Broken English version of classic English" [7, p.256]. For example, from 1980 the project "Maritime English» (Seaspeak) started – a language with a limited vocabulary [8, p.160-161]. At the turn of the century "Aviation English» (Airspeak) achieved a worldwide development. Remarkably, the operation of "clear, understandable standard language" primarily in the aviation industry has become not only desirable but extremely vital as it deals mainly with safety. The practice proves that even a minor mistake or misunderstanding in the language of communication between pilots and airport traffic control system can cause a great disaster. In particular, the tragic consequences of a "language failure" the scientists typically illustrate by the known one of the largest plane crashes in the history of international aviation (583 dead), which occurred in 1977 at the runway of Los Rodeos airport on the Spanish island of Tenerife (Canary Islands). As it turned out, except for a certain convergence of some adverse circumstances (poor visibility due to fog, congestion passenger traffic due to a terrorist attack in Las Palmas airport on the Canary Islands), the main cause of the collision of two Boeing 747 planes lied in a language communication. A KLM airline pilot while talking to the controller used the colloquial phrase «We are now at take-off», that is "We take off", which the air traffic controller took as "We are on the runway and preparing for take-off." Then the controller replied «O.K», which misled the crew, who understood the answer as a permission to take off. [9].

The mentioned Tenerife plane crash forced International Civil Aviation Organization (ICAO) to take a number of measures to prevent accidents in the aviation practice. At the beginning of 1980th ICAO published a revised version of the standard English phraseology, which help pilots during talks with air traffic controllers (Air Traffic Control, ATC), which helped to avoid misunderstanding due to the ambiguity of certain expressions. In particular, the aviation terms «cleared» («approved») and «take-off» («off»), which often caused a confusion if the native language of the speaking colleagues was not English, were replaced by the words "approved" ("pass") and "departure" ("leave") "for all the instructions, except for the procedure of control before take-off (actual take-off clearance) [10].

Note that after this accident English rapidly and smoothly began to displace other languages from international aviation. Actually, 1977 is a kind of starting point of a new stage of English spreading in the world. However, according to the ICAO English is not the only language of international aviation but it is possible to use national, regional and local languages. But the right of using in English is top-priority. Besides all, some countries – members of the International Civil Aviation Organization on their own initiative conduct a more stringent, than required by the ICAO standards, language policy, under which it is acceptable to use only English at international airports [11, p.65-66]. It would strengthen the standardization of professional English in the aviation industry allowed to solve the problem of verbal communication and finally – to prevent all possible causes of plane crashes due to the so-called "Language failures". But the experience proves that such efforts have not given the desired effect, but they showed another language collision – between classical English and simplified English. Significantly, the life always convincingly confirmed that various attempts to absorb a living language in the strict limits of a universal standard formula not only protects from certain misunderstandings of language in different situations, but can also cause a language degradation. Of course, if we evaluate the trends of standardization and unification of English as a professional language, and as a global language from a position of the average consumer-pragmatist, they seem quite acceptable. As a limited, unambiguous language, standard phraseology, simple syntax does not require much effort for learning this language, facilitate understanding, makes a comfortable use it as a means of communication. Instead, it is not difficult to notice that in this appealing simplicity there are a lot of dangers. First of all, a simplified language is destructive for a creative brain, as its native speakers lose their ability to think independently and only able to reproduce other people's opinions, but not their own ones. It should be emphasized that at this stage along with the process of "humanization" of robots can clearly be seen the process of "robotic automation" of a human being. And this second process, which has features of depersonalization and insensibility, becomes dangerous due to the linguistic unification and standardization. And this process is very beneficial for those transnational and financial corporations that are interested in enriching and strive for the world domination and unlimited power. Thus, the global language becomes an important tool in achieving this goal.

Conclusion

So, a significant expression of the modern era is the total globalization, which affected all spheres of life as a separate human being, as the entire international community. The formation of a single worldwide economic, scientific, information environment has been very favorable for the formation of a global society, global culture, and global language. Under these conditions extremely severe has become the contradiction between of an international lingua franca, which promotes the international communication, while – is the rapid displacement of other languages of the important spheres of human activity. The trends of linguistic unification and standardization are becoming threatening. For solving the aforementioned contradictions it is necessary to pursue a balanced and fair language policy, which is fundamental to the principles of complementarity and multilingualismlinguistic homogenization and standardization caused by globalization and the natural desire to preserve linguistic diversity. The analysis of the linguistic situation in the modern aviation showed that here, as elsewhere in the globalized world, there are very contradictory, ambiguous and very unpredictable processes, traced the rapid acquisition of English the status.

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Improving the professional speech culture of the aviation sector's future employees by compiling non-normative glossary

In the article the efficiency of nontraditional ways of improving the professional speech culture of future employees in the aviation sector is substantiated. It proves the importance of getting involved them in compiling non-normative words and expressions glossary. The method of using it at Ukrainian language lessons for professional purposes is described.

The usage of Ukrainian language in our country, as the state language, makes the problem of creating the professional speech culture for the future workers of any profession. Professional language culture is – «1) the conscious perception of language as the means not only of communication, but also the knowledge representation (naming) objects and content of the opinions, as the way to appeal to the recipient, establishing contact with him, expressing the will of the speaker, feelings and emotions, creating the image of the world and a man, and 2) professionally oriented synthesis of grammatical rules and options for word usage, syntactical phrases, constructing texts that provide language (oral and written) designing process and results of work in the relevant field of professional activity» [2, p. 5].

The issue has become topical as it is caused by the state needs of qualified specialists with a high level of communication skills.

The aviation sector isn't an exception. By A. Kovtun's generalization, «working professionals whose professional activity is connected with the aviation industry, aviation infrastructure and air transport» [4, p. 205]. The importance of the relevant level of skills and professional communication skills of the employees in this sector, such as pilots and air traffic controllers, «explains by the high cost of error, because of the dialogue depends not only on the success of the human activity, but also the lives of the passengers». [3, p. 175].

Unfortunately, according to own observations, the state of compliance of language standards by future Ukrainian language experts, including the aviation sector is far from ideal. Many students ignore Ukrainian literary language, preferring mixed Russian-Ukrainian dialect (surzhyk) often try to find a right word in a particular speech situation and make a significant number of speech errors caused by violation of all types of rules, often vocabulary and grammar.

Problems of speech culture, including the professional speech, are focused in the research of N. Babich, N. Voloschak, N. Savage, S. Ermolenko, S. Karavansky, A. Ponomarev, A. Serbenskoyi and other scientists. In their works qualities of speech are outlined, the norms of modern Ukrainian literary language are characterized and attention is drawn to the typical cases of violation. Methodological aspects of the definite problem were studied by O. Belyaev, S. Dubovik, L. Golden, K. Klimov, T. Okunevych M. Pentylyuk and others. However, despite some success, methods of formation and improvement of speech culture of high school students is not studied completely and needs to find new, innovative ways to solve it.

The objective of the article is to draw the high school lecturers' attention to the system work with the glossary of non – normative words and expressions as one of the effective ways to eliminate the common errors of the future specialists' professional speech.

The proposed system implementation into educational process should begin with the students' implication to the project of compiling the glossary of the typical violations speech norms (non-normative words) in specialists' professional speech of the chosen field. The essence of this activity is based on creating among the initiative students, a special research team, whose purpose is to identify the common errors in students' speech, to figure out the ways of their elimination and bring the results of their work to the student audience (the idea of creating such glossary is borrowed from A. Serbenskoyi [1]. The implementation of this goal is carried out in four phases: 1) studying the literature of the speech culture; 2) observation over students' speech and selecting the negative speech examples (negative examples); 3) analyzing the selected non-standard words and phrases and their marking according to the types of speech errors; 4) designing the results of work by creating the non-normative glossary of words and phrases.

The result of this project research team work is a glossary-handbook of non-normative words in specialists' professional speech of a certain area. It will include wrong-dangerous words and communication formula (phrases and even whole sentences) typical for a particular field of activity which are gathered by its members. All actual language material is worth to be divided into two columns: some words are not typical for Ukrainian language or communication formula with the typical mistake of speech are given on the left column, and the literary equivalents of linguistic units are on the right column. For quick orientation the non-normative words should be italicized and arranged in alphabetical order.

To bring students to the conscious learning the norms of Ukrainian literary language and to provide the glossary with more practical importance, it is advisable next to each non-normative linguistic unit, which is located on the left column, give a reference character of the language mistake in brackets according to the language levels. Specifically, the orthoepy mistake should be marked by the letter O accentology – A, lexical – L, phraseology – F, morphological – M, syntax – S. The most common mistakes are lexical, which should be specified in the following varieties: usage the words in unusual meaning (L-1); violation of lexical word-conjunction (L-2); loan translation from Russian language (L-3); russianism (L-4); use extra words – pleonasm (L-5).

The work with the compiled glossary can be done in the course «Ukrainian language for professional purposes». It should begin with a presentation of students' research group implementation and it should be done from the first lesson of the discipline. It should be emphasize that for the skilled workers of the chosen specialty is very important to master the language. Furthermore, while informing students with the rating point's allocation by the types of learning activities, announce the sanctions: take the points for the mistakes in the literary language. In this way, we create for future professionals the regulation to master the normative language.

In order to convince in the urgency of the issue it is suggested for students to make a self-diagnosis of their speech culture competence. To do this, they are asked to translate into Ukrainian language statements that members of the certain professions have to use in their professional speech nearly every day.

The findings which are made by each student after checking such tasks will be the basis for serious reflections, and encourage students to improve their own speech.

Students should be immediately informed about the main way to achieve this goal: they must learn to control themselves, especially in the use of so-called wrong-dangerous words and phrases, those units of language, where the violation of literary norms is observed. But the conscious self-control can be achieved only when you know common errors and how to eliminate them. Just this information can be taken from the glossary of non-normative words created by students' research group. Further the glossary presentation and the acquaintance with the peculiarities of its structure are made.

Then students are encouraged to join to its replenishment. It is offered an optional task such as to collect materials for glossary, for its fulfillment students can get bonus points by the end of the term. Each error is marked on a separate card with the following headings: 1) a word or expression with the faulted literary norm; 2) an edited version; 3) the address of the error; 4) who discovered. This form of work teaches students how to be more attentive to their own and other people's speech, and produces the ability to work with various glossaries and reference books on the speech culture.

An important element of purposeful work to improve the norms of students' speech can be cultural-language five-minute tasks with an intensive use of the non-normative glossary at every lesson. At these lessons it would be reasonable to give the tasks of identifying non-normative words among suggested words; text editing; finding examples on the certain selection of rules; grouping negative examples by the type of speech errors; error detection and explaining the method of its correction and more. The form of these tasks can be a quiz or a competition.

The suggested system of work with the usage of non-normative glossary was tested at the school department of Humanitarian Pedagogical College, Vinnytsia, during 2012-2015. The result of its implementation was the publication entitled «Glossary-handbook of non-normative words in the professional teacher's speech» [see: 5].

Conclusions

Our experience has shown that an effective way of improving the norms of students' speech is their involvement into the project of compiling the non-normative glossary and its active use at the lessons. No doubt, the proposed system does not show all the methodological reserves formation of students' speech, but it will help future professionals to test their cultural-language competence, to determine their level and if necessary to learn the normative words and phrases typical for the speech of the chosen profession. Therefore it will help to raise their speech culture.

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Translating suffixal English aviation terms in classroom

The paper is devoted to the problems students face during translations of suffixal aviation terms in class. The most common difficulties that an instructor pays attention to include lack of linguistic and professional skills among others.

Terms in aviation sphere, just as in other areas, are formed according to general English and Ukrainian word-building patterns. Instead of creating new terms, secondary nomination becomes a major means of enriching terminology. Coining new words is obviously connected with the primary meaning of those words which become aviation terms, such as *feather – > to feather – feathering*. Just as with any other field of knowledge, aviation nomination system consists of virtually all parts of speech, which are formed according to the common language word-forming rules. In general, English aviation terminology makes use of productive suffixes that form nominal, adjectival and verbal forms, or differentiate abstract and concrete meaning. For example, suffixes – *ty, – ness, – ancy* are used to make abstract terms from adjectives: *redundancy, airworthiness, visibility,* etc.

The patterns of coining terms vary, e.g.:

N + er / or: *thruster, alternator*;

V + ion / ation / ment / ure / age / ance / ing: *ablation, refueling, compression, reinforcement, departure, blockage,* etc.;

A + (i)ty / ness / e(a)ncy: *abnormality, thickness, redundancy*.

For translation of the aviation term, as a rule, the translator is recommended to analyze the context in which the term is used and to pay attention to the original meaning of the root morpheme which was used to coin the term [2, p. 36]. Yet, when students were asked to translate a text containing a number of words not found in the aviation dictionary, they failed to perform such analysis. The most common strategy was to use a form that sounded "better" without any linguistic analysis. For instance, the term from a Wikipedia article *Helmet Mounted Sighting System* is a complex one, in which the suffixal part *sighting* presented the major difficulty, as students had to choose between two Ukrainian forms *прицільний* and *прицілювальний*. The former one is easily found in the dictionary and has the meaning of "designed to aim at the object" [3], but what about the latter one? It appears when googled: *прицілювальний* comes in such combinations as *прицілювальний пристрій, прицілювальна планка, прицілювальний пристрій* and others. Looking into the meaning of the suffix – у(ю)валь-, we see that it refers to the capacity or aim for performing some action [1, p. 130]. As is the case with participles, the reference to action is strong in *прицілювальний*, while the attributive characteristic is more prominent in *прицільний*; therefore, it is offered in the dictionary as a part of complex terms, such as: *прицільна рамка, прицільний видошукач* [3]. We believe, it would be more correct to say *прицілювальний жест*, but *прицільна система* or *система прицілу*, which students fail to notice.

In fact, the most common problems that students encounter during translation of suffixal terms include:

- lack of knowledge of the aviation field and its terminology;
- poor knowledge of the principles of nominations in both languages;
- lack of skill in choosing between the meanings of polysemantic words;
- insufficient understanding of how to perform structural analysis of complex terms;
- lack of attention to semantic changes that suffixes lead to;
- inability to establish semantic connections between the words of a word-group, among others.

Among other difficulties that students face during translation is that they tend to fail to notice that English suffixal terms are not necessarily translated as Ukrainian suffixal ones, for example: *wingless* can be translated as word-combination *без крила* or *безкрилий* as in *wingless design* and *wingless aircraft*. It is important to tell the students that the functions of the terms, and thus the selection of translation techniques, are dependent on the requirements of the aviation discourse, or an environment in which this term exists.

At times students also forget that a terminological word-combination may not necessarily preserve the meaning of its separate components. The meaning of complex terms often has semantic independence, as *air traffic clearance* or *mixing arm*. This concerns those terms which have all its components belonging to the aviation sphere and the ones in which one or more of the elements belong to the common sphere of use. In the first case, students have to choose between interdisciplinary homonyms offered by the dictionaries to be able to translate a complex term, and in the second one, to decide whether the primary meaning of the word was preserved or a new meaning was ascribed to common lexis.

When students have to translate orally and they do not have time to analyze the terms, they often stumble on internationalisms and false translator’s friends, such as *actual altitude, aviation graphic solutions*, etc.

In class students should be reminded of the translational methods that may come handy during the process, such as transcoding (*reflector – рефлектор*), descriptive translation (*localizer – курсовий посадковий радіомаяк*), calquing (*transmitter – передавач*) and others. It was noted that students seem to be afraid of transformations during translation and are often too careful about using additions, omissions and part of speech changes, as in *altitude conversion table – таблиця перерахунку висоти*.

One more problem that the instructor faces in the class, connected not only with the suffixal terms, is the unwillingness of the students to use dictionaries and reference materials for checking their ideas and translational decisions. This is also true about malapropisms, or commonly confused words, such as principal and principle, continual and continuous, as in *continual airworthiness* and *continuous maintenance*, which often leads of clumsy translations.

The students should also be made aware of careful attitude to coining new terms, if the text requires it. Two aspects that are to be remembered in this respect are formal-semantic and semasiological ones. The first one guarantees closeness of meanings of the components of the term and their formal characteristics, the second one allows to deal with the plurality of meanings.

One of the major requirements to the translation of terms in general is achievement of adequacy and equivalence. To reach both with regard to suffixal terms, the students are offered to follow the following steps:

- to recognize the suffixal term and analyze its word-building pattern and semantic structure;
- if the word is a part of a complex term, it is important to find the main word in the group and analyze the relation of the suffixal one to it;
- translate the main word first, and then the depending ones, preserving syntactic relations and semantic features in the word-group.

This means that a student translates a complex suffixal word-group applying necessary semantic and grammatical transformations in line with the rules of the Ukrainian language, for example: *effective acceptance bandwidth – ширина смуги ефективного прийому радіосигналів*.

And finally, students should be reminded to take into account not only the context in which the term appears, but also possible changes in the meanings of the terms with times, standards in corporate translation or clients' preferences, style of the text (using of professional jargon or parlance), etc.

Conclusion

All in all, during the translation of suffixal aviation terms students encounter different problems which are mainly connected with polysemantic nature of their components. Lack of skills and knowledge often lead to faulty translations. Not only should a student be acquainted with the general principles and terms of the aviation field, but know how to analyze the terms and terminological units from the perspective of their morphological, syntactical and semantic structures. Even though a student must know specialist terminology and ways of translation, he or she should also be flexible in using a variety of translation techniques, understanding semantic and syntactic connections between the elements of complex terms, realizing the meaning of the morphemes that constitute a term and understanding the requirements to translation in general.

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Language deviation in EARD as an interpretation challenge

The article deals with the analysis of the main peculiarities and deviated features in English Aviation Radiotelephony Discourse (EARD) at phonetic, lexical, and grammatical language levels. Because of breaking linguistic rules, interpretation of language deviated forms in EARD is regarded as particularly challenging activity for future interpreters in the area of aviation.

The rapid development of the global aviation industry necessitated the usage of the intermediary language for professional communication of aviation specialists, belonging to different linguistic communities. In 1947, the International Civil Aviation Organization (ICAO) proclaimed that the international radio communication of pilots and air traffic controllers should be in English. Over the years, Aviation English coupled with Human Factor has become of paramount importance in ensuring flight safety. Thus, any fatal accident occurred because of communication failure is elaborately analyzed by experts and goes public in such documentaries as “Air Crash Investigation”, “Mayday”, “Air Crash Confidential”, “Air Crash World” and others. All these nonfictional TV series, originally in English, are dubbed into many languages including Russian and Ukrainian.

Although the rules of English aviation radiotelephony discourse (EARD) are strictly regulated in the ICAO document “Procedures for Air Navigation Services: Air Traffic Management (Doc 4444 ATM/504)”, the radiotelephony communication is of special interest for linguists. All language peculiarities of the radiotelephony communication make the speech of pilots and air traffic controllers concise, clear, and non-ambiguous. Thus, the information in EARD has the special form that meets all the requirements of this type of discourse through language code. This language code includes discursive formulas and provides for the use of specific encoded language and stereotyped expressions that are clear for only aeronautical language community. Yet, as they break English language rules, from the linguistic perspective, we regard these peculiarities as deviations.

Future interpreters in the area of aviation, as a part of their professional training, are taught to interpret aviation popular-science and documentary films, where radio communication phraseology is the most challenging for interpretation. When it comes to practice, students often are puzzled with interpreting EARD, as they cannot recognize or understand specially deviated from Standard English forms in speech. As a result, they either omit important information from the radio communication message or misinterpret it. This article is aimed at establishing the main deviations of phonetic, lexical, and grammar English language rules in EARD, that can cause difficulties for aviation industry future interpreters or translators. Once the latter get this knowledge, they can successfully interpret EARD into Ukrainian or Russian.

Phonetic deviation. Phonetic organization of EARD is based not upon precise following articulation norms but upon ensuring clarity of expression, that assumes deviations from the standard pronunciation, caused by spoken accents of Aviation

English users. The main purpose of these phonetic deviations is to achieve intelligibility between a pilot and an air traffic controller. As it is written in ICAO Doc 9835 AN/42, "Proficient speakers shall use a dialect or accent which is intelligible to the aeronautical community… Mutually comprehensible pronunciation is desirable and, in the context of aviation communications, necessary". Thus, the main phonetic deviations in EARD are:

1) Pronunciation of numerals: a) substitution of sound [θ] for [t]: *three [θ r i: – t r i:]; thousand [ˈθ a ʊ z ə n̩ d – t a ʊ z ə n̩ d];* b) devocalization of voiced consonant at the end of the word, which is not typical in English: *five [f a i v – f a i f];* c) pronunciation change in numerals: *nine [n a ɪ n – ˈn a ɪ n ə r].*

2) Slower rate of speech. While the average speech rate in English is about 3-6 syllables per second or 130-150 words per minute, in radiotelephony it mustn't exceed 100 words per minute according to ICAO documents.

3) Limited amount of information in one utterance and pauses after each intonation group to achieve appropriate rate of speech.

4) The radiotelephony spelling alphabet. When proper names, service abbreviations and words of which the spelling is doubtful are spelled out in radiotelephony the spelling alphabet should be used: *A – Alfa [ˈæ l f ə]; B – Bravo [ˌb r a: ˈv ə ʊ]; C – Charlie [ˈt ʃ a:l i]; D – Delta [ˈd e l t ə]* and so on.

The first three phonetic deviations can only put students into an embarrassing situation for a moment, but are not likely to create problems in interpreting. The last phonetic deviation, expressed above, can puzzle students or inexperienced interpreter in aviation sphere, unless they are thoroughly learned and practiced during a training course.

Lexical deviation. To comply with the main principles of professional aviation communication between an air traffic controller and a pilot EARD must be stylistically and emotionally neutral at the lexical level. Thus, radio communication is marked by specific aviation radiotelephonic terminology. Term formation in EARD is the linguistic process of adaptation of word from standard language to the aviation term system through semantic conversion: *backtrack – рулити в зворотному напрямі (radio communication) – відмовитись, порушити обіцянку (Standard English).* Polysemy of terms is inadmissible, that's why the main aviation terminology principle of EARD is "*One word one meaning"*. For example, the word *right* is the adjective which means the direction but not the correct opinion or agreement. It is translated into Ukrainian as *«право, направо».* To express correctness in somebody's judgment or statement the phrase *that's correct* is used, but not *that's right.* EARD is highly characterized by usage of abbreviation, clipping and blending that can be difficult for interpretation: *cumulonimbus – CB; gradually – GRADU; IFR – Instrument Flight Rules; ILS – Instrument Landing System; wilco – will comply, selcall – selective calling.* Abbreviation in radio communication contributes to effective functioning of the language code in Aviation English and makes it possible to receive more information in one unit of time.

Having described the main lexical peculiarities of EARD that can be treated ambiguously in interpretation, we should pay attention to words and phrases, which have deviated meaning at all:

1) Special transmission of numbers in different aviation parameters (flight level, speed, frequency, flight course). Each number is pronounced separately, using

numerals *0-9 or hundred, thousand*. For example, *runway 36* will sound like *runway three six; the height of 12 thousand feet* in radio communication is pronounced like *the height of one two thousand feet.* Usually, students who do not practice interpretation of radio communication a lot, can confuse this reading and misinterpret it like *«висота 1-2 тисячі футів»*.

2) Discursive formulas with specific markers. Discursive formulas in EARD are specially created code words and expressions that contain information component and are used in strictly determined meaning: *How do you read me? Read you 5. – Як чуєте мене? Чую Вас відмінно*.

3) Special codes and lexical units. To express agreement/disagreement, confirmation/cancellation standard *yes/no* words are replaced in radio communication by words *affirmative/negative* only. To say that something is understandable and acceptable the word *Roger* should be used.

Students, who are not acquainted with these codes, usually, try to omit them in interpretation because literal meaning of these phrases has no sense at all. As a result, loss of the important information in interpretation takes place. Misinterpretation of lexically deviated forms is the most serious mistake as it totally disturbs meaning of message in radio communication.

Grammatical deviation. At the grammatical level EARD is characterized by the following peculiarities: interrogative sentences are avoided in radiotelephony communication; Imperative and Indicative Mood are preferable; both Active and Passive Voice are common in radiotelephony communication; Present Indefinite, Present Continuous, and Future Indefinite are the most common tenses used in radiotelephony communication. EARD has a lot of deviations at grammatical level as for sentence structure:

1) Expression of negation. While in Standard English negation is mainly expressed by negative pronoun *not*, in radio telecommunication it is rarely used. Instead, negative suffixes are commonly used, for example: *Centerline taxiway lighting unserviceable. – Не працює освітлення центральної лінії руліжної доріжки.*

2) Omission of auxiliaries and link-verbs: *Ice on runway 21 right. – Лід на злітно-посадковій смузі 21 права. Large flock of birds north of runway 27 near central taxiway. – Велика зграя птахів на північ від злітно-посадкової смуги 27 біля центральної руліжної доріжки.*

3) Omission of subject: *Ready to take-off. – Готовий до взльоту. Following Air France Airbus. – Слідую за Ер Франс Ербас.*

4) Omission of articles: *Station, calling Newtown Ground, you are unreadable. – Станція, яка викликає Н'ютаун Ґраунд, вас не чути.*

5) Omission of prepositions: *Large flock of birds north of runway 27 near central taxiway. – Велика зграя птахів на північ від злітно-посадкової смуги 27 біля центральної руліжної доріжки.*

6) Omission of personal pronouns *I, you.* It obviously happens because the communication takes place between the air traffic controller and the pilot; there is no third person in communication. For instance, *Request return to stand. – Дозвольте повернутися на стоянку.*

Grammatical skills, obtained by students in training, help them to understand and produce grammatically correct structures, organized according to the language rules.

Although, grammatical deviations in EARD can put students into an embarrassing situation, if they don’t have enough experience, future interpreters tend to understand them intuitively in many cases but sometimes misinterpret them.

Conclusion

All in all, language deviations are particularly challenging for students, who interpret EARD. Mistakes are often come as a result of misunderstanding or lack of knowledge of radio communication phraseology. To avoid human factor in interpretation, early in their training students should be pointed out such faults, and analysis of special terminology and sentence structure should become a standard practice before the actual interpretation.

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Intra-branch homonyms and ways of their translation in the aviation industry

The article deals with homonymy in the aviation industry and difficulties which arise as a result of using homonymous lexical units in various contexts. It suggests translation solutions and offers ways of avoiding translation mistakes.

In the process of translation significant difficulties arise due to homonymous words (lexical units identical in form but different in meaning). As a rule, various equivalents are stipulated by the context. The process of developing the theory of homonymy has a long tradition and is associated with the names of such scholars as L. Barkhudarov, V. Leychik, L. Scherba and others.

Homonymy of terms is quite a common phenomenon, which significantly complicates the job of any translator. Traditionally scientists distinguished two basic types of terms-homonyms: internal and cross-industry.

Intra-homonym is a term of a field of knowledge which underwent rethinking and entered the terminological system of other sciences. Two main features of intra-homonymy are: different definitions should be assigned to the terms and these terms should function in different terminology systems. For example, the term *leader* in physics has the meaning of «іскровий або грозовий розряд, лідер» in film industry – «зарядка ділянки кіноплівки, рекорд», in cybernetics – «початок масиву», in locksmith – «ходовий гвинт», in mining – «направляюча стріла копра», in political science – «провідник, керівник», in printing – «пунктир, пунктирна лінія», in botany – «головна галузь», in agriculture – «основний сорт». Another vivid example is the term *pocket* – карман. It has special meanings in the following industries: in aviation «повітряна яма», in the military sphere – «оточення», in radio communication – «мертва зона», in geology – «гніздо, місцезнаходження», in electrical engineering – «кабельний канал» [4].

The above-mentioned examples prove that the meaning of these homonymous terms is determined by their belonging to one or another field of science and technology and the specific topics involved.

Intra homonymy of terms is also quite common. The terms have the same form but the meaning is different within the same field of science or technology [2, p. 125].

In aviation industry the number of these terms is quite high. This is the biggest difficulty in the translation process, since these terms have different meanings, not only in various fields of science and technology, but even in one area.

Most aviation homonymous terms are one-word units:

range – діапазон, інтервал, область зміни,

jet – реактивний двигун, розпилення, випускання струменя, струмінь газу, реактивний літак, форсунка.

A word that has multiple dictionary matching options, similar in their meaning, is translated by means of variant-analogue, which is the closest to the word units that surround the term, depend on them and is in close connection with this term. Particular attention should be paid to the translation of the homonymous terms with attributive relation when an attribute is preceded by the term. In this case, the phrase becomes a branch or narrow-branch term. We have considered, for example, translation variants of the term *"engine"*. Its main dictionary meanings are: «машина, двигун, паровоз, процесор» [4, p. 65]. But on the other hand, the word can be considered as a general scientific term with the same semantic meaning. Polytechnic dictionaries represent it as a widely-used term. If we add to this term an attributive component the word unit takes the following meaning:

- ➢ *air* engine – компресор (технічне промислове обладнання);
- ➢ *beating* engine – розмелювальна машина, рол (виробництво паперу);
- ➢ *blast* engine – повітродувка (металургія);
- ➢ *field* engine – трактор (сільськогосподарська техніка);
- ➢ *fire* engine – пожежний насос;
- ➢ *man* engine – підйомник для людей, кліть (шахтне виробництво);
- ➢ *oil-electric* engine – дизель-генератор (енергетична промисловість);
- ➢ *hoisting* engine – підйомна машина (будівництво);
- ➢ *pumping* engine – насос (водопостачальні системи);
- ➢ *reheat* engine – двигун з форсажною камерою (авіація);
- ➢ *skid* engine – скідер, механічна лебідка, двигун;
- ➢ *winding* engine – лебідка.

In these cases the attribute is left-sided. Examples of term formation by adding an attribute *engine* from the right side can be the following:

- ❖ *engine* crew – паровозна бригада;
- ❖ *engine* driver – машиніст;
- ❖ *engine* room – машинне відділення.

All in all, the polytechnic dictionary offers 105 meanings of the term *engine* with the attributive components.

In our research we identified a few examples of the term intra-homonymy. Thus, in aviation industry the term *calibration* is translated as 1) маркування, калібрування, 2) тарування. However, in combination with other words, this term can change the meaning. For example:

calibration acoustic – акустичне калібрування;

calibration air-speed indicator – тарування покажчика повітряної швидкості;

calibration airworthiness – перевірка стану льотної придатності;

calibration compass – списання девіації компаса;

calibration flight – обліт наземних радіозасобів;

calibration prelaunch – передстартове калібрування.

Another example can be the term *air engine,* which is used in the meaning of «пневматичний двигун»:

air-chamber diesel engine – повітряно-камерний двигун;

(air) ramjet engine – безкомпресорний повітряно-реактивний двигун;

side-by-side (air) engine – двигун з паралельно розміщеними циліндрами;

(air) twin engine – двигун з V-подібним розміщенням циліндрів, дворядний двигун;

(air) arrow engine – двигун з W-подібним розміщенням циліндрів.

While exploring the macro-field of “flight crew certification” and “maintenance” we identified several reductions that can be interpreted differently. Homonymy exists in case of terms acronyms and abbreviations as well. D. Scherba distinguishes the following structural types of reductions: alphabetic abbreviations, syllable reductions, partial, compound, digital reductions and truncated words [79, p. 55]. As far as acronyms and abbreviations are composed of a small number of letters, the possibility of matches in form in different areas of science and technology exists. An example can be reduction *AC*, which has several meanings in aviation sphere and can be translated as *управління висотою польотів (altitude control), управління доступом (access control), диспетчер (air controller), апарат для кондиціювання повітря (air conditioner).* Another example is reduction *DC* which also has several meanings and is included into the category of intra-homonymic reductions: *попередження аварії (damage control), код даних (data code), код затримки (delay code).*

Conclusion

Having taken into account the above-mentioned examples we can claim that a translator must have special knowledge in the aviation industry and be text-oriented to avoid wrong encyclopedia homonymous terms. Clearly, the choice of translation equivalent is defined by the topic of the original text. However, translation mistakes can still occur due to wrong choice of homonymous term related to the field of science and engineering.

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English aviation terminology: translation problems

The paper provides an analysis of rendering the English aviation terminology into the Ukrainian language. The research concludes that the key ways of rendering aviation terms into Ukrainian are as follows: lexical equivalent translation, descriptive translation, loan translation, transcription, translation transformations.

Language plays an important role in the aviation. Especially if a piece of information is to be translated into Ukrainian in order to let Ukrainian aviators and professionals in the field know the last news. Here a role of an interpreter or a translator should not be underestimated since the incorrect translation of the aviation terminology can affect even the aviation safety. Thus, it's vitally important to have professional, highly-qualified translators in the branch.

The study is urgent as a comprehensive approach to the aviation terminology arises. The idea is to analyze the aviation text rich in terms, phraseology, sometimes neologisms and identify the main ways of aviation terminology rendering.

Text rendering is not only language substitution, it's a substitution of culture elements. The strive of every translator is get the product which can be read as an original. In line with good knowledge of aviation terminology and addressing reference materials in case of necessity a qualified translator should be aware of service norms and standards of aircraft, know the basics of aircraft systems operation and the like.

We found out that while translating English aviation texts it's difficult to choose an appropriate equivalent in a target language. It can be explained by double-meaning and stylistic neutralism of the terms.

In most cases terms are rendered by equivalent terms of the target language. So, descriptive translation, synonym substitution and other transformations are used in case of unavailable equivalents. In the process of our study we found out that there are a lot of polysemantic aviation terms in line with monosemantic ones. For example: *Gear* has the meanings: «*нога», «опора», «шасі», «шестерня», «редуктор»* and others. Thus, polysemantic terms cause one of the main problems in terminology translation. To make the translation adequate one should take into account the context and the situation.

The most common ways of aviation terminology rendering are translation as it is (choosing a full equivalent to a source language term); loan translation (word by word translation); explication (descriptive translation, rendering a term not available in the target language by describing its meaning); transcription (rendering every sound in a target language) / transliteration (rendering every letter in a target language); translation transformations.

Let's prove our observations with examples:

1) Choosing full lexical equivalent

The Montreal Convention or the Warsaw Convention system may be applicable to your journey and these Conventions govern and may limit the liability of air carriers for death or bodily injury, for loss of or damage to baggage, and for delay. – Монреальська Конвенція або Система Варшавської Конвенції може бути *застосована до вашої подорожі, та ці Конвенції визначають та можуть обмежувати відповідальність авіаперевізників за спричинення смерті або тілесних ушкоджень, за втрату, затримку або пошкодження багажу.*

As we can see in this very example the aviation terms or lexical units concerning transportation are rendered with the help of choosing direct lexical equivalents.

2) Loan translation

Aircraft are occasionally damaged by ground equipment at the airport. – Іноді повітряні судна пошкоджуються наземним обладнанням у аеропорту.

Here the word combination *ground equipment* is rendered into Ukrainian by choosing first equivalent from the dictionary for every element of the combination *наземне обладнання*.

3) Explication

This translation method is usually used for the lexical units which have no Ukrainian equivalents. These can be neologisms or realias.

Reimportation – реімпорт (ввіз попередньо вивезених товарів, ввіз з-за кордону вітчизняних товарів (не проданих, забракованих тощо), що не підлягають переробці.

4) Applying transliteration we render a graphical form (letter by letter) of the source language word, while using transcription – a sound form: *logistics – логістика, container – контейнер, terminal – термінал, charter – чартер, passport – паспорт, visa – віза, convention – конвенція.*

5) A lot of terms are rendered into Ukrainian by means of transformations.

Dangerous goods include but are not limited to: compressed gases, corrosives, explosives, flammable liquids and solids, radioactive materials, oxidising materials, poisons, infectious substances, and briefcases with installed alarm devices. – До небезпечних предметів відносяться (але не обмежуються ними): стиснуті гази, їдкі, вибухові речовини, легкозаймисті рідини та тверді речовини, радіоактивні матеріали, окислювачі, отрути, інфекційні субстанції, портфелі та кейси з вмонтованими сигнальними пристроями.

Here the transformation of addition is used in case with the word *briefcases*. In the Ukrainian translation we have *портфелі та кейси* which is one and the same but still added. On the contrary, with *oxidising materials* the transformation of omission is used which is quite justified here as no necessity to use *окислюючі матеріали*.

Let's have a look at another example:

Flights may be overbooked, and there is a slight chance that a seat will not be available on a flight even if you have a confirmed reservation.– На рейсах можливий перепродаж, отже є невелика ймовірніть, що вільні місця будуть відсутні на рейсі, навіть за умови, що ви маєте підтверджене бронювання.

Here we come across the transformation of substitution: a verbal word combination *may be overbooked* is substituted in the Ukrainian by adjective+noun word combination *можливий перепродаж.*

On the syntactical level transformations are usually used in combination with each other, rarely a single transformation is applied.

It is obvious that any special text as well as aviation one is full of terms and they can be repeated several times in the text. Thus, to make the best translation of an unknown or unavailable in the dictionary term a translator should take into account and compare all cases of its usage in this very text and afterwards try to clarify its meaning.

The main problems in the process of translation arise not with single terms fixed in the terminology dictionaries but with rendering the correct meaning of the whole phrase where word by word translation cannot be applied. For this reason background knowledge on the topic is a must.

A translator should easily operate the aviation terminology and notions. It is recommended to avoid synonymous usage of terminological units and use terms which best represent the most important signs of the object. It's not worth looking for a loan word if there is a lexical unit having the same meaning in the mother tongue. Lexical gaps should be filled with internationalisms. It is necessary to use target language terminology fixed by national terminological standards. In case of neologisms a translator should find an equivalent addressing the reference books or having consultations with specialists in the field. In rare cases English aviation terms should be rendered descriptively, by loan translation, transcription and the like.

Conclusions

As the result of our study we can claim that English aviation terms are translated into Ukrainian in the same ways as other terms. The polysemantics of aviation terms and terminological word combinations causes the greatest problems.

Terminology takes a distinguished role in the vocabulary of a special aviation sub-language. It has nominative and informational load in a professional language. Terminology is a main way of expressing and rendering special scientific notions.

As it was above mentioned the most common ways of aviation terminology rendering into Ukrainian are: lexical equivalent translation, loan translation, explication, transcription/transliteration, translation transformations.

We believe it is necessary to focus our attention on lexical and semantic ways of aviation terminology rendering in the future.

All in all, an aviation translator performs not only linguistic part of the work, he also saves people's lives by providing highly-qualified product. As a wrong translation can affect the safety and security in aviation.

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Professional language training in flight safety provision

The article deals with challenges of professional language training and its impact on the efficiency and safety of fight operations. It gives an overview of the radiotelephony communication as a part of aviation discourse with the focus on its linguistic differences on the base of ICAO documents and live communication of aviation specialists. With the view of ICAO's language proficiency standards main objectives are outlined for aviation staff language training course. Some recommendations are offered for higher education institutions as for improvement of language proficiency of aviation staff training via implementation of the program of professional education in English.

The radiotelephony communication as a part of the aviation language is a professional communication carried out between the pilot and air traffic controller by radio equipment and having the aim of improving the efficiency of flight operations and safety. Attention to radiotelephony communication as an integral part of aviation discourse is caused by the growth in global air traffic, the frequency of professional multicultural interactions and, so by global implications for training safe communications in aviation operations. Radiotelephony communication has generally been considered as one of the best models for studying the communication process, as nowhere else the effectiveness of information exchange has been more important, since it may fatally affect safety.

Domestic and foreign researchers have noted the specificity of aviation English, related to the use of phraseology and aviation professional technical terms, combining elements of technical, professional and spoken English [1]. Compared with the commonly used English, the radiotelephony language has slight differences in pronunciation and intonation, it contains specific requirements for the rate of speech, has significant differences in grammatical structures [2,3,4] and a standardized phraseology.

The ICAO standard phraseology, designed to ensure an effective, clear, concise and unambiguous communication prescribes a simplified grammar, which is characterized by a large number of elliptical forms, omission of articles, personal and possessive pronouns, auxiliary and link verbs, and some adjectives. Much more frequent than in plain language (approximately 50%) is found the use of the imperatives, infinitive forms of the verbs and the passive voice [4], as well as the use of standard phraseology words in declarative sentences to transfer the functions of an interrogative sentence.

As a functional style the language of radiotelephony communication is characterized by rigid structuring, saturation of numerals, terminology and pseudo technical vocabulary [2], the use of digital and alphabetic codes as equivalent names for concepts of natural language. Among the stylistic features of this professional communication the researchers define its prescriptive character, accuracy and unambiguousness, stereotyped patterns, and standardization [3].

However, air dialogue is above all a verbal communication in the professional field, limited by the framework of a particular situation that specifies the selection of linguistic resources, their combination and building regulations as well as subject of statements. Thus, radiotelephony communication has a direct access to human behavior and practical activities, as a pragmatic component of a statement prevails over the informative, emotional, and other components. Information is a means of influencing the interlocutor to guide his activities [3], where the maximum effect is achieved by convergence of illocutionary intentions of a statement with perlocutionary power of utterance. That is why two basic ICAO requirements for radiotelephony language proficiency are conciseness and unambiguousness to ensure the correct interpretation of the interlocutor, since, in the long run, it can be crucial to flight safety.

The introduction of language proficiency standards developed by ICAO should ensure that all operational personnel speak and understand English at an "operational" level. Although miscommunication in operational communication cannot be completely eliminated, the ICAO language proficiency requirements are aimed at speakers' sufficient proficiency to handle non-routine situations. In compliance with the mentioned requirements speakers are expected to recognize communication errors and work towards the successful and safe resolution of misunderstanding.

However, in practice a third of accidents and incidents on international routes is caused by lack of pilots', air traffic controllers' and aeronautical station operators' language proficiency in English. The focus of the flight educational institutions only on the study of general English language and standardized phraseology in many cases makes it impossible for the pilot to pass the air traffic controller vital information about the complications of flight conditions or the occurrence of abnormal situations in flight. Being proficient in radiotelephony English, the pilot successfully copes with the tasks when it comes to routine situations. In non-routine situations, when the controller needs to go beyond the usual standardized set of instructions, misunderstandings may occur. Pilots are not always able to quickly and accurately respond to the air traffic controller, cannot explain the emergency situation on the board associated with equipment or aircraft systems failures, air navigation problems, dangerous goods on board etc.

As language is not only a cause of the incident but a factor in its safe resolution, we should draw more attention to the implementation of ICAO's language proficiency standards in training all aviation operational staff. English course in higher aviation educational institutions should pursue the following objectives: to teach the use of unconventional speech in the workplace; develop communicative language skills; cover all six skills of the ICAO Rating Scale of Language Proficiency and five common signs of language proficiency; ensure the achievement of the fourth (operational) level in all six assessed elements [5, 6]. Optimization of specialized knowledge and skills in the English language through the study of specific basic subjects in English, will make achievement of these goals much faster and more efficient.

The program of professional education in English launched in Ukrainian higher education institutions has made possible for future aviation specialists to master a high quality English while continually staying in the language environment. Education in English is provided in accordance with the majors where all disciplines are taught in English. The academic syllabi, designed to be an optimal integration of the native educational traditions and modern western technique enables future aviation specialists to be fluent not only in aviation operational-related English but also in "plain language". Aviation specialists are taught to communicate on common, concrete and work related topics common to their field of workplace knowledge, as well as socio-political topics defined by their Course Training Program.

While studying disciplines in English learners' language proficiency is not limited to memorized phraseologies but ranges across a relatively broad area of work-related communicative domains, such as aircraft design and maintenance, aircraft manufacture and repair technologies, aircraft technical operation, aerodynamics, air navigation, flight safety, airport functioning and airport technologies, etc. It can be expected that if the pilot masters technical terms and concepts in English on professionally-oriented applied disciplines, in emergency situations caused by air-navigation systems or avionics failure, the pilot will be able to report on what has happened, handle the situation due to his knowledge of special subjects and be competent to make the right decision and implement the solution.

In specific-purpose language training the curriculum specialists deliberately select content to work with as the selection of appropriate professionally-oriented program content enhances common interest and motivation of learners. Even at very low levels, learners will be motivated by aviation-related materials, both because such materials will be of high interest to the learners and because such material will be seen as relevant to their work [6,7]. Among various pedagogical approaches preference is given to communicative one as it involves practical use of the language with the professional purposes. Abundant practice with tasks requiring speakers to fully participate in conversations about themselves, their operational environment and the world around them with focus on pronunciation, consistent emphasis on intelligibility, communicability, self-monitoring and self-correction [7] will enable them to get a required degree of language proficiency. Dealing with communicative role-tasks which include giving instructions and directions, handling situations with complications (for example, system and equipment failures, emergency situations, loss of luggage or misfiled hotel reservation) the speakers learn to use language as a tool to identify and solve a potential problem before it becomes a disaster.

Professionally-oriented language training is a complex process, which should be provided with a focus on the impact of all linguistic, paralinguistic, psychological, cultural, environmental and hierarchical barriers affecting the communication process in aviation. The optimization of English learning process in aviation, its adequate management will reduce the potential for air disasters as well as maximize safety. Exceptionally serious learning objectives require the teaching staff to have a high level of professional and personal dedication.

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English language competence in the context of aviation safety

This article analyzes English language competence in the context of aviation safety. It explains the essence and necessity of language proficiency in the activity of aviation specialists. The article details the linguistics requirements which aviation specialists should meet, language skills and knowledge they should possess, and Ukraine's commitments to ICAO standards.

None of a man can imagine his life without aviation, the fastest way of reaching any point worldwide. As the number of air travelers is increasing steeply, the major priority to maintain aviation industry vitality is to ensure safe, secure, efficient and environmentally-friendly operations at the global, regional and national levels.

Ukraine became the member of International Civil Aviation Organization (ICAO) in 1992 and is obliged to meet the demands of this organization including language training. So the aviation specialists should master English language and it is the necessary condition for operating flights at international routes as it is defined by ICAO for its member-countries. ICAO has developed demands for the aircrew and air-traffic controllers language competence.

In modern competitive surrounding aviation specialists should be able to master new technologies, to adapt easily to changeable labour conditions, to orient professionally in the informational flows and use foreign language in professional communication. Therefore, common safety rules constitute the backbone of the aviation safety system through the uniform requirements to operators, manufacturers and aviation personnel, certification of aviation products and services, as well as the establishment and implementation of regulatory frameworks, including those for language competence.

Communicative competence is one of the main competences required for the specialists of different profiles to be productive in various fields of modern human activities.

The complex approach to the formation of communicative competence involves the study of all communication components: listening – comprehension – speaking – speak-up activity.

Foreign language professional communicative competence does not mean only the knowledge of grammar rules or vocabulary, but it is the complex of knowledge and skills used in professional activity, the ability to get the required professional qualities and experience in a certain area.

Professionalism of aviation specialists is the essence of flight safety and security. Therefore, in March 2003, ICAO imposed the aviation language proficiency requirements for pilots and traffic controllers to promote and implement safety-critical language provisions stated in ICAO Annexes 1, 6, 10 and 11. Annex 1 determines pilots' and controllers' language proficiency for radiotelephony communications on international routes either in English or the language used by ground services.

The ICAO Language Proficiency requirements are applicable to both native and non – native English speakers. ICAO Doc 9835 states: "Native speakers of English, too, have a fundamentally important role to play in the international efforts to increase communication safety."

Aviation language proficiency stands for the ability to communicate in a foreign language, commonly used English, both in voice (for radio) and in the face-to-face situations, e.g. at pre-flight briefings, trainings or interacting with other crew members. ¾ of the language ensures accurate pilot-controller communication; ¾ contains specific vocabulary, expressions and functions; ¾ of operational efficiency relies on proficiency assessment; ¾ of communication is chiefly oral and most often with no visual contact.

The language proficiency assessment is carried out in accordance with ICAO Annex 1 standards to the expert level, excluding technical context. As a rule, the assessment is conducted by qualified native English-speakers, usually over the phone, and is scored on a rating scale, starting from Level 1 to Level 6: Level 6 as "Expert", Levels 4-5 as "Operational" and levels 1-3 as "below Operational".

In 2003, ICAO set a deadline of March 2008 for English language proficiency at Level 4 and above for all pilots flying international routes and air traffic controllers serving international airports and routes.

Level 4 is the minimal required for operating international flights and does not require, as well as Level 5 and 6, additional training, but periodic assessment.

The language is assed according to all six ICAO English language proficiency criteria:

- Pronunciation
- Fluency
- Structure
- Vocabulary
- Comprehension
- Interaction.

Operational level 4 provides the possession of basic grammatical structures and sentence

patterns, sufficient and accurate vocabulary to fluent communication, accurate comprehension and immediate response to work-related topics.

In addition, the applicants should demonstrate their ability to communicate clearly using standard radiotelephony phraseology, deliver and understand messages in usual and abnormal situations.

However, those obtained Level 3 must undergo additional training to be licensed for flight operations.

The same is true to airport and ground staff. As you know, an airport is an area of the heavy flow of passengers, cargo, freight etc. It requires its staff to be flexible, productive, well-trained and educated to satisfy passengers' and customers' needs and demands. One of the major priorities here is to promote foreign language competence for airport and ground staff daily tasks performance. To this effect, a number of training programs and courses have been designed, implemented and are being launched. They include grammar, vocabulary and pronunciation syllabuses (e.g., models, conditionals when giving suggestions, signposts (baggage claim, ticketing, customs inspection), pronunciation (fall, high rise, low rise, fall rise and rise fall); language in context (dialogues, role plays, videos, listening to recordings, communicative tasks, etc.) The learners study conversational expressions, the ways of problem-solving in various situation and dialogue communications, e.g. security guards, ground handlers, catering staff, drivers and others.

The learners are offered the following topics in Aviation English:

- Geography, topographical features, countries, and nationalities.]
- Terrain reports.
- Animals and birds.
- Health, medicine, standard and non-standard situations.
- Transportation, travel, types of vehicles.
- Weather, climate, meteorology.
- Sensation and perception.
- Materials, structure, and aircraft components.

As to grammar, it should be noted that Future Simple is mostly used by security guards, ground handlers and drivers to describe their actions; direct orders are mainly used by security guards and bus drivers to make passengers moving. Catering staff and bus drivers should focus on polite forms of address, offers and requests along with greetings, farewells, pleases and thanks.

The aviation industry specific feature is ongoing interaction with a large number of people representing different social groups and classes, different levels of education and different positions in society. Thus, the task of a competent professional is to choose the right strategy of communication with each individual to achieve the desired result if you build communication based on the psycholinguistic approach, which assumes that every person has his/her main channel of perception and information storage (the so-called "representational system") [24. P. 17-36].

Airport officers daily have to solve communicative tasks not only in their native but also in a foreign language. These tasks require the employee not only to speak a foreign language at a high level, but also to know the culture, history, traditions, customs and manners of representatives of different cultures. In this regard, the foreign language should become a means of studying cultural systems and intercultural situations as well. This will help future professionals in the aviation sector to overcome the cultural barriers that can be much more dangerous in comparison to the language barriers because cultural mistakes entail a complete lack of understanding.

To overcome the language barrier is not enough to just know a foreign language; we need to strengthen the role of the socio-cultural component in the process communicative skills of formation. According to some experts, the language barrier is not the only obstacle to understanding in different cultural contacts. National-specific features of the various cultural components (for example, traditions, customs, peculiarities of communicants' national character, emotional condition, and thinking) can hinder the intercultural communication process .

During the theoretical course, language competence includes international law and psychology syllabuses. Almost every adult, having experience in communication, can accurately determine from a person's appearance, his manner of speaking and behavior many socio-psychological characteristics such as psychological traits, age, social status, estimated activity [4. P. 123].

However, learner's image is also very important to this effect and is conventionally divided into semantic and personal. Semantic means learner's overall development, views, outlook, awareness, professional and educational knowledge. Personal information is more valuable. It describes a verbal statement paying attention to the style, grammar, logic which make a judgment about the physical, psychological and social image of the individual, his/ her age and sex, constitutional characteristics, anatomical features, traits, education, intelligence, the presence of dialect features (depending on place of birth and place of residence).

It should be noted that learning foreign language is a very complex process which requires a lot of personal efforts as well as material background and support which should be granted by the state.

Kyiv-based ICAO Institute developed the national system of language proficiency based on

Doc 9835 and ICAO Circulars 318 and 323 to be implemented through training programs and courses being carried out by seven certified aviation training centers located in this country's regions. Teachers and instructors must be certified by the State Aviation Administration of Ukraine. The test results are recorded in the assessment form and are the direct evidence for a language proficiency certificate.

However, the LPR training and testing process in Ukraine faces some challenges, especially, a lack of sufficient funding to invite native trainers, purchase the required equipment, provide recurrent training of teachers, instructors, raters and examiners abroad, as well as discord in educational programs and curricula of aviation universities and colleges. Moreover, the Ministry of Education and Science of Ukraine does not take into consideration the importance, vitality and the urgent need to back up and foster Aviation English as a key instrument to ensure this country's greater safety and security by mitigating the risk of misunderstanding and wrong actions of pilots and air traffic controllers, and to encourage her closer move towards European integration. In the first place, the matter concerns insufficient time for teaching Language for Specific Purposes (principally, English as it is most widely used in common by the global aviation community) in the curricula of aviation educational institutions that make the students unable to acquire the required knowledge to pass the Aviation English proficiency tests after graduation.

Conclusions

Learning foreign language is a very complex process which requires a lot of personal efforts as well as material background and support which should be granted by the state. Foreign language professional communicative competence does not mean only the knowledge of grammar rules or vocabulary, but it is the complex of knowledge and skills used in professional activity, the ability to get the required professional qualities and experience in a certain area.

The language proficiency assessment is carried out in accordance with ICAO Annex 1 standards to the expert level, excluding technical context. As a rule, the assessment is conducted by qualified native English-speakers, usually over the phone, and is scored on a rating scale, starting from Level 1 to Level 6: Level 6 as “Expert”, Levels 4-5 as “Operational” and levels 1-3 as “below Operational”.

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Effective language training for air traffic controllers

The article deals with a critical aspect of effective language training for air traffic controllers. The training consists in that the student not only learns a way of doing things, but also develops the right way of thinking, so that actions taken in a split are correct and operationally sound. Today, the practical international language of the airways is English. Thus, it is considered that the quickest way of achieving efficiency is to think and act in English.

Language is a great deal more complex than the use of it in our daily lives would suggest. In fact, much common wisdom about language use and language learning may be erroneous. An example is the widespread belief that children learn a new language more readily than adults. Research does not entirely substantiate this; studies show that, while adolescents have some advantage over both adults and children, adults can employ learning strategies that help them make better progress than children. While this is not to say that age does not affect language learning at all, factors other than age-personality, access to the language, or motivation – may have a stronger influence.

Training in such cases often becomes counter-productive and, as the pace and scale of the training intensify, the student’s morale becomes affected. Of course, the more professional institutions have long recognized this language problem and have acted to provide language training courses to precede the technical training.

National Aviation University is particularly active in this area, offering a number of specially tailored courses in the English language to meet the needs of each type of entrant. Here, non-English speakers first undertake what we call the English for Specific Purposes (ESP) course which will ensure a technical appreciation of the language prior to more formal training.

This innovation makes it possible to find solution for the language problem in question, although progress has not always been as rapid as desired.

However, we have yet another difficulty to address. Long experience has demonstrated that the language problem is the most serious concern of all when dealing with students for whom English is not their first language. Even those with sound academic backgrounds and the right emotional attitude often happen to be unacceptably deficient in the use of the English language.

There is also a common perception that anyone speaking a language well can also teach that language. In reality, language teaching is a professional activity that requires specialized training, and no substitute for effort and time has been found for learning new languages.

An important consideration in the development of an efficient and effective language training programme is the choice of an appropriately prepared individual to direct the task. Language programme teachers need training or education in a number of relevant areas of study. Teaching methodologies, linguistic principles, language acquisition and learning strategies all combine to give professional language teachers the knowledge and competence needed to create optimal learning environment and experience. Qualified individuals shall have academic credentials from an accredited language teacher preparation program.

Aviation is often at the forefront of technological advancements in both creating and implementing them. However, in this rapidly changing industry there is a constant need to communicate in a language common to all involved including key personnel such as pilots and air traffic controllers; hence the vital role of Aviation English. Worldwide, for more people speaking English it is the second language and they actually outnumber native speakers. Even in English-speaking countries, English is often the second language and it cannot be taken for granted that all aviation personnel are native speakers. In fact, the aviation industry involves people from all language backgrounds and understanding how people communicate effectively in such an environment as well as the factors leading to miscommunication is vital.

English teachers can teach Aviation English successfully after they become familiar with the aviation content, which they can do in a number of ways, such as obtaining experience in aviation operations, or through a short course designed to provide this familiarity (e.g., air traffic controllers' course). On being introduced to aviation content, experienced teachers of English for Specific Purposes will be able to select, modify and use appropriate material and information for the benefit of their students.

Alternatively, joint work of a qualified English language teacher with an aviation subject matter expert has proved to be a useful solution, the role of the subject matter expert in the language classroom being to guide the selection and verify the accuracy of the aviation content; while the role of the trained language specialist is to arrange for optimal language learning to occur in the context of the aviation content provided or supervised by the subject matter expert. Such partnerships have been found to be among the most effective technical English language teaching approaches.

While it is commonly understood that organizations will turn to aviation experts for their valuable technical knowledge, it is important to recognize that language learning does not involve mere rote memorization. Research proves that language learning is a complex phenomenon, and that it occurs most effectively when students are engaged in communicative language activities. However, it is the quality of training as opposed to the quantity of exposure that leads to performance improvement in aviation communication, and in Aviation English. More practice is not always the best way to achieve proficiency without quality of training. It is obvious that native speakers and those learners for whom English is the second language will not have the same training needs in relation to language and communication, however we do emphasize that the end result of training should be that all speakers communicate effectively with each other, and demonstrate not only knowledge of specific language and procedures associated with aviation communication. Individuals with flight experience or an air traffic control background make valuable subject matter experts, but the task of teaching language classes or developing appropriate language learning materials should be delegated to language teaching professionals. In the aviation language teaching environment the role of aviation experts – and it is an important role – is that of the subject matter expert providing the content. While the role of guiding the delivery is a task best left to the teaching specialist. Attempts to economize on selecting teachers, material or program developers are likely to cost far more in the long run than selecting people who are appropriately qualified in these areas.

Being a semiotic system (i.e. a set of representative symbols) language is able to convey various meanings at different levels or times. Consider, for example, how interpersonal exchanges can be influenced by mood. The speech delivery of a highly confident individual can be smooth and articulate. By way of contrast, strongly negative attitudes and emotions can result in ineffective communication.

Let us consider how an established context can lend interpretation to messages. Undoubtedly, no pilot would misunderstand a tower directive to “clear the runway”. If, however, this transmission was heard by a snow plough operator, an altogether different activity to that expected might occur (ICAO standardized phraseology is “vacate the runway”). Expectation, predisposition and anticipation can add to, take away from, and distort the intention of the speaker.

When it comes to communication between pilots and ATC, pilots can rely on the specific aviation language with its carefully constructed phraseology, specified pronunciation and turn-taking rules. This system approach safely provides multiple redundancies, which in the unlikely event of an error, capture the error and allow for correction, and at least minimize potential consequences from the error.

Many pilots will have experience of being repeatedly cleared to a certain flight level at a descent point along a certain route, only to “hear” the anticipated clearance when, in reality, the controller has assigned something different. Similarly, many air traffic controllers will have experienced “hearing” the read back of an expected flight level only to realize on tape playback that in fact the pilot read back a different level altogether. Such idiosyncrasies of communication cause daily misunderstandings in casual conversations and business transactions. The results are variously amusing, embarrassing and, sometimes, costly. Therefore, the research on the problem is of great importance and the results of research should translate into improved knowledge to help determine how aviation communication should be taught and assess how to improve effective radio communication

In the context of aviation radiotelephony, however, they are a threat to safety. In urgent circumstances, or when the communications undergo the impact of fatigue or other impairments, the results can be fatal.

There is yet another aspect of linguistic nuances that needs to be understood. This has to do with the difficulty implicit in communication in a non-native language, a phenomenon known as “code switching”

This reminds of the well-known Freudian blunder, an uncontrolled moment of never consciously intended verbal expression. When under stress and communicating in a non-native language, speakers tend to revert to their native language. It takes a high level of proficiency or strong self-discipline to continue speech in non-native language when under stress, but even then something of a revision may occur in the grammatical construction. The outcome of code switching, which may be difficult to recognize, can be confusion and contradiction. What’s worse, the statement may make perfect sense to the listener but may not reflect the meaning intended.

It is difficult enough for non-native speakers to pronounce distinctly English words and put them in proper English grammatical context, even in everyday conversation. It is much more difficult for foreign air controllers to communicate properly when under pressure, especially in an emergency. This difficulty can lead to miscommunication and threaten safety. In cross-cultural communication, even if conducted in a common language, there is a critical need to guard against confusion by being scrupulous in using standard phraseology and proper radiotelephony techniques.

Success of international civil aviation depends upon standardisation of aviation procedures, of which communication is one. In formulating its policy for air traffic control language, ICAO recommended that English be available at all control facilities serving international traffic, which resulted in the de facto use of English as the international language of air traffic control. English became the lingua franca for international aviation simply on the basis of economic, geographic and cultural dominance. This process continues today as Russia and China, which previously had no reason to adhere to the English language policy, are making major efforts to improve and expand the English language skills of their controllers and pilots with the aim to open their airspaces to more commercial traffic.

As long as radiotelephony communications may be conducted in the language of the ground facility, a prescribed level of proficiency in the English Language alone would fail to improve communication overall. Clearly, regulations must apply for all languages used in radiotelephony. Thus, the proficiency requirement and scale have been developed with native and non-native speakers in mind, and can be applied to any language, not just English.

The improvement of radiotelephony communications to a higher level of safety is no small matter, and requires widespread cooperation and continuous concerted effort, particularly from operating controllers and flight crew. In particular, it is vital that both native and non-native speakers conform more closely to the requirements of existing provisions, particularly the standard phraseology. The communication of operational information is critical and requires accuracy of content and exact delivery, hence the careful development of standardized phraseology.

Language is not, however, ideally suited for transmission of precise information because it is fundamentally symbolic – that is its words and phrases are representative of the objects and concepts described. This feature becomes more evident and problematic when communication involves non-native speakers. Understanding this principle, and why conformity with standardized phraseology is so important, is essential.

Communication is mainly understood to be a means of reference to an unambiguous object, but communication also conveys a strong sense of relationship. Studies have shown communication to be very sensitive to social rank. Sensitive communication facilitates smooth interaction between flight crews and between air traffic controllers. Communication that is not so sensitive may be less effective.

Conclusions

Errors in communications and, therefore, in co-ordination are regarded as causal factors in failures within the air traffic system. The effectiveness of the system depends upon the highly dynamic information passed by voice between air traffic controllers and pilots. Without current, unambiguous information, neither pilots nor air traffic controllers can make appropriate decisions. Miscommunication, therefore, has obvious safety implications. The difficulty is not so much in routine situations but when situations become non-routine. The importance of language in problem solving should not be underestimated. Inappropriate language structures can make simple problems difficult, or even impossible, to solve.

Thus there is a need to raise awareness among pilots and air traffic controllers of the nuances of language. As part of their training, they should be provided with a deeper insight into the structures of language and the way that phrases and words can be misinterpreted. They need to be mindful of how a transmission is heard by a recipient – a successful message must be sent, received and correctly interpreted – and be aware of, and avoid, common types of linguistic misunderstandings.

It is well-known that teamwork among operational personnel depends on positive relationships. More particularly, building effective teams requires an appreciation of how timing, phrasing, intonation and non-verbal aspects of communication as well as the interplay between English language proficiency and contributing factors such as workload, phase of flight, controller accent influence group dynamics. It's widely believed that controller or pilot accent increases the likelihood of communication difficulties as well as non-standard phraseology, noise and fatigue. What appears more certain is that aviation would benefit from specific courses teaching Aviation English.

Quality English language training programs for air traffic controllers tend to seek teachers who have either an educational background specifically in English language teaching or practical experience in applied linguistics and English as a second language teaching at an appropriate level, personal motivation to learn about the current principles of language teaching and learning being of particular importance. Such knowledge and experience will suggest ways to mitigate miscommunication in aviation which can be applicable to high stress situations requiring processing of information in a complex environment. It is clear that gaps and weaknesses in the current policy of communication training should be identified and the quality of communication training needs to be improved.

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Typical pilot's mistakes in radio traffic communication

The article deals with radio traffic communication and peculiarities of pilot's professional language. The most typical mistakes of pilots and dispatchers have been analyzed.

Radio traffic is professional communicative interaction of pilots and ground support services, professional exchange and transmission of messages by radio aboard the plane [1].

From the linguistic point of view radio traffic is complex of phonetic, grammatical and lexical units of language providing speech communication between the participants of the air traffic (dispatcher and pilot) during the flight and presented in the form of dialogues "pilot – dispatcher".

Discourse of radio traffic is done in the research works of M. Moskalieva, D. Fakhrutdinova (study of terms), O. Akimova (word-formation aspects), M. Kazachkova (linguistic-cultural aspects), T. Malkovskaya (pragmalinguistic aspects), V. Vysotskyi, V. Solnyshkina (study of stylistics) [4].

The greater part of the researches describes misunderstanding of messages in radio traffic communication by russian or ukrainian-speaking pilots. Finding typical mistakes made by pilots listening to the messages of air traffic dispatchers can help us to improve the quality of training of pilots and dispatchers and prevent possible air accidents connected with not-understanding or wrong understanding dispatcher's words.

It is crucial question in the field of air safety nowadays: the latest research shows that 80% of air accidents are caused by "human factor" and mistakes of pilots and dispatchers [6].

Even satisfactory level of knowledge of English does not guarantee adequate understanding of radio traffic. There are a lot of difficulties and mistakes in describing emergency situations, correct understanding of numbers or understanding the sense of the whole phrase.

Typical English mistakes made by russian-speaking pilots in radio traffic communication are given below:

Grammatical mistakes are the following:

- Usage of incorrect tense form, for example: A 320 STOP ON THE RW < A 320 *has stopped* on the RW;
- Wrong usage of the word NOT < no in the phrase *No* speed restrictions;
- Exchange of plural and singular forms of nouns: RESTRICTION < restrictions;
- Usage of gerund and verb: REACH < reaching; HEAD < heading; CLIMBING < climb;
- Usage of wrong parts of speech: TCAS DESCENT GBL < TCAS *descend* GBL; READY FOR IMMEDIATELY DEPARTURE < Ready for *immediate* departure.

Wrong understanding of numbers is one of the worst mistakes made by pilots and can be found in the following examples:

AIRBORNE 09 < airborne 1905; AIRBORNE AT 9.05 < airborne 1905; AIRBORNE 10.50 < airborne 1905; HEADING 150 < heading 050; HEADING 050 < heading 350; HEADING 090 < Heading 050; FLIGHT LEVEL 1520 < flight level 120; LEVEL 1000 FEET < level 5000 feet; PASSING 1500 FEET < passing 5000 feet; REPORT 15000 FEET < report 5000 feet; WIND 3 DEGREES < wind 180 degrees; WIND 280 DEGREES < wind 180 degrees.

As it is rather common mistake among the pilots and dispatchers of air control it is recommended to the pilot to repeat the whole phrase (*readback*) and to the dispatcher to check it [5].

The sense of the phrase can be changed to its polar meaning as it is illustrated by the following examples:

CONFLICT AT LEVEL 5000 < Clear of conflict, level at 5000; CONFLICT TRAFFIC AT 5000 FEET < Clear of conflict, level at 5000; WE HAVE CONFLICT < Clear of conflict; WE HAVE CONFLICT LEFT < Clear of conflict, level at 5000; HOW POSITION < Hold position; ACCOMPLISH THE CHECK < I can’t issue take-off clearance; ACCOMPLISH TAKE-OFF < I can’t issue take-off clearance; HOLD DEPARTURE < Line up and hold, prepare for departure; READY FOR IMMEDIATE DEPARTURE < Ready 5 minute departure.

Words are frequently changed into the similar words or word combinations:

ABOUND < Airborne in the sentence GBL *airborne* 1905; THEN < when in the sentence Report *when* you are past 5000 feet; WHEN CONFIRM < Can you confirm into *Can you* confirm climb back 120?; COME BACK < Climb back into Can you confirm *climb back* 120?; CALL YOU CONTROL FLIGHT LEVEL 120 < *Can you confirm* climb back 120?; NOT SPEAK RESTRICTIONS < *No speed* restrictions; SINCE < seems into There *seems* to be a problem; I CAME SINCE PROBLEM < *There seems* to be a problem; HOW POSITION < *Hold* position; ACCOMPLISH THE CHECK < *I can’t issue* take-off clearance; COCKPIT CHECK < *I can’t issue* take-off clearance; CANCEL LINE-UP, KNOWLEDGE < Cancel line-up, *acknowledge*.

Such kind of mistakes can be explained: spoken abbreviation *d'you* is used instead of *do you*: DUE OR FLING < *D’you want* to file a report?; TILL FURTHER REPORT < D’you want *to file a report*?; DUE FINAL REPORT < D’you want *to file a report*? (Abbreviations in standard radio traffic communications are usually prohibited).

Omission of important elements of the phrase (especially prepositions) can change the whole meaning of the sentence:

- prepositions: CLEAR TRAFFIC < clear *of* traffic; WAIT LANDING A 320, VACATE RW 24 < Wait *for* landing A 320 *to* vacate RW 24;
- omission of the auxiliary verbs in the general questions: YOU WANT TO FILE A REPORT? < *D’yo*u want to file a report?; CONFIRM CLIMB BACK 120? < *Can you* confirm climb back 120?;
- omission of the words: CONTINUE 120 < Continue *climb flight level* 120; CONTINUE CLIMB 120 < Continue climb *flight level* 120; REPORT 5000 FEET < Report *when you’re past* 5000 feet.

All these mistakes are the result of pilots’ non-standard way of thinking that “depends on nowadays technologies and logics of professional activity” [2].

Adding nonexistent elements: REPORT *AT* HOLDING POINT L3 < report holding point L3; TIME *AT* 23 < time 23; TIME *IS* 23 < time 23.

Using synonyms pilots typically pay attention at the sense of the message but not its phonation:

OUT OF TRAFFIC < clear of traffic; REPORT REACHING < call on reaching; CALL WHEN REACH < call on reaching; CROSSING 5000 FEET < passing 5000 feet; SPEEDBIRD 937 WE HAVE PUSH BACK < Speedbird 937 is pushing back; CLEARED TO PUSH BACK < push back approved; TAXI TO HOLDING POINT FOR RW (Runway) 24 < taxi to holding point L3.

As the conclusion it can be said that teaching pilots the standard forms of professional-oriented English is not enough. They can't be used properly without knowing basic spoken English.

Knowledge of standard phrases of radio traffic communication helps the pilot to deal with standard situations but is not always enough to deal with emergency cases.

Conclusions

Further researches can be carried out in the field of training pilots how to talk correctly in the case of emergency accidents.

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Standardized and non-standard phraseology in aviation

This article deals with non-standard phraseology, which is sometimes adopted unilaterally by national or local air traffic services in an attempt to alleviate problems; however, standard phraseology minimises the potential for misunderstanding.

As the world becomes more and more “global”, language becomes a key factor in the efficiency of Pilot – Air Traffic Control (ATC) communications. Language and communication issues are very important because a miscommunication could potentially lead to a dangerous situation without any of the involved stakeholders being aware. The use of standardized phraseology is one of the most important factors involved in the process of communication. It provides for quick and effective communication allowing us to overcome differences in language and at the same time reducing the opportunity for misunderstanding. Ambiguous or non-standard phraseology is a frequent causal or contributory factor in aircraft accidents and incidents. The International Air Transport Association (IATA), together with the International Federation of Air Line Pilots' Associations (IFALPA) and the International Federation of Air Traffic Controllers’ Associations (IFATCA), has jointly prepared an on-line survey regarding communication issues, focusing on the non-use of ICAO standard phraseology. Separate surveys for both airline Pilots and Air Traffic Controllers were prepared to collate the lessons learned in the area of communications. The survey questionnaires were prepared and set-up so that participants could easily respond via a survey engine website on the internet. The use of “Aviation English” was explicitly excluded from the report as this issue has been managed through other venues. The surveys were designed to identify areas where established phraseology, or local phraseology, has been, or has the potential, to be misunderstood. Regional differences and analyses were made using the IATA regions, as shown in.

Aviation has enjoyed numerous advances in aerodynamics, power plant efficiency and reliability, flightdeck automation, and navigation systems. However, ATC/aircraft communications have changed little over the years, and still exhibit the age-old limitations of natural and human-made interference that can distort messages, difficulties with language barriers, and the problems of pronunciation and phraseology. At the same time, the volume of ground-to-air (ATC/aircraft) communication has increased dramatically because of the remarkable increase in air traffic. Satellite links and discrete communication technology promise communications solutions for the future-until then, aviation is forced to deal with the communications status quo. One of the greatest problems inherent in voice communications today is the use of non-standard phraseology.

Of the many factors involved in the process of communication, phraseology is perhaps the most important because it enables us to communicate quickly and effectively despite differences in language and reduces the opportunity for misunderstanding.

Aviation English is the highly specialized language and sequences used by pilots, air traffic control, and other aviation personnel and it focuses on a particular pronunciation, vocabulary, grammatical structure, and discourse styles that are used in specific aviation-related contexts. The language used by pilots and air traffic controllers during radiotelephony communication can be categorized into two types: standard phraseology, and plain language repertoire. Standard phraseology is the specialized phrasing commonly used by the aviation community to effectively communicate, and plain language is a more normal language used in everyday life.

Many non-native English speaking pilots and air traffic controllers learn English during their flight training and use it in a highly practical level while safely operating an aircraft and maintaining the safety of airspace, which can be highly stressful.

Below we can see a fun list of standard and. Non-standard phrases. Standard American English is an ever-evolving entity, and experts disagree on many aspects of what is “correct,” and as a result, many of us use slightly different spellings for the same words. Dictionaries and textbooks vary when it comes to standards of usage, and it is often up to the writer to determine which rules of grammar to follow.

But when it comes to word choice, should use *toward* or *towards*? *Cannot* or *can not*? If you’re like most writers, you turn to the dictionary and discover that *towards* is listed as a “variant,” which leads you to believe it is “nonstandard.” What does that mean? Is it correct or not? Does that help you to know how to spell it? Dictionaries list non-standard words to indicate that they are commonly used but are not necessarily correct.

We’ll also find jargon and colloquialisms in the dictionary, but wouldn’t use the word “ain’t” in personal essay just because it’s in the dictionary. (Naturally, it can be used in dialogue.) In other words, err on the side of standard usage.

Standard American English is “substantially uniform and well-established by usage in the speech and writing of the educated and widely recognized as acceptable” according to *Merriam-Webster*. Based on that definition, we have put together the following list of standard and nonstandard words and phrases.

Standard	**Non-standard**
a lot	alot
all right	alright
anyway	anyways
considered to be	considered as
in comparison to	in comparison with
in contrast to	in contrast with
somewhat	kind of
regarded as	regarded to be
regardless	rregardless
would have	would of
might have	might of
in regard to	in regards to

should have	should of
thus	thusly
use	utilize

Standard phraseology reduces the risk that a message will be misunderstood and aids the read-back/hear-back process so that any error is quickly detected. Ambiguous or non-standard phraseology is a frequent causal or contributory factor in aircraft accidents and incidents.

Where non-standard phraseology is introduced after careful consideration to address a particular problem, it can make a positive contribution to flight safety; however, this must be balanced with the possibility of confusion for pilots or ATCOs not familiar with the phraseology used.

Conclusions

Therefore non-standard phraseology, which is sometimes adopted unilaterally by national or local air traffic services in an attempt to alleviate problems; however, standard phraseology minimises the potential for misunderstanding.

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Primary focus on effective communication in aviation: linguistic and cultural aspect

The article focuses on the features of effective professional communication in the flight crew teamwork. The authors consider cross-cultural barriers and some causes of communication failure in different situational contexts.

Review of accident investigations and recommendations by the National Transportation Safety show that the flight safety has been jeopardized by poor crew communication. Lots of materials prove the importance of communication to aviation where language problems of some type contributed to the crash. It is considered that with communication we make our intention known to others, request and provide information, invite others to share their thoughts and suggestions, direct others to take actions, and manage social relations among participants [8].

One of the requirements of effective communication is efficient coordination among team members. In the general context of human and air space interaction we can identify both verbal and non-verbal communication situations that can equally affect the quality of teamwork and in the aviation system. However, communication as an important factor of influence on social processes takes the priority place. Verbal communication "occurs as a purposeful process of creating, transmitting and interpreting messages by means of the speech code" [6]. The form of objectification of this phenomenon is the communicative process with member-communicant entities which come into verbal contact to achieve communication goals.

Effective communication depends on successful coordination between the flight crew and cabin attendance, between flight crew and controllers, dispatchers and maintenance personnel on the ground. Every participant of the crew involves in concert communicative situation. Every fragment of communicative process is carried out at a particular time in a particular place according to the rules of the communicative code of a particular lingvo culture that entails a number of factors that actually make it possible causes of communication errors and misunderstandings. In this case cross-cultural misunderstandings reflect language problems. For instance, primary language of the crew could be French and the controllers' primary language could be Dutch, but all of them use English as a professional language. Use of the second language may lead to misunderstanding in communication. It could be revealed on each level of verbal code: productive and receptive lexicon, grammar and phonology. A similar problem can occur in grammar which consists of inflections, functional words and rules for constructing statements. It plays an important role in creating messages. Phonology has got the structural units and it distinguishes the meaning of words, morphemes, and sentences during speech production. Use of the second language in a flight crew communication also may have contributed to a lack of precision in non standard terminology.

So, language and other cultural factors may lead to the problem of misunderstanding. One of the scientific articles describes the situation when the controller used a non-standard format for giving the clearance and the pilot incorrectly read back the clearance because of the second language. Another fact shows the language and culture problems that have contributed to the failure of crew to request assistance [9].

According to the reports of Aviation Safety Reporting System (ASRS) there are some causes of communication failure. Mostly they are problems in the transmission of information, problems concerning the content of communication, problems arising from social interaction style [9]. From analysis of 100 reports submitted to the ASRS we can discern at least three ways why communication can go wrong. First it is **massage transmission** when information not getting through to the addressee. It can happen because message may suffer in its distribution. The main reason of this problem lies into two categories **Language/Accent and Dual Language Switching** [9]. So we can reveal difficulty with Language and Accent most likely during takeoffs and landings when controllers face a problem of understanding clearances. This can lead to errors in interpretation or resulted in missed information.

Secondly, the failure of communication refers to wrong understanding of the message even if it may be translated accurately. In this case the reason of misunderstanding may be grounded in various types of ambiguity or use of jargon. It shows us the second most commonly problem **Partial Readback** [9]**.** So the lack of Readback leads to confusions arising when only some part of the clearance transmitted by the controller is read back by a pilot. In this way the message not be understood as intended and leaves the referent ambiguous. For example, if a controller says *"Cleared to 240"*, and the readback is "*240"*,this could refer to a heading, speed or altitude, leaving other pilots in the dark and the controller not sure that the message was understood [9].

The third way in which communication can go wrong it is **Unfamiliar Terminology** and **Speech Act confusion**. Use of unfamiliar terminology reveals another type of communication failure in the flight crew teamwork. This case refers to use of local jargon more often than standardized terminology approved by the International Civil Aviation Organization (ICAO). In this situation message can be understood as intended and can be transmitted accurately but there can appear a failure of recipient and conversant to build a shared understanding of the situation. An example that has caused recent confusion is, "Line up and hold." Does this mean to hold short of the active runway or to taxi into position on the runway and hold prior to takeoff clearance? Speech Act confusion results when an utterance intended to be one speech act is interpreted as another, for example, a declarative taken as an imperative: "Traffic at 2 o'clock, 3 miles, level at 6,000, to pass under you." The phrase "level at 6,000" referred to the traffic, but was interpreted as a directive and the pilot leveled off at 6,000 feet [9].

Communication and teamwork can be improved when participants try to achieve a common strategic outcome. Effective communication and teamwork is aimed at creating a common mental model, or "getting everyone in the same movie". Equally important is creating an environment that feels "safe" to team members so they will speak up when they have safety concerns [9]. To improve the quality and efficiency of communication skills of flight crew become obvious national cultural and psychological factors. Thus, anthropological, social, mental, gender, age, professional characteristics should be taken into account in the analysis of individual or social communicative consciousness. Currently, researching of mental communication categories organizes and enhances knowledge of the rules of communication implementation in a particular situational context [2]. When analyzing the teamwork of the crew in order to improve group communication type of professional should identify the following features of speech communication such as: speech communications which depends on context; situational conditionality; emotional fullness and significance; semantic ambiguity; personal dependency, and so on. Consider the following elements of the strategy and tactics of verbal communication, and especially communicative behavior of the process. Communicative behavior is directly related to the communicative ethnic consciousness and it is the "way of communicative consciousness exteriorization"[6].

Conclusions

During our analysis we try to reveal some problems and features of effective communication in the flight crew teamwork. So we can say that communication first of all should be informative then relevant and perspicuous. So and in this case one of the most effective crews can be those that address message-relevant content and build common mental models for emergent problems. In addition terms and professional vocabulary play an important role in qualitative communication. In order to improve group communication type of professional should identify the following features of speech communication such as: speech communications which depends on context; situational conditionality; emotional fullness and significance; semantic ambiguity; personal dependency.

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Economy of term formal structure as a means to laconic speech of professionals in aviation sphere

The abbreviation way of composing of aviation terms is investigated. Abbreviations are considered as to their functioning, the attempt is being made to provide recommendations on using abbreviations in communicative acts.

International experience of exploitation of civil aviation gives evidence that the safety of flights is influenced by different factors, namely by the communicative factor.

In civil aviation there are established normative forms of speech working relations and the rules of their realization in terms of flights execution. Among the main principles on which phraseology norms of equipage are based during the flight one may define the following: "…number of words in radio communication sessions and their duration have to be as minimal as possible". [4, P.87-88].

Thus, a laconic language as form of delivery of aviation messages is recognized as an important factor of flight safety at the international level.

The object of our research is terminology field "safety of aviation", in particular abbreviation way of composing of new terms. The aim – is to investigate the formation of abbreviations in the system of contemporary aviation terminology with the aims to optimize the external form of terms.

Abbreviations differ from other complex words because they are formed not from the entire but from cut word stems or "cut pieces of words which form synonymic phrase, the basic element of which may be an entire, not cut word". [5, P.175].

An intensive introduction of abbreviations into communication on the one hand is caused by strengthening of extra-linguistic factors, in particular by strengthening of international connections of Ukraine in international sphere, by cooperation with international organizations ICAO, IATA and others, on the other hand – by communicative factors – abbreviations appear as a consequence of action of universal communicative tendency to economize instruments of verbal expression, which applies to all languages in the world without exception.

The characteristic feature of abbreviations is that they "appear after the full naming", therefore in the language abbreviations and word phrases formed on their base function in parallel, for instance, *літак з ГТД* (*літак газотурбінним двигуном*). Notably, that multi-component terms, after compression form new words not changing the semantics of the initial term: *авіаційний двигун – авіадвигун* and others.

Abbreviations by structure differ from words formed on their base. In particular they are more compact by structure and have own grammar features.

Traditionally among abbreviations one may define *initial, structured, mixed and combined.* Some researchers define one more type – *graphic* (*conventional*) [6, P. 8 – 9]. In our research we will base on this qualification of types of abbreviations.

To **initial** abbreviations (acronyms) belong lexical units which emerged from starting sounds or letters of complex naming, therefore among initial abbreviations one may define literal, sound, literal-sound, literal and sound with qualitative compose: *АБ ← **а**віаційна **б**езпека, БП ← **б**езпека **п**ольотів, САБ ← **с**лужба **а**віаційної **б**езпеки, Ан-78 ← літак КБ Антонова, РТІ "Нагляд – 2 м" – **р**ентгено**т**елевізійний **і**нтроскоп "Нагляд – 2 м".* Literal abbreviations, for instance, *РЛС* – ер-ел-ес (радіолокаційна станція). By sound are named abbreviations which are pronounces not by the name of letters, but by sounds: *ПАХ – **п**-оверхнева **а**-кустична **х**-виля*; *НКАУ – **н**-аціональне **к**-осмічне **а**-генство **У**-країни.*

One may concern to positive features of initial abbreviations that they are the most easily created, but it is worth mentioning that one may not use these abbreviations too frequently.

In the sphere of functioning what shows the complexity of concrete-sphere forming of terms and using of terms sometimes we might observe overwhelming quantity of initial abbreviations. For instance, in the textbook [2, P.87] one may find 27 initial abbreviations only on one page. The authors of the textbook appeal to different normative documents of SBU, MVS, other ministries and structures of Ukraine, including documents of Verhovna Rada. In the text of this textbook the abbreviation VR is functioning to define different meanings – Verhovna Rada and the explosive mixture. Of course, the context helps to understand about which meaning one is talking about. But, in our opinion, there is no point to fill up text with similar abbreviations, especially taking into account that the language has widespread abbreviations already.

Some initial abbreviations are able to cause additional unwanted associations, for instance, *ВОР* – всеспрямований ультракороткохвильовий радіомаяк [3, с. 13]. Both lexical units – abbreviation and its full naming, in our opinion, are unsuccessful. It is necessary to remember that the term – is a symbol, a label of scientific meaning, it has to be laconic and pleasantly sounded, not to rise additional context associations or connotations.

The mistakes are made also during the translation of initial abbreviations. For instance, in Russian language there is a *ВОРЛ – вторичный обзорный радіолокатор.* As in Ukrainian language this term phrase is translated as *вторинний оглядовий радіомаяк,* then logically, Ukrainian initial abbreviation should be *ВОРМ*, but authors translate it as *ВОРЛ* in Ukrainian part [3, с.13].

Another problem, in our opinion, is not pleasantly sound of many, in particular, initial abbreviations, and as a consequence, these abbreviations are hard to pronounce: *ЗДСПТ – загальнодержавна система протидії тероризму.*

Structured abbreviations are formed by the cutting of two or more words. The example of successful forming of abbreviation of this type is *Укравіатранс – Державний департамент авіаційного транспорту України.* By one word authors replace the term phrases formed by 5 components. This abbreviation can't be "developed" into complete terms phrase, as two components out of five are missed. In our opinion, such abbreviations are necessary as they satisfy the aim of terms – to be a symbol of language sign, not growing into a definition. The tendency to replace poly-structured terms by one-structured is very positive because it helps to make scientific language more laconic.

Mixed abbreviations are formed from initial parts (part) and full word: *авіасалон – авіаційний салон*; *авіазавод – авіаційний завод, Державіаслужба – Державна служба авіації* and others.

As the form of one word remains unchanged, on the one hand, provides more transparency of internal form of terms, makes the understanding of the context by recipients more easy, and on the other hand, it speeds up de-terminology and further codification of these lexical units.

In aviation terminological system there are very productive univerbats (condensates, compressives) – lexemes formed by tightening of components of word phrase as a consequence of uniting cut word – definitive and full word – defined. Borrowed lexeme-morphemes are most frequently used as initial abbreviated components – complex terms-composites with bases **авіа –** (*авіадизель, авіатраса, авіафрахт*), **аеро –** (*аеролог, аеролоція, аеротаксі*) an others. For instance in the vocabulary by N. Kirichenko and V. Loboda [3] we found 70 terms-abbreviations with the first component **авіа –** : *авіалінія – авіаційна лінія, авіапошта – авіаційна пошта, авіаквиток – авіаційний квиток, авіаметеослужба – авіаційна метеорологічна служба;* more than 250 terms with the component **авто**-: *автопілот ЛА, автоводозаправник, автодалекомір*; 408 terms with component **аеро-.** After the completing a research about lexical units with the aforementioned component, among them we defined 102 one-word-terms, the majority of which is formed by two roots (64 terms): *аеробус, аеровокзал.* The minority of terms consists of 3 (32 units): *аеродинамометр, аерофоторозвідка, аерогідролабораторія* and in some cases 4 (6 terms) roots: *аерофотограмметрист*.

Graphic abbreviations are formed by extraction of the first letter of simple of complex word of word phrase: *Т-подібний, V-подібний*, *S-подібний*, *пА* ← *п-іко-а-мпер.*

Combined abbreviations are formed from uniting of other aforementioned types: *УКХ-прийомопередавач* (*ультракороткі хвилі*), *мініБПКА* (*багаторазовий повітряно-космічний апарат*).

Today in aviation terminology system of Ukrainian language there is widely presented type of frequently used in aviation of international abbreviations (their content is translated into Ukrainian, but their form is remained untouched).: *ICAO* (*International Civil Aviation*) – Міжнародна організація цивільної авіації; *IATA* (*The Air Transport Association*) – Міжнародна асоціація транспортної авіації; *MWARA* – зона головних світових авіаліній, *RTOL* – повітряне судно вкороченого зльоту й посадки.

Functioning of these abbreviations, on the one hand, is connected with the acting of international standards of aviation, which are spread in those countries which belong in particular to International civic aviation organization or other similar organizations, and on the other hand, by introduction of these abbreviations to international scientific-technical terminology fond.

In conclusion it is worth stressing that abbreviations respond to demands of language economy, which is formulated by contemporary science towards terms as special type of special naming. Positive features, on the one hand, may be considered as laconic of their forms, on the other hand, they have higher level of concreteness of meanings and transfer several “ideas” with one word.

But it is necessary to remember, that abbreviation way of forming of lexical innovations consists a danger – may become the reason of misunderstanding and technical mistakes.

Having researched abbreviations, which are used in terminology field “safety of aviation, we came to the conclusion that in communicative acts it is not worth to use abbreviations of initial type. With the functional view, the most appropriate in verbal or written discourse are abbreviations of mixed type as the existing of full, not cut word provides more transparency of inner form of these term units, makes easier understanding of their content.

To consciously model aviation terminology system, to make effective term planning one need to focus on the condition of full research and evaluation of language phenomena on the subject of their positive and negative characteristics and adequacy towards demands raised by contemporary science to terms as special language phenomena.

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Peculiarities of phraseological units forming in aviation sphere

The methodology of investigation of phraseological units is described and investigated in the article. Also it is pointed on the roots of origin of Ukrainian phraseological units which are used in American aviation.

Language is not only a material base which is relied on by cognitive thinking in the process of its expression, but also is a material in which it is performed [3, c. 13]. Phraseology as a part of every language is a treasury of nation's spirit, trophy of its wisdom and culture, which contains reach material about its habits, traditions, beliefs, history, ideals, dreams and hopes. Indeed, there is no such sphere or part of nation's life that can't be displayed with the help of phraseological units. Relations between people, the products of their mind activity, physical and psychological state of a person, different successful evaluations and characteristics can be shown by phraseological units.

Phraseology as a linguistic discipline was built thanks to efforts of many scientists; nevertheless O. Potebnya differs from others. Interpretation of material side of the sound, semantic concept and sensuous image as a mirror of nation's mentality is organically connected with the learning about inner form of the word and phraseological unit. [6, P. 39]. O. Potebnya is one of the founders of ethnolinguistics, who "in his concept was far ahead of thoughts of E. Sapir and B. Whorf" [6, P. 430].

An important input to investigation of Ukrainian phraseology was made by such scientists as M. Alefirenko, N. Amosova, Y. Baran, L. Bulakhovsliy, A. Vezhbytska, V. Cinogradov, V. Zhaivoronok, A. Ivchenko, O. Nakonechna, V. Rusanivskiy, L. Skrypnyk, V. Teliya, V. Uzhchenko and others. Scientists continue to investigate diachronic and system connections of pharesological unit. During this process sphere's terminology is specified. [6, P. 430].

At the same time investigations from the point of view of *linguistic cultural studies* and *ethnolingustics* are of extreme importance for studying Ukrainian phraseology. As it is mentioned by V. Uzhchenko and D. Uzhchenko "this views differ one from another as ethnolinguistic is applied in retrospective and cultural studies – at synchronic level". [5, P. 434]. Also scientists think that image base of phraseological metaphor, denotative base (retrospective) simultaneously serves as connotative and culturally categorize factor. At the scale «native//foreign», for instance phraseological units with zoological images *horse* // *camel* are perceived (in «Galician-russian folklore sayings» I. Franko found more than 100 sayings with the word *horse* and practically didn't find any with the word *camel*). Meanwhile in Asian nations scientists count more than 1000 sayings with the name of «ship of the desert» [6, P. 434].

The main and foremost task of cultural studies is the description of phraseological picture of the world, and showing the specifics of folklore language, especially finding basic ethnocultural concepts in it. In this relation issues of investigation of phraseological units as methods of expression of nation's mentality, investigation of ethnophrases as language phenomenon and linguistic cultural analysis of Ukrainian phraseology are very timely. System investigation of language picture of the world is based on the solid foundation of linguistic country studies. [6, P. 435], and investigation of phraseological units persuade us that phraseology is the root of linguistic country studies' notifications. It is a shelter for multifunctional being of nation: historical memory, ethnocultural traditions, national uniqueness, working experience, power of spirit, pain and anger, grief and happiness. [3, P. 14].

The investigation of *dialect (areal) phraseology* is also important. Areal description of Ukrainian dialects, as phraseology of other Slavonic languages, is on the stage of initial gathering and systematization of facts, working out and approbation of investigation methods [1, P. 3]. The great input was made in investigation by N. Babych, G. Dobrolyozhi, A. Ivchenko, V. Uzhchenko and D. Uzhchenko, V. Chabanenko and others. Scientists try to systematize dialect phraseological units and also make an attempt to overcome areal phraseology as a system, to elaborate effective methodic of areal description, to analyze phraseology in ideographic-thematic aspect, to specify and adequately show derivation base, ways and factors of forming of phraseological units, to include phraseology of new regions as an object of investigation, to show concrete (active) language processes on the base of similar processes in other dialects. [6, P. 431].

In this context one has to remember *onomasiological* (ideographic, thematic-ideographic) description of phraseological systems of literature and areal phraseology. As today among phraseologists the interest towards "system investigation of phraseology", which have an opportunity to use computer technologies, is actively shown [6, P. 436]. Onomasiological description allows activating greatly etymology investigations, as it provides etymologists with information about system and non-system phraseological units forming processes in Ukrainian folk phraseology [2, P. 6]. A. Ivchenko says that thematic-ideographical scheme is an important task in theoretical understanding of Ukrainian language's phraseology. It allows with maximum effectiveness to use gathered and systematized material in comparative, areal and etymological investigations as Ukrainian phrase system, so phraseology of other Slavonic languages. Scientists who appeal to ideographic problems give preference to analysis of phraseology of literature language, dialect phraseology and especially jargon (argotic) has less attention [2, P. 6].

At the same time in the view of scientists there is phraseology deepened in living, beliefs, history, social relations between people, people's attitude towards living and inorganic nature as "phraseological units show mentality of different ranks of society" [6, c. 440] .

The base of Ukrainian phraseology consists of units which before were independent syntax word phrases, and after they transformed into phrases with special features. The initial lexical meaning of components was lost, was re-thought mainly due to methaphorization, the phraseological semantics was formed.

Thus a phrase *точити баляси* – means to lead pointless talks, in other words *теревенити, базікати, плескати язиком* тощо. But independently taken words *точити and баляси* do not have base «говорити» in its semantics. Only a special etymology analysis may give an explanation to ways of methaphoric re-thinking of components, caused phraseological unit.

Phraseological units that model one or another situation in aviation are also interesting. These specific phraseological units and professional words are used by pilots, who have a romantic glaze as to their profession. Therefore aviation terms with time are used in language and have a indirect meaning, for instance:

- to go into a nose dive or synonymic phraseological unit to take a nose dive has the following meanings:
- (for an airplane) to suddenly dive towards the ground, nose first;
- to go into a rapid emotional or financial decline, or a decline in health (informal).

Similarly semantics of phraseological unit to go into a tailspin is developed:

- (for an airplane) to lose control and spin to the earth, nose first;
- (for someone) to become disoriented or panicked; (for someone's life) to fall apart (informal): After her father died, Mary's world fell apart, and she went into a tailspin [5, c. 137].

Conclusion

Thus phraseological units play an important role in national culture, as they in one way or another mirror cultural, folk-psychological and mythological phenomena, understanding of the world. Also it is important to use methodic and methodology in phraseological units investigation, thanks to which one may specify phraseological units and professional words of the aviation sphere.

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Human factor impact on safety of aviation in Ukraine

The research is devoted to the issues of human factors impact on safety of aviation in Ukraine. Ukraine demonstrates the positive dynamics of reducing aviation cases during 2010-2015 years. And human factors are defined as the main reason of them. But Ukraine should implement measures aimed at preventing aviation cases.

Human factors have an exceptionally important impact in the current conditions of the civil aviation development. Circular *Human Factors Digest № 1* ICAO addressed the systemic nature of human error and the management of Human Factors [4]. According to FAA human factors awareness can lead to improved quality, an environment that ensures continuing worker and aircraft safety, and a more involved and responsible work force [3]. Reducing even minor errors the air transport enterprise will get additional measurable benefits, such as: cost reductions, fewer missed deadlines, reduction in work related injuries, reduction of warranty claims, and reduction in more significant events.

Human factors science or technologies are multidisciplinary fields incorporating contributions from psychology, engineering, industrial design, statistics, operations research, and anthropometry [3]. It is considered as an important element of safety of aviation. Understanding why people and organisations involved in aviation make errors helps to provide aviation safety by reducing the likelihood of aircraft accidents.

Today in Ukraine operators of aircrafts, which have valid operator's certificates issued by the State Aviation Administration of Ukraine, carry out safety management in accordance with the conceptual framework provided by Annex 19 “Safety Management” [5] to the Convention on International Civil Aviation.

In addition, it was adopted the Branch Program on Safety Management for 2014-2016 years [1], which sets out strategic directions to ensure safe performance of air transportation and works.

However, in Ukraine there is observed the following dynamics of aviation cases presented in Figure 1.

As Figure 1 shows, the most numerous aviation cases in Ukraine are incidents. But it should be noted that during 2013-2015 years it has been seen a positive trend of their reduction. The total number of all other categories of aviation cases has also decreased. But here it lays the problem of the impossibility of taking into account the statistics of aviation cases occurred in the territory annexed Crimea and temporarily occupied territories of Donetsk and Lugansk regions.

The main factor that caused unsafe aviation cases were human errors, namely: incorrect assessment of the situation and delayed actions. That is, we should note the direct impact of the human factors on safety of aviation in Ukraine. It confirms the need for systemic measures aimed at reducing the risk of safety of aviation related to the human factors impact.

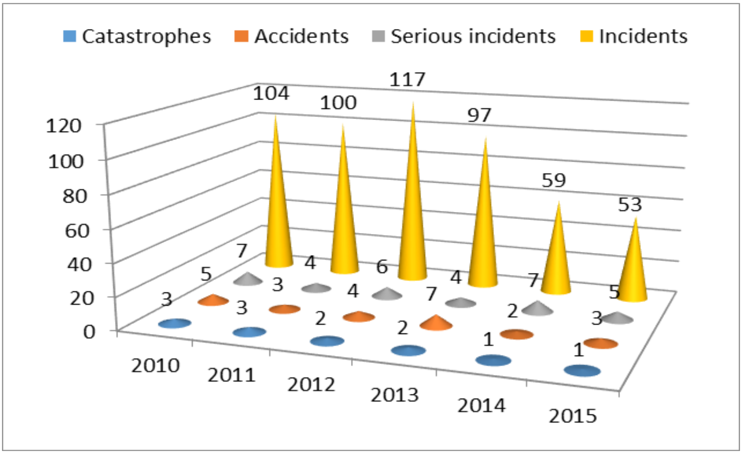

Fig.1. Dynamics of aviation cases in Ukraine during 2010-2015 years
(Source: calculated by the author on the base of [2])

ICAO defines eight critical elements related to the state safety oversight system [5]. The most focused on overcoming the negative impact of human factors on safety of aviation is CE-4 Qualified technical personnel. As at 2015, according to the ICAO requirements CE-4 in Ukraine is implemented on 73.26%, which is higher than the average global level.

In addition, by the direction PEL (Personnel Licensing) the effectiveness of implementation of ICAO standards in Ukraine is estimated on 79.01%, which is below the average target level.

However, the above figures are also below the level of 87% planned to satisfy standards of ICAO in the Branch Program on Safety Management for 2014-2016 years [1].

To ensure the safety of civil aviation the authorized body on civil aviation State Aviation Administration of Ukraine carries out a range of measures aimed at preventing aviation cases [2]:

– establishing criteria for safety of aviation;

– establishing the necessary level of safety of aviation;

– analysing and determining the existing level of safety of aviation;

– conducting scheduled and unscheduled inspections, inspecting subjects and objects of aviation activity;

– setting deadlines and exercising control over the conduct of corrective actions by subjects of the aviation activity;

– prohibition, cancellation, temporary cessation or changes in performing any kind of flights and aviation activity in case of threats to the safety of aviation or their discrepancy to the established standards and aviation rules of Ukraine;

– annulment, temporary cessation of certificates, documents, licenses, permits, limiting the rights granted by these documents, cancellation of approval of candidates;

– imposing fines and taking other measures to ensure safety of aviation.

Conclusions

Consistent implementation of the aforementioned measures will minimize the risks of safety of aviation related to the impact of human factors. In particular, the increase of the realization level of ICAO standards Ukraine in the direction of PEL is directly connected with the efficiency of implementing measures on certificates, licenses, permits, limiting the rights given by these documents, cancellation of approval of aviation personnel candidates. It is also connected with the level of social responsibility of aviation personnel at individual level, the air transport enterprises as their employers at micro level, the aviation branch authorities at mezo level, the state in the sphere of safety of aviation at macro level, and the international aviation authorities at mega level.

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Professional communicative competence of future air traffic controllers as a required component of flight safety

The article analyzes professional communicative competence of future air traffic controllers, considers the structure of this competence and defines its main components. It proposes interactive teaching methods to optimize the process of developing professional communicative competence.

The human factor has always been an important area for investigations because it is considered to be one of the main reasons leading to aircraft accidents. Prevention of human errors is one of the principal safety issues in aviation. Although the human factor can involve all aeronautical personnel related to aircraft operations, it concerns mainly air traffic controllers and pilots who play the crucial roles in aircraft operations.

The objectives of an air traffic controller are to ensure the safe flight by directing and controlling the flow of air traffic; prevent collisions between aircraft, an aircraft and obstructions on its area; give landing and takeoff instructions to pilots; provide pilots with advice and information (such as weather updates and other essential data); assist the pilots in reaching their destinations, etc. To achieve these objectives they have to conduct multiple functions (thinking, listening and speaking) simultaneously. Taking into consideration the complexity of this task, there is the high probability for an air traffic controller to make errors when traffic is heavy and when communication is in non-native English.

In order to improve flight safety and eliminate errors, ICAO has strengthened English language proficiency requirements for the air traffic controllers who communicate with foreign pilots and for the pilots operating on international routes. ICAO Doc 9835 states that these specialists must have ICAO English Language Level 4 (Operational) or above. These standards require from air traffic controllers and pilots to be able to communicate proficiently using both ICAO phraseology and plain English [5, P. 3-5–3-6]. ICAO phraseology must be applied in all specified situations which are encountered in the daily practice of air traffic controllers and cabin crews. However, when the unexpected situations happen (e.g. a pilot loses his way, the aircraft has a technical problem, equipment fails, someone provokes a bomb alert, etc) and the standardized phraseology is not sufficient for successful interaction, plain English can be used. But plain English is also restricted by the functions and topics and by specific safety-critical requirements for intelligibility, directness, non-ambiguity and conciseness. [5, P. 3-5].

Proficiency in aviation English is very essential for these specialists even if it is not their native language. Air traffic controllers must comprehend the information and come up with appropriate actions quickly. They must be able to transmit messages to pilots, understand different accents, ask and answer questions, inform about intensions and unusual situations, request information from pilots, solve linguistic difficulties, clarify misunderstandings, etc. Above-mentioned skills are one of the components of professional competence of air traffic controllers – professional communicative competence. Inadequate knowledge of English and skills such as: inability to transmit the message and communicate with pilots quickly, clearly and unambiguously can result in a tragedy the price of which is a human life.

Since the development of communicative competence as an essential component of air traffic controllers' professional activity is one of the main tasks of modern aviation universities, it encourages modern researchers to look for effective methods, techniques and pedagogical conditions for developing this competence.

The investigations by N. Bibik, N. Hlushanytsia, L. Karpova, N. Lobanova, O. Lokshyna, A. Makarova, L. Mitina, H. Onkovych, O. Ovcharuk, O. Pometun, O. Savchenko, V. Slastionin, I. Ziaziun and others are devoted to the problem of improving the professional competence of specialists in different areas. The main aspects of professional competence of aviation specialists including air traffic controllers are shown in the scientific papers of Ukrainian scientists (Ye. Kmita, L. Nemlii, V. Piven, T. Tarnavska, T. Lavrukhina, G. Paschenko, O. Kovtun, S. Tymchenko,V. Yahupov et al.). The analysis of these publications confirms the necessity of further investigation into new ways to improve the future controllers' professional communicative competence in order to provide the international airways with highly qualified professionals.

Since the second part of the XXth century the professional aviation communication has been considered as an important component of aviation operators' professional competence and activity that is directly related with flight safety [2]. As air traffic controllers assist pilots during all phases of flight – from aircraft take-off to its full stop at the parking lot or in a hangar after a flight, their interaction and communication directly influence flight safety. Today a number of aviation organizations are concerned about the role of the language factor in aviation accidents and incidents.

Accident researchers identify the factors that ultimately cause an accident. The language misuse or misunderstandings contribute both directly and indirectly to an accident. According to ICAO Doc 9835, there are three language factors leading to accidents and incidents: incorrect use of standardized phraseology, lack of plain language proficiency, and the use of more than one language in the same airspace [5, P.1-1].

V. Yahupov explains them from the point of view of air traffic controllers' competence development and adds some more reasons:

a) incorrect use of standardized phraseology (underdeveloped foreign language competence);

b) lack of plain language proficiency (insufficient spoken language competence development);

c) the use of several languages in the same airspace (lack of social and strategic competence);

d) availability of sufficient knowledge and skills for aeronautical radiotelephony communication with pilots but lack the ability to apply them in extreme cases (incomplete formation of professional foreign language communicative competence);

e) availability of sufficient knowledge and skills for aeronautical radiotelephony communication with pilots but the sudden use of a native language both in standard and non-standard situations [2].

Thus, professional communicative competence is one of the most important components of professional competence for air traffic controllers in order to be competitive specialists.

Air traffic controllers' professional (foreign language) communicative competence is a complex of his/her foreign-language communication knowledge and skills, the ability to use them properly for communication in the process of aeronautical radiotelephony communication with a pilot on the international air routes in different conditions of professional interaction [2].

There are different approaches to define the structure of professional communicative competence. Let's consider this competence in details.

M. Canale and M. Swain consider that communicative competence includes three main components: grammatical, sociolinguistic and strategic competence [3]. D. Hymes proposes essentially the same classification but he uses the broader term 'linguistic competence' instead of 'grammatical competence' and adds a discourse competence [4].

ICAO Doc 9835 combines the aforementioned components to describe air traffic controllers' communicative competence:

- linguistic competence (knowledge and application of the linguistic features of a given language);
- sociolinguistic competence (understanding the occupational and social context in which language is used);
- pragmatic competences (a number of skills used to make or give meaning to language in a definite situation or context) that includes strategic competence, discourse competence and functional competence [5, P. 2-2].

N. Hlushanytsia identifies three competences as the components of foreign language communicative competence (linguistic, language and sociocultural competences) [1, P. 103], and R. Valeeva supplements this list with three additional components (discourse, educational-cognitive and strategic competences) [6, P. 176].

V. Yahupov and Ye. Kmita propose their own theory of professional communicative competence of an aviation specialist that includes the following components: value-motivation component, emotional-willed component, cognitive component, operational component, foreign language communicative competence, characteristics important from the professional point of view, control-valuation competence, and a subject component [2].

On the basis of the investigations into competences carried out by Ukrainian [1, 2] and foreign scientists [3, 4, 6], we define the following main components of future air traffic controllers' professional communicative competence:

1. *Linguistic competence.* It refers to the knowledge of vocabulary, grammar, pronunciation and spelling of a given language and its appropriate use. It has the following subskills: lexical skills (single words and expressions), grammatical skills

(syntax and morphology rules), semantic skills (meanings of words and expressions) and phonological skills (sounds, structure of syllables, intonation, rhythm, and sentence stress).

2. *Language competence.* It refers to speech skills (monologues and dialogues), as well as listening, reading and writing skills.

3. *Sociolinguistic competence*. It refers to understanding the social and professional context where English is used. This competence means being able to use appropriately the markers of register differences, different dialects and accents, social relations, and politeness conventions.

4. *Strategic competence.* It refers to the ability to use verbal and non-verbal strategies to compensate for the lack of linguistic knowledge; the ability to balance the lack of linguistic knowledge (and the lack of foreign language knowledge) in the communication process [6, P. 177].

5. *Discourse competence.* It refers to the ability to combine several sentences to construct coherent texts. This component also means the ability to construct discourse, i.e. to apply and interpret forms and meanings of words to construct texts, the ability to organize coherent texts and use cohesion means.

6. *Functional competence.* It refers to the knowledge of and ability to apply the rules for interpreting language structures; the ways in which these functions are usually sequenced to make conversational structures; and assessment of results of the use of language in the real professional activity.

7. *Cognitive competence.* It refers to general and special training skills, methods and techniques of language and culture learning including the use of new information technologies; the awareness of and ability to gain and develop knowledge, identify and analyze factors influencing the working process.

8. *Professional component* of the competence, which includes:

– motivation component (formation and development of positive motivation, interests, values, needs and special attitude to air traffic controllers' future professional activity);

– competence in using one's own subject-related expertise and the available learning resources, i.e. being an expert in future profession;

– operational component (special experience, habits, behavior, technical abilities, analytical skills and logical thinking, the skills of fast and effective decision making in the lack of time conditions and in difficult situations).

The development of future air traffic controllers' professional communicative competence is carried out during their study at aviation universities. The professional communicative competence is the objective of language teaching: the preparation of air traffic controllers for profession-oriented communication. The effective teaching methods at ESP classes for improving the knowledge of standardized phraseology and plain English and developing professional communicative competence are interactive methods. When applying interactive methods, all students in a group interact and communicate. Due to these methods students get knowledge, develop critical thinking, reflection, ability to reason and solve problems quickly. The most effective interactive teaching methods for air traffic controllers include case methods (problem-solving activities), brainstorming, project methods, discussions and round-tables, business games, role-plays, pair work, etc. Case methods promote the development of critical reflection and better understanding of the theory, teach to solve problems and analyze them. Applying this method in teaching makes the educational process similar to the real conditions of the future profession, promotes the development of listening and speaking skills, stimulates to read additional material. Project methods form communication skills, communication culture, the ability to formulate clear and concise thoughts, be tolerate to the opinion of the partners in a dialogue, develop the ability to receive information from different sources, create the language environment, which causes the natural need to communicate in English.

Conclusions

Professional communicative competence of air traffic controllers is a very significant part of the professional competence that is caused by special features of their professional activity both in standard and non-standard conditions. The high level of developed competence leads to efficient interpersonal communication. The identified competences can serve as a basis for improving or changing the existing learning practices. The culture of professional communication of the future air traffic controllers is formed during ESP classes where the use of interactive methods broadens the personal potential of future specialists, giving them more opportunities to study English successfully and promotes the rational use of training time.

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Chicago Convention and safety in aviation

Chicago Convention and its primary articles reflecting the settlement of safety issue in aviation were considered.

Increase in the role of civil aviation in international air-passenger and – freight operations, raise of international airline traffic concentration and rapid development of aviation equipment require particular attention to the issues of international legal enforcement of international aviation safety.

The regulatory embodiment of the notion “safety” was given in the Chicago Convention on International Civil Aviation signed in 1944.

The Convention on International Civil Aviation, also known as the Chicago Convention, was signed at Chicago on 7 December 1944 and superseding the Convention relating to the Regulation of Aerial Navigation (or Paris Convention) signed at Paris on 13 October 1919 and the Pan American Convention on Commercial Aviation (or Havana Convention), signed at Havana on 20 February 1928. It contained the basic principles and arrangements in order that international civil aviation be developed in a safe and orderly manner, and that international air transport services be established on the basis of equality of opportunity and operated soundly and economically. The Chicago Convention also established the International Civil Aviation Organization (ICAO) [1], a specialized agency of the United Nations charged with coordinating and regulating international air travel.

The document (Chicago Convention) was signed in Chicago by 52 signatory states. It received the requisite 26th ratification on March 5, 1947 and went into effect on April 4, 1947, the same date that ICAO came into being. In October of the same year, ICAO became a specialized agency of the United Nations Economic and Social Council (ECOSOC). The Convention has since been revised eight times (in 1959, 1963, 1969, 1975, 1980, 1997, 2000 and 2006). As of 2013, the Chicago Convention has 191 state parties, which includes all member states of the United Nations except Dominica, Liechtenstein, and Tuvalu as well as the Cook Islands. The convention has been extended to cover Liechtenstein by the ratification of Switzerland [2]. A text of Convention drawn up in the English, French, and Spanish languages, each of which shall be of equal authenticity, shall be opened for signature at Washington, D. C. Both texts shall be deposited in the archives of the Government of the United States of America, and certified copies shall be transmitted by that Government to the governments of all the States which may sign or adhere to this Convention [3].

The Chicago Convention provided for the sovereignty of airspace above the territory of each state, together with five freedoms (later expanded to nine by the addition of four unofficial freedoms) which govern the freedom of states to operate air transport flights (including the carriage of passengers, cargo and mail) across, into and within the airspace of other states. Only the first two of these freedoms (right to overfly a foreign country without landing and right to refuel or carry out maintenance in a foreign country) apply automatically to signatory states, the remainder being subject to national agreement [4].

Three groups of legal rules defining the term “safety” can be distinguished.

The term is used in its most restricted sense in the first group. For example, article 5 says that Each contracting State agrees that all aircraft scheduled flight of the other contracting States, being aircraft not engaged in scheduled international air services shall have the right, subject to the observance of the terms of this Convention, to make flights into or in transit non-stop across its territory and to make stops for non-traffic purposes without the necessity of obtaining prior permission, and subject to the right of the State flown over to require landing. So, each contracting State nevertheless reserves the right, for reasons of safety of flight, to require aircraft desiring to proceed over regions which are inaccessible or without adequate air navigation facilities to follow prescribe routes, or to obtain special perm lesion for such flights. Article 8 – no aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of each authorization. Each contracting State undertake8 to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft [5].

Positions, emphasising the possible influence use of civil aviation on safety of other fields of public activities, except for civil aviation itself, are referred to the second group. So, preamble of the Convention on international civil aviation says that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically. Each contracting State may, for reasons of areas military necessity or public safety, restrict or prohibit uniformly the aircraft of other States from flying over certain areas of its territory, provided than no distinction in this respect is made between the aircraft of the State whose territory is involved, engaged in international scheduled airline services, and the aircraft of the other contracting States likewise engaged. Such prohibited areas shall be of I reasonable extent and location so as not to interfere unnecessarily with air navigation. Descriptions of such prohibited areas in the territory of a contracting State, as well as any subsequent alterations therein, shall be communicated as soon as possible to the other contracting States and to the International Civil Aviation Organization (article 9); each contracting State reserves the right, for reasons of public-order and safety, to regulate or prohibit the carriage in or above its territory of articles other than those enumerated in paragraph: provided that no distinction is made in this respect between its national aircraft engaged in international navigation and the aircraft of the other States so engaged; and provided further that no restriction shall be imposed which may interfere with the carriage and use on aircraft of apparatus necessary for the operation or navigation of the aircraft or the safety of the personnel or passengers (article 35); the Organization may, with respect to air matters arrangement s within its competence directly affecting world security, by vote of the Assembly enter into appropriate arrangements with any general organization set up by the nations of the world to preserve peace (article 64) [6].

The third group consists of the positions, where the term “safety” cannot be brought to its most restricted meaning only, and at the same time positions concerning the “safety of civil aviation” itself. Each contracting State undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures, and organization in relation to aircraft, personnel, airways and auxiliary services in all matters in which such uniformity will facilitate and improve air navigation. To this end the International Civil Aviation Organization shall adopt and amend from time to time, as may be necessary, international. standards and recommended practices and procedures dealing with: communications systems and air navigation aids, including ground marking; characteristics of airports and landing areas; rules of the air and air traffic control practices; licensing of operating and mechanical personnel; airworthiness of aircraft; registration and identification of aircraft; collection and exchange of meteorological information; log books; aeronautical maps and charts; customs and immigration procedures; aircraft in distress and investigation of accidents; and each other matters concerned with the safety, regularity, and efficiency of air navigation as may from time to time appear appropriate [7].

The problem of international legal enforcement of civil aviation is divided into two separate yet interrelated issues. Firstly, it is concerned to the adoption of appropriate measures and establishment of rules regarding the technical serviceability of aviation equipment as certain “safety measures”. Secondly, specific legal issues of fighting against acts of unlawful interference in civil aviation activities threatening its safety are the part of it. International legal rules regarding safety enforcement of international civil aviation have been developing in these two directions since the first years of aviation. Their analysis gives possibility to have a notion of the history and establishment of “international civil aviation safety” principle in international air law.

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Cross-cultural communication aspects in aviation

The article presents the analysis of the role and function of cross-cultural communication in all spheres of human life and in aviation in particular. The author explores the content and the quality of information transferred by means of verbal and non-verbal forms of communication used by members of a board crew.

Using and following the rules of cross-cultural communication in aviation is one of the complicated issues facing the linguists, behavioral analysists, psychologists, educators etc. The traditional components of cross-cultural communication in aviation, unlike many other professions, in general, do not necessarily possess the same inclinations and their meanings might have a slight difference. Thus, we can observe the additional role of non-verbal components used to develop muscle memory action in the management of the aircraft while the flight stage and useful time reduction of fellowship crewmembers between themselves during the flight.

That leads us to the main aim of the article that is to investigate which component of cross-cultural communication, verbal or non-verbal, plays more important role in aviation (on the example of crewmembers), and to find out if there are some differences in general rules and meanings of these components under flight conditions.

Today, cross-cultural communication occupies an important place in various areas worldwide. The desire for unity caused by globalization and necessity for cooperation appeals to the search for ways of mutual understanding between different cultures. We consider intercultural communication to be a multifaceted social process of interaction between different cultures in order to transmit and receive information of specific nature and content defined by traditions, etiquette, customs, beliefs, convictions and life of a nation.

Permissions and prohibitions, stereotypical communicative situations, etiquette forms of greeting, farewell etc., traditional systems of images, comparisons, characters and others usually refer to cultural differences. One of the striking cultural differences that satisfies not only material but also spiritual needs of its members, and at the same time fulfills the relevant social and personal functions, reflects worldview, aesthetic preferences and the mentality of the people is a non-verbal aspect of communication, starting with gestures and mimics and ending with a modern clothing or suit.

During verbal communication, all information transmits through language and, accordingly, participants act in a certain way at each other. The non-verbal interaction is more complicated and uses more components. Non-verbal communication mainly accompanies and complements the language in its own way reflecting the sense of the made or received. According to scientists, about 60-80% of the information transmitted in direct communication by non-verbal means that are different sensor systems: seeing, hearing, tactile sensations, etc. Here we are talking about special importance of optical-kinetic system of signs (facial expressions, pantomime), paralinguistic (system of vocalizations, i.e. voice quality, range, tone etc.) and extra linguistic (coughing, crying, laughing, and so on) and the system of signs (signs copies, signs-signs, signs – signals, signs-symbols etc.).

Extra linguistic aspects of communication cover the order-related sphere, within which develops language. They are olfactory studying the impact of odors of the body and cosmetics on communication (despite the significant changes of smell function of a person in the evolution process, smells also significantly affect the perception and transmission of information in communication) and the influence of the time factor on communication (waiting, call duration etc.).

Ukrainian educator I.A. Zyazyun notes that a significant role in the communication process is played by mimics – expression, dynamics (velocity, expressiveness) and their changes; pantomimic – posture, gait and gestures; kinetics and communicative significant movement (image gestures, images, attitudes); informative eye contact (direction, frequency, duration); tactility – touching, patting, shaking hands; non-verbal steps – body movements, rubbing hands, manipulate objects, shuffling fingers [4, P. 58-59].

Therefore, communication is the close interaction of verbal and nonverbal components that complement and reinforce each other. The lack of attention to non-verbal means of business communication, which we consider "crewmember-client" communication to be, can sometimes disorient the interlocutors, in our case crewmembers and passengers, even encourage their refusal from previous intentions, if the facial expressions, gestures, behavior are not properly understood or ignored. In many countries, airlines pay as much attention to these issues as to the skills of personnel.

During a flight, which for some people is psychologically stressful or difficult, non-verbal communication tools, especially in the situation "client-professional", play a greater role. Here we can define two huge areas for investigation: verbal and non-verbal behavior of passengers and of crewmembers. In this article, we would like to concentrate on the means of communication of crewmembers and the information they transmit with the help of these means.

Most passengers, in addition to aid, expect sympathy from professionals because they believe that those who do not understand their problems are unlikely to solve, somehow appease, or make it easier for passengers to accommodate to uncomfortable situation. Team members must demonstrate that they listen to all told by the client, to express interest. This can be achieved by specific behavior of crewmembers and their special training.

Thus, in the process of communication, partners can gather useful information by analyzing posture and its dynamics. Communication partners in ordinary conditions can demonstrate being closed (leaning back, crossing arms on the chest, intertwining fingers), dominance (leaning over the interlocutor, hands on shoulders), dependence (view from below), or opposition (clenched fists, shoulders directed forward). So, in terms of already existing psychological stress, crewmembers should be aware they are projecting the internal openness (head and body toward the interlocutor, shoulders are free) and inner harmony in communication (the same body posture, muscles relaxation etc.).

To achieve the latter, we are witnessing the following gestures of crewmembers that demonstrate only positive psychological state of the crew: open hands, often accompanied by showing arms, open palms, as if saying: "What can I help you with?"

Trust is another feeling preferable to evoke in the passengers by a member of a crew. Projecting trust can be achieved by speaking confidently, without unnecessary gestures and face touching (covering mouth, rubbing nose or head). Proud, straight posture are evidences of trust, confidence and knowledge.

Tilting the head sideways associated with interest and attention. This gesture is especially useful to remember, trying to convey maximum information at minimum time, especially during informing about safety rules. When the passengers lose their attention, their shoulders and heads rise then fall, the eyes begin to wander around, to other people. That is a sign for a member of the crew to change the tactics of instruction giving.

Moreover, mimicry cannot express anger, contempt, suffering, fear, surprise etc. The eyes considered a mirror of a human soul can also show a lot. According to the psychologists, glittering eyes express joy, matte ones project concern. Wide pupils is an evidence of fear, still – concentration, running – anxiety. Brief glances and frequent looks down evoke fear, as they show guilt, discomfort and timidity.

If the personnel can control gestures and posture to some extent, facial expressions are virtually uncontrolled. Facial expressions can reveal a variety of feelings, which is why it is the most difficult area for studying and experimenting.

Distance is one more interesting aspect of investigation during flights in condition of closed and relatively confined space. The distance between interlocutors is defined by human cultural environment, social status of the individuals. Generally, it can be divided into four main types. Intimate zone is 15 to 45 cm. Only the closest people (parents, children, family members, close friends and relatives) are allowed to enter it. Personal zone (from 46 cm to 1.22 m) is a distance we keep at parties, official receptions, friendly meetings or at work. Social zone (from 1.22 to 3.6 m) is if we meet with outsiders, then we want to keep them at a distance from us. Finally, public area (over 3.6 m) applies to groups of people, such a distance for us is the best and most comfortable. If you want people to feel comfortable in your company, keep your distance. In public transport (airplane), all these distance rules seem to fade and people do not respond to others in their invasion of the intimate area.

Conclusions

Cross-cultural communication in aviation being a business communication under uncommon conditions depends greatly on non-verbal component of human interaction. Non-verbal forms of communication are gestures, facial expressions, and posture of the people as a manifestation of their condition, feelings, and attitudes. The ability to read these dumb signals helps to understand the truthfulness or untruthfulness of the information presented in verbal form. Knowledge of forms of non-verbal communication is essential in both individual and group business communication.

In the process of communication, all the gestures must be skillfully used in order to make a positive impression on partners and be able to decipher their gestures to achieve understanding or positive emotions. The ability to use right non-verbal means is one of the main features of a talented crewmember.

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Unmanned aircraft systems of Ukraine: production and usage

In the article analysis the problem of development and use unmanned aerial vehicles in Ukraine. Analyzed typical flight technical and operational characteristics, made conclusions about the prospects of development of the UAV. Formulated tactical and technical characteristics of aircraft. Conducted a brief overview of some of them.

Unmanned aerial vehicles (UAVS), also known as a drone, as an unmanned aircraft system (UAS), or by several other names, is an aircraft without a human pilot aboard and widely used in both military and in peaceful purposes. UAVS are able to conduct air reconnaissance and surveillance, transfer photos and video in real time. They can be carriers and targets, to operate in extreme conditions, including in areas that have undergone radiation, chemical or biological contamination in areas of disasters or intense fire countermeasures.

Multiple terms are used for unmanned aerial vehicles, which generally refer to the same concept. The term drone, more widely used by the public, was coined in reference to the resemblance of dumb-looking navigation and loud-and-regular motor sounds of old military unmanned aircraft to the male bee. The term has encountered strong opposition from aviation professionals and government regulators [8].

The term unmanned aircraft system (UAS) was adopted by the United States Department of Defense (DoD) and the United States Federal Aviation Administration in 2005 according to their Unmanned Aircraft System Roadmap 2005 – 2030.[5] The International Civil Aviation Organization (ICAO) and the British Civil Aviation Authority adopted this term, also used in the European Union's Single-European-Sky (SES) Air-Traffic-Management (ATM) Research (SESAR Joint Undertaking) roadmap for 2020 [3]. This term emphasizes the importance of elements other than the aircraft. It includes elements such as ground control stations, data links and other support equipment. A similar term is an unmanned-aircraft vehicle system (UAVS) remotely piloted aerial vehicle (RPAV), remotely piloted aircraft system (RPAS). Many similar terms are in use.

Unmanned technologies there since World War II. At first they were complex and expensive systems, which have only military purpose. Over the past two decades in this subject field was a real scientific and technological breakthrough. According to a leading international Association of unmanned systems UVS International, presently in development units are actively involved around hundreds of public and private enterprises in different countries [3].Ukraine in this case is also no exception.

In Ukraine, created the necessary production and technological base that has rich experience in development, testing and production of drones. These models not only technical characteristics do not concede their world counterparts, but in many cases even surpass them.

Our country is one of the few countries that have a strong air design potential. The development of aviation industries can overcome the lag in building unmanned aircraft systems, competitive and take their place in the production and operation. One of the areas that allow to implement new ideas and professional expertise in the form of final products is the creation of small unmanned systems.

UAVs typically fall into one of six functional categories (although multi-role airframe platforms are becoming more prevalent): target and decoy – providing ground and aerial gunnery a target that simulates an enemy aircraft or missile; reconnaissance – providing battlefield intelligence; combat – providing attack capability for high-risk missions; logistics – delivering cargo; border control; research and development – improve UAV technologies; civil and commercial UAVs – agriculture, aerial photography, data collection [8].

The main advantage of UAVS, which recognize all experts is the lack of a the Board of the person, regardless of the complexity and danger of the tasks performed by UAVS, life pilots nothing threatening. UAV is able to act in the areas of biological, radioactive and chemical contamination. He does not need a complex system of life support crew. In a crisis situation the apparatus you can donate.

Depending on the management principles distinguish the following types of unmanned aerial systems: unmanned untethered; unmanned automatic; unmanned remotely-manned aircrafts (DPLA). In aviation after 2000 comes rapid expansion it is the last type of apparatus, and they said when taking the term «drone» or the abbreviation UAV [9, 1]. That is, the term «Remotely piloted vehicle», «AL», «UAV» meant exactly aircraft, which through communication channels managed by one or more pilots.

The crew of the UAV can also include Commander, operator of the sensors, the operator of fire weapons. UAV crews during long-term missions are changing, as generally, every 4 hours. Unmanned aerial vehicles, according to NATO standards, as well as aircraft with a pilot on board, divided into 3 classes: I – the full take-off weight of 150 kg, II – the full take-off weight of 600 kg, III – the full take-off mass of more than 600 kg. Class I is divided into categories: «micro» – up to 2 kg, «mini» – up to 15 kg, «small» – from 15 kg [9].

Ukrainian developments of UAVS, as at the beginning of the Russian armed aggression against Ukraine, Ukraine's armed forces have not had own modern unmanned aircraft. The existing armed with TU – 141 «swift» were morally obsolete. In desperate need of unmanned airplanes-scout First Nations meet the volunteers by adapting civilian vehicles to the requirements of military [4]. Were created, including Bat-1, PD-1 UAV «Fury». The latter was designed by Kiev NNP «Athlone AVIA» in 2014, his name came up with the most fighters who use this machine almost from the start of fighting in Donbass. The first battalion, who used «Fury» was «Donbass». In July 22, 2015 new unmanned aerial vehicles «Fury» officially taken by national Guard, as the Minister of the Interior Affairs of Ukraine Arsen Avakov reported [4]. These UAVS are also in service with the armed forces of Ukraine.

The Ukrainian state-owned defense company Ukroboronprom has built the country’s first military unmanned aerial vehicle (UAV) to bolster Ukraine’s combat against Russia-backed insurgents in the country’s east [7].

The first batch of three drones was supplied to the Ukrainian Armed Forces, Ukrobonoprom said in a statement. The BpAK-MP-1 UAV was built by the firm's subsidiary Meridian in cooperation with a research team from the Kiev Technical

University. «The path from the design phase to production was just one year,» the statement said.

Yuriy Paschenko, the deputy director general of Ukroboronprom, said that the tactical version of the new drone, which will be fitted with combat capabilities, will made in late 2016 and supplied to the Ukrainian Armed Forces in the first quarter of 2017 [9].

In 2015 the students of Kyiv Polytechnic Institute were created by unmanned aircraft complexes of the Spectator. Production of JSC established Meridian named S.P. Korolev, incorporated DC «Ukroboronprom» [3] . Also, to date the only UAV container start class micro, which passes the stage of flight and ground test is a UAV «Sokol-2», which is a joint development of the NTUU «KPI» and SE «DKKB», «Luch». An experimental sample of the UAV was presented to the largest in the Middle East and North Africa, the international exhibition of armaments and defence technologies «IDEX-2001» [3] and received the highest award in one of the seven nominations.

On the basis of the National Aviation University was created Center of unmanned aircraft «Virazh» [5], which is actively engaged in the development, tests and launch aircraft of different classifications. Among these BPS m-10-1 and m-10-2 «Eye», two-engine aircraft m-B5 «Sky Patrol», a multipurpose unmanned aerial complex m-6-3 «Skylark» etc.

Among domestic developer BpAK is worth noting [2, p. 38]: Institute of problems of physical modeling National Aerospace University «Kharkiv Aviation Institute», who created a series of BpAK with relatively high characteristics («Stork», «Snipe», «Peregrine Falcon», «Golden Eagle»); CB «Rise», LLC «Uavia» Chuhuyiv aircraft repair plant, RPI «Ukrtehno-Atom».

In January 2016 Secretary Oleksandr Turchynov stated about production shock unmanned vehicles at SE «Antonov» [6]. The main function of the new tactical Multipurpose unmanned air complex is intelligence. However, it will be able to carry a small combat load and hit the ground targets. In particular, it arms should be able to destroy heavy armor, for example, tank [6].

Conclusions

As a result of the research shows that the existing in Ukraine UAVS of different types largely reflect the concept of their operational use in the right situation, but there are still a number of issues that require fundamental research:

- theoretical-experimental search for optimal aerodynamics outline that best meets the geometric, massive and operational restrictions;
- improvement of efficiency coefficient of electric power installation the application of more efficient sources of electric energy;
– theoretical-experimental work on complete devices;
– implementation of the regulatory framework created, certification, registration and use of BpAK;
- creation of a system of technical support, repair and modernization of BpAK;
- deployment of a system of training of operators-pilots and engineering-technical composition;

Delineated areas solve problems require complex approach taking into account and using advanced achievements in the field of air crafting, newest technology, navigation and radio electronics.

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The dream of wings (life and scientific achievements of Stepan Hryzodubov)

The article deals with the life and scientific achievements of Stepan Hryzodubov who is credited with building and flying one of the first airplanes. Shown is his contribution to the development of aviation and mechanics.

The biography of Stepan Vasyliovych Hryzodubov (1884-1965) is full of creative activity. He was born on 13 July 1884 in the village of Parkhomivki, Bohodukhiv county, Kharkiv province. Among his ancestors were clergymen and nobles. His grandfather was a nobleman and distinguished policeman and was awarded very prestigious orders of the Russian Empire (among them are those of St. Vladimir, St. Anna, and St. Stanislav) four times [1]. His father was Marshal of the Nobility of Sumy County.

The future inventor moved to Kharkiv in his adolescent years. In 1904 he graduated from the Kharkiv Railroad Technical School of the South Railway. Today it is known as the Order of the Badge of Honor Kharkiv Electromechanical College of Transport Facilities Construction. This school was founded in July 1872 and until 1917 it produced around 1000 specialists. S. Hryzodubov is the most famous of them. As a specialist in electro-mechanics he worked in a steam locomotive repair shop. In the turbulent 1905 he participated in a strike and, as a result, lost his job. But he did not give way to despair and organized a private workshop. [6].

The crucial point in the life of the future aircraft designer was the end of 1908 when he saw in a cinema a documentary about the first flight of Orville and Wilbur Wright. On 17 December 1903 these American inventors made the first flight in history on their Flyer I airplane. S. Hryzodubov was so fascinated with what he had seen that he persuaded the projectionist to sell him several picture frames which he later used for the construction of his own airplane. It took him several years to achieve his dream. In 1910 he created the airplane G1. The plane’s technical innovations met the requirements of that time. In many aspects Hryzodubov’s airplane was similar to that of the Wright brothers. The difference was that his airplane had a stabilizer and chassis with wooden wheels. To get the chassis, Hryzodubov had to arrange a paid exhibition of his airplane. Hryzodubov equipped his airplane with a four-cylinder liquid-cooled gasoline engine of his own design. In fact S. Hryzodubov became the creator of the first aviation gasoline engine in Tsarist Russia [3].

The G1 airplane test was scheduled for the spring of 1911. In the territory of the Kharkiv hippodrome Hryzodubov tried to take off, but all his efforts ended in failure, he only drove across the field. However, the failure did not stop the inventor; he designed new models of airplanes: G2, G3 and G4. The G3 was the first among them to take off. The G4 cost 5500 rubles and it was a serious sum for S. Hryzodubov. Thus he had to borrow the money or purchase on credit. [6]

With the advent of the First Word War S. Hryzodubov joined the army. In February 1916 he was enrolled into the war pilot school at the Imperial All-Russian Flying Club where he received a pilot diploma.

After the 1917 October coup S. Hryzodubov continued to work in the sphere of aviation. In 1919-1924 he was in charge of the aircraft repair shop of the Kharkiv airplane park. During the Civil War he repaired military planes for the Red Army. From 1924 the aircraft designer worked in the Occupational Hygiene and Diseases Research Institute where he led the work on designing, developing, manufacturing, testing, and installation of control equipment for various industries. S. Hryzodubov worked there until the Nazi occupation of Kharkiv.

But the dream of the sky did not leave him. From 1925 S. Hryzodubov headed the gliding section at the Society of Aviation and Aeronautics of Ukraine and Crimea (SAAUC). He is one of the organizers of gliding in Ukraine; he took part in creation of some gliders. In 1939 he designed and constructed with the help of the flying club activists a glider and tested it. From 1928 to 1938 Hryzodubov developed and built three types of snow-planes (self-propelled sleighs which are moved by the driving force of the screw) [3].

Hryzodubov was an amazing polymath. There is a saying that a gifted person has many talents. Hryzodubov had talents for many things: aviation, mechanical engineering, writing, molding, welding ... 18 in total [1].

Stepan Hryzodubov had a daughter, Valentina Stepanovna Hrizodubova (1909-1993), who also brought glory to the Hryzodubov family. She was the only woman in the Soviet Union who had both highest Soviet decorations – Golden Star Medal of the Hero of the Soviet Union and Golden Star Medal of the Hero of Socialist Labor. When she was 15 her father took her to Crimea to watch a glider competition where she performed a solo flight on a glider [1]. She, like her father, had many talents. She played piano, graduated from a conservatory and later from the Kharkov Technical Institute. She could also speak several foreign languages. In 1928 she was enrolled in the Kharkiv flying school and after graduating from it became a professional pilot. In 1938 she, together with M. Raskova and P. Osipenko, performed on a long-range bomber DB-2-B "Motherland" a strait flight from Moscow to the Far East and became famous all over the Soviet Union. For that flight she received her first Golden Star. In general, she set 5 world records in velocity and height. Valentina also worked as a flight instructor and trained over 80 pilots, many of whom were later decorated with prestigious Soviet medals and orders. [2] During the Second World War she was an air regiment commander. The subordinates respected and loved her and called her "Mother" among themselves. During the war she personally flew about 200 sorties, mainly nocturnal, behind enemy lines. From 1937 till 1946 she was a deputy of the Supreme Soviet of the USSR and thanks to that position and her glory she managed to save thousands of Soviet people from repressions [2].

In the center of Kharkiv, there is a memorial museum-apartment of the Hryzodubov family. According to Vitalii Vlasko, director of the museum, S. Hryzodubov was also a gifted photographer. The museum holds a collection of over 300 hundred pictures made by the famous aircraft designer. The pictures reveal the history of aviation in Ukraine. Many of them are rarity [4].

Stepan Hryzodubov stopped his engineering activity after the Second World War and switched to popularization of the achievements of the Soviet aviation among school and university students. He died on 11 December 1965, at age 81 in Kharkiv. In 1968 one of Kharkiv's streets was named after him.

All who knew S. Hryzodubov remember him as a modest and patriotic man. Igor Sikorsky, an outstanding helicopter designer, invited Hryzodubov to the United States, promising him big money. According to his daughter, Valentina Hryzodubova, her father answered: "My Motherland is here! I will work for my people!" [5].

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Website "Aviation Safety Network" as a communication channel and a source of information about flight safety

In the article it was found out, that the website "Aviation Safety Network " is a communication channel and a source of communication. The website is a complex structure, which contains materials about the aviation accidents, incidents, and hijackings.

The concept of security is closely linked to the concepts of aviation accidents and incidents, hijackings. In order to improve safety, it is necessary to know the types and causes of accidents.

An aviation accident is defined by the Convention on International Civil Aviation [1] Annex 13 as an occurrence associated with the operation of an aircraft, which takes place between the time a person boards the aircraft with the intention of flight until all such persons have disembarked, where a person is fatally or seriously injured, the aircraft sustains damage or structural failure or the aircraft is missing or is completely inaccessible. If the aircraft is destroyed or severely damaged so that it must be written off, it is further defined as a hull loss accident. Annex 13 further defines an aviation incident as an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

Aircraft hijacking (also known as air piracy or aircraft piracy, especially within the special aircraft jurisdiction of the United States, and informally as skyjacking) is the unlawful seizure of an aircraft by an individual or a group. In most cases, the pilot is forced to fly according to the orders of the hijackers. Occasionally, however, the hijackers have flown the aircraft themselves, such as the September 11 attacks. In at least three cases, the plane was hijacked by the official pilot or co-pilot.

Unlike the typical hijackings of land vehicles or ships, skyjacking is not usually committed for robbery or theft. Most aircraft hijackers intend to use the passengers as hostages, either for monetary ransom or for some political or administrative concession by authorities. Various motives have driven such occurrences, including demanding the release of certain inmates (notably IC-814), highlighting the grievances of a particular community (notably AF 8969), or political asylum (notably ET 961). Hijackers also have used aircraft as a weapon to target particular locations (notably during the September 11, 2001 attacks).

Hijackings for hostages commonly produce an armed stand off during a period of negotiation between hijackers and authorities, followed by some form of settlement. Settlements do not always meet the hijackers' original demands. If the hijackers' demands are deemed too great and the perpetrators show no inclination to surrender, authorities sometimes employ armed special forces to attempt a rescue of the hostages (notably Operation Entebbe).

Information on accidents, incidents and hijackings is located on the aviation websites. There are 25 of the most popular websites: "Airliners. net", "AirNav.com", "Aviation Safety Network", "DUATS", "Key Publishing", "OpenAirplane", "PPRuNe", "SKYbrary" and others.

"AirNav.com" [2] is a supplemental resource for pilots and aviation enthusiasts. The site publishes aeronautical and airport information released by the Federal Aviation Administration (FAA) such as runway distances, airfield traffic patterns, airport frequencies (common traffic advisory frequency (CTAF), tower, ground, Automatic Terminal Information Service (ATIS)/Automated Weather Observing System (AWOS)/Automated Surface Observing System (ASOS), instrument landing system (ILS), approach and departure, center or ARTCC, clearance delivery, emergency, and Flight Service Station (FSS)/fixed-base operator (FBO) frequencies), airport operations, facilities and services, chart location, navigational coordinates and locations, radio aids, ownership information and other pertinent information that all pilots need when traveling into or out of an airport or around the United States National Airspace System (NAS). The same information is published in the Airport/Facility Directory (A/FD), updated every 56 days.

"Airliners. net" [3] – website about Aviation, founded by Johan Lundgren in 1997. It includes a large photo gallery, forums, articles about aircraft and aviation history. It is considered the largest aviation website (daily attendance – 3 million views from 200 000 people).

The website's photo gallery has reached more than two million images in 2016. Photos are a variety of background information about aircraft, airlines, location shooting and so on. This information can be used when searching for photos. Editors review all photos, and then publish. This control helps to maintain a high level of quality of the materials. Usually spotters provide photos to the site.

Forums of this website is divided into sections on civil and military aircraft, as well as technical topics. Now more than 160 000 people were registered on the site, and the number of messages in the forum on civil aviation has exceeded 5 million.

These websites are very popular, but most of the information about the incidents is posted on the "Aviation Safety Network".

"Aviation Safety Network" (ASN) is a website that keeps track of aviation accidents, incidents, and hijackings [4].

Harro Ranter is the founder of the site. He began to collect information on accidents in 1983. In the summer of 1985, he published a book that details covered more than 1,000 aviation accidents. Then, in January 1996 Harro created «Aviation Safety Web Pages» about airliner accidents. Fabian Lujan started working with Ranter in 1999. It is proposed to rename the site «Aviation Safety Network» and move it to the new domain name.

Now "Aviation Safety Network" is an exclusive service of Flight Safety Foundation. Their database contains details of over 11,000 reports. The ASN includes an aviation database with aviation investigations, news, photos and statistics. Much of the information in the database ASN was obtained from official sources. The government of the country in which the incident occurred, provides information about the event. Information about the events that occurred before 1996, comes from ICAO and the US National Transportation Safety Board. ASN is supported entirely by private donations. Many security bureaus recognized ASN as a reliable source of information for many years. Aviation Safety Network provides services free mailing list (Aircraft Accident Digest e-mail service). Its subscribers within a few days receive detailed information about the recent air accidents. Currently, more than 10 000 people in 170 countries use this service.

ASN's mission is to provide accurate and current information about the accident and about security matters. In addition to an extensive database of incidents and statistics there is a large section of photographs of the accident.

The structure consists of such sections: “Home”, “Aviation safety”, “Database”, “Investigation”, “News”, “Photos”, “Statistics”, “E-mail”, “About”. The section “Aviation safety” contains information regarding airline safety, safety assessment actions, and passenger safety. It includes “Industry safety reports (ICAO, IATA, Airbus, Boeing)”, “Passenger Safety Information”, “Safest location in case of an accident”, “Emergency exits locations”, “Safety enforcement (fines etc.)”, “International Safety Assessment Initiatives”.

The ASN Safety Database, updated every week, contains descriptions of over 15,800 airliner, military transport category aircraft and corporate jet aircraft safety occurrences since 1921. Airliners are considered here as aircraft that are capable of carrying at least 12 passengers. Accident investigation boards are placed in the section “Investigation”. Daily news about aviation flights are printed in the section “News”. The section “Photos” contains photos of aircraft taken before the crash; photos taken after the actual accident and miscellaneous photos (ARFF, emergency exits, safety placards). Generalized statistics are also published.

The Aviation Safety Network staff answer questions about passenger list of an aircraft that has crashed, safety information of a specific airline or aircraft type, information regarding a specific accident.

Conclusions

The study results confirm the need for analysis of aircraft accidents. The information of website “Aviation Safety Network” is a source for research and scientific debate. The sole objective of the investigation of an accident or incident is the prevention of accidents and incidents. Investigations are conducted in accordance with the international standards and recommended practices as described in ICAO Annex 13 – Aircraft accident and incident investigation.

While the initial field phase of an accident investigation can be concluded within weeks or even days, the investigators' final report and recommendations often take years to complete. The final report consists of factual information about the accident, an analysis, conclusions (probable cause) and also includes safety recommendations.

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The human factor in the engineering activity of I.I. Sikorsky in the early 20th century

The article deals with the human factor characteristic aspects in the activity of aircraft designer I.I. Sikorsky: purposefulness, education, knowledge, experience, commitment to aviation, pragmatism, creativity, persistence, responsibility for the safety of aircraft and flight.

The human factor from the beginning of the creation of aviation in the early twentieth century has always been important, though its terminology and concept appeared somewhat later. Typically, experts associate it with the behavior of aviation workers during the preparation period and in the conditions of flight. There are various views on the contraposition of personal, subjective and human factors, or the identification of the terms “human factor,” “ergonomics,” and “human capital.” [1, pp. 9-10].

The International Civil Aviation Organization (ICAO) describes the human factor in its documents as “the whole complex of aspects of human activity in the aviation system.” In particular, the *Basic Principles of the Human Factor* gives the following definition: “The human factor is the people in their working environment and their relationship with the equipment, working procedures and physical environment.” In fact it is an interaction between people. [2. p. 8].

The problem of human factor in recent decades has become more urgent, as evidenced by the ICAO decision on the introduction of the course on the human factor into their requirements for the preparation and issuance of certificates to aviation personnel (1989).

The human factor was the fundamental principle for the emergence of national aviation since it was created through public initiative and with the help of aeronautics enthusiasts’ money.

Realization of specific aspects of the human factor was decisive in the formation of resident of Kyiv I.I. Sikorsky as a prominent aircraft designer of the twentieth century and one of the founders of national aviation.

Among the main aspects of these is a commitment to achieving the goal, which originated in his childhood. Ihor’s dream to fly, to which he dedicated all his life, originated in a Kyiv apartment from his mother’s stories of Leonardo da Vinci’s manuscripts on the air machine that was lifted into the air by means of screws. His favorite book was Jules Verne’s novel “Robur the Conqueror,” which tells about the journey of a giant airship. The eleven year old boy had once a dream of flying on such a ship and he remembered that dream all his life [3]. When he was 12 years old, Ihor created his first model of helicopter powered by a rubber tourniquet.

After graduating from the first Kyiv Gymnasium in 1903, I. Sikorsky entered St Petesburg Marine Cadet Corp. But here he realized that a military profession was not his calling and in 1906 he left the Marine Cadet Corp to deal with aviation [4].

An essential part in the human factor was studying the experience of aviation pioneers. Thus in 1906 in the time of the First Russian Revolution when higher education institutions practically did not work, I. Sikorsky on the advice of his father and with recommendation letters from M.B. Delone, a well-known professor and the head of the aeronautical section of the mechanical circle at the Kyiv Polytechnic Institute, went to the Duvignaud de Lano Paris Technical School where he listened to lectures, mastered the experience of European aviators, and became interested in the idea of "vertical screwing of the machine into the sky" i.e. helicopter [5].

In 1907 I.I. Sikorsky became a student at the Kyiv Polytechnic Institute where he took part in the work of the aeronautic section of the helicopter department and was also engaged in designing an aircraft in his home studio. On his vocation he went to Germany to get acquainted with the experience of European inventors in aeronautics and aviation [5].

After returning to Kyiv I. Sikorsky revealed his creativity in the choice of a model aircraft. Airplanes did not impress him anymore and he decided to create a helicopter. Besides, he learnt that in France in the fall of 1907 Paul Cornu and Brothers Louis and Jacques Breguet had made attempts to raise their model helicopters into the air [3]. To get a powerful engine for his helicopter he asked his family to give him money to travel to Paris to buy the necessary engine and gain some knowledge. In January I. Sikorsky went to Paris where he watched flights at the aerodromes of Issy-les-Moulineaux and Juvisy. [6, p. 65] There he got acquainted with Ferdinand Ferber and was enrolled in his school [5].

I. Sikorsky returned to Kyiv and by July 1909 he had completed the construction of his first helicopter S-1, which, however, failed to get into the air [7 p. 125].

In search of new engines and new experiences I. Sikorsky again went to France in the autumn of 1909. All aircraft designers he knew recommended him to give up the idea of creating a helicopter; instead they recommended him to switch his attention to designing airplanes. Chairman of the Aviation Union of Students of the Lviv Polytechnic Institute, Professor S.K. Dzhevetsky (who permanently lived in France), even called this trend in aviation "false" [5]. But I. Sikorsky did not give up the idea of creating a helicopter. At the same time he became engaged in designing a snow plane and successfully finished this work in the winter of 1910 with the help of the students of the mechanical circle of the Kyiv Polytechnic Institute.

Simultaneously the aircraft designer was working at creating a somewhat improved S-2 helicopter which was able, however, to lift into the air only its own weight (182 kg). After that Sikorsky decided to stop building helicopters and started designing airplanes. The aircraft designer explained that decision by a "lack of money, time, and energy necessary for solving the helicopter issue" [6, p. 125].

In 1910, together with the Kyiv Polytechnic Institute students F.I. Bylinkin and V.V. Iordan, I.I. Sikorsky created his first airplane – biplane BIS-1, which was only able to bounce over the surface. Sikorsky managed to go up in the air only on the 3d of June, 1910 on another plane – BIS-2 (C-2). That was the 3d plane in the Russian Empire capable of flying (the first one was designed by O. Kudashev, and the second – by Y. Gakkel).

The following models (C-3 and C-4) designed by Sikorsky were more sophisticated. But it was only his fifth plane C-5 (created in April 1911) that made him famous. On this plane, I. Sikorsky passed the exam for the title of pilot and set four All-Russian records (height – 500m, distance – 85km, time – 52 minutes, velocity – 125km/h). He also performed demonstration flights and even took some passengers.

I.I. Sikorsky liked to be not only an aircraft designer and test pilot, but also a pilot instructor. Newspapers and magazines started to write about this Kyivan student's workshops and pilot school; he was called a "Russian Farman."

In 1911 Sikorsky designed his sixth plane (C-6). Trying to improve the aerodynamic characteristics of this model, the designer built a small aerodynamic laboratory. The upgraded plane C-6A won the Grand Gold Medal at the Moscow aeronautic exhibition in April 1912, and shortly before this, the Russian Technical Society awarded Sikorsky the Medal of Honor "for useful work on aeronautics and the independent development of the airplane, which gave excellent results" [4].

The student who had not yet finished his studies received in April 1912 two offers from St Petesburg: the position of chief engineer of the Naval Aviation and the position of chief designer of the Aviation Department of the Russo-Balt Company (the Russo-Baltic Wagon Factory). He accepted both offers and moved to the capital.

Realizing that without a team of specialists it will be difficult to design aircraft, I. Sikorsky invited Kyiv designers G.P. Adler, K.K. Ergant, O.S. Kudashev, A.O. Serebrennikov, mechanic V.S. Panasiuk and others to his department in the capital. Therefore, their activity in the Russo-Balt Company was actually a continuation of the work of Kyiv aircraft designers.

Due to such circumstances, I. Sikorsky managed to make a major contribution to the creation of the Russian aircraft of the Navy and he can rightly be considered as one of its founders. After serving just a year, he retired from naval service and totally focused on the job at the Russo-Balt Company. Here, one by one, new Sikorsky aircraft – biplanes and monoplanes appeared; they brought glory to Russia as one of the leading aviation countries.

The most important aspect of the human factor in I.I. Sikorsky's engineering activity was responsibility for flight safety. In the autumn of 1911 during a demonstration flight for the military staff near Kyiv, I. Sikorsky barely escaped death. That event made I. Sikorsky devote much attention to the issue of flight safety. As a result, he came to conclusion that airplanes needed more than one engine. For the first time his idea of multiengine aircraft was outlined in the report "An Airplane Flight Conditions" at the general meeting of Kyiv Aeronautics Society on February 18, 1912.

With the support of the Russo-Balt Chairman M.V. Shidlovsky, the 23-year-old designer started the construction of a multiengine aircraft in late 1912. In March 1913 the world's first four-engine giant airplane called "The Great Baltic" or "Grand" was built. During its trials, this giant aircraft (weight 3,500 kg, the scope of the upper wing 27 meters and the bottom – 20 m) got the name "Russian Knight." On August 2, 1913 this plane with I. Sikorsky and seven passengers on board set a new record of flight duration – 1 hour and 54 minutes. Emperor Nikolas II expressed a desire to see the plane. Thus, the plane was moved to Red Village (one of the royal residences), where the tsar went on board, and soon Sikorsky received a memorable gift from the tsar – a gold watch. The plane surpassing in size and take-off weight all other planes that had been built before, initiated a new direction in aviation – heavy aircraft.

At the same time I.I. Sikorsky passed on his experience to others, speaking in particular to students of the aeronautics courses at Peter the Great St Petersburg Polytechnic Institute.

The creation of multiengine giant airplanes brought worldwide fame to I. Sikorsky. He became a national hero in Russia. However, the "Russian Knight" flew not long. In the third contest of the Russian military aircraft held on September 11, 1913, an airplane, which was flying over the "Russian Knight," lost its engine which fell on the giant biplane's wing and severely damaged it. I. Sikorsky decided not to repair the damaged plane and started the construction of a new giant plane known as "Illia Muromets." This four-engine aircraft differed from its predecessors in appearance and internal structure; it had a payload of 1.5 tons. The plane took off in December 1913. Through design improvements and new engines "Argus" of 140 and 125 hp, in 1914 it set a series of world records in capacity, height and range. On February 12, 1914 I. Sikorsky on his plane "Illia Muromets" set a world record by lifting on board 16 people and a dog. This giant aircraft was quite reliable and could continue flying even when two of its four engines were disabled. Moreover, it was possible to repair the engines during flight.

In June 1914, after successful flights of "Illia Muroments," the Council of Kyiv Aeronautics Society asked Peter the Great St. Petersburg Polytechnic Institute to give a title of mechanical engineer to I. Sikorsky without the defense of his diploma project. The request of the Kyiv Aeronautics Society was granted.

On the world's largest airplane "Illia Muromets" I. Sikorsky performed an extraordinary for the time flight from St Petersburg to Kyiv and on June 17, 1914, he landed at the Kurenivka aerodrome in Kyiv. On board the plane, besides I. Sikorsky, were the 2nd pilot Kh. F. Prussis, flight navigator G.I. Lavrov, and mechanic V.S. Panasiuk. All of them felt well during the flight. After the return flight "Kyiv – St Petersburg" the plane was called "Illia Muroments from Kyiv."

The Russo-Balt was the first company in the world to start mass production of gigantic aircraft. By 1917 the Russo-Balt had produced over 90 aircraft of that type in six variations. They differed in engines, equipment, weapons, but their aerodynamic layout did not change.

Aircraft designed by I. Sikorsky were used on the fronts of World War One. He personally took part in the organization of the "Squadron of Airships," instructed crews and worked out some combat tactics. The designer spent much time at the front, watching his aircraft in operation and making necessary changes to their design.

From 1909 to 1917, within the borders of the Russian Empire, I. Sikorsky created over two dozen basic types of aircraft (not counting their modifications and joint designs), two helicopters, three snow-planes, and one aircraft engine. The government appreciated the man who increased the power and fame of the country. I.I. Sikorsky was awarded the order of St Vladimir of the 4th degree.

The Revolution abruptly changed the fate of the famous designer. He decided to immigrate. In the United States he created his own company and brought glory to that country. I.I. Sikorsky died on October 26, 1972 and was buried in Easton, Connecticut. The inscription on his tombstone says: "Rare is the man of vision whose dreams become reality. Rather still is one whose vision brings a better life to others while fulfilling his own. Such a man was Igor I. Sikorsky, aeronautical pioneer, 'father of the helicopter,' inventor and philosopher" [3].

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On importance of human factor training to aviation maintenance technicians for ensuring airworthiness

Proper maintenances operation is dealt to all components of security in aviation transportation as civil as cargo providing steady functioning of a profitable economy branch along with quality of airworthy services. Human factors studies for quality of training of aviation specialists are in demand for all contracting states of ICAO.

Modern aviation industry includes not only aircraft as transportation means but numerous branches and services in it. The industrial countries have tackled with steady development and modernization of aviation. The mankind has relied on security of air transportation. The quality of air service depends on a proper function of all the multileveled departments such as manufacturing plants, design bureaus, aviation proficient institutions and colleges, mastering in proficiency of aviation trainers in aviation education establishments. But except these above mentioned components, of course, aviation institutions rely on personal traits, abilities and capabilities of their students or trainees, their potential to proficient upgrading during livelong work.

Serviceability of aviation industry is provided by numerous personnel from technicians services on the ground to pilots in a crew of aircraft during flight in the air. All categories of personnel in aviation have been taught in aviation institutions, colleges with wide range of subjects not only their majors. For example, the objective of the studies for Aircraft Maintenance proficiency is fulfilled by all EU Commission Regulation 2042/2003 aircraft maintenance personnel training requirements. The studies include two compulsory sections and proficient subject sections in Curriculum. The first one is Introduction to aviation which consists of serious technical subjects from Mathematics to Basic Aerodynamics. The second compulsory one is Aircraft Maintenance technology that consists of material and hardware, Maintenance Practices, Human Factor, Aviation legislation. Then they have to study the proficient subjects [1].

The goal of learning of Human Factor as heath, safety, ability to function can be assessed through observation matter that can affect flight safety and human factor in activity and in practical training. Students must be assessed through skills in following instructions, working in team, ensuring safety of materials and tools, removing and repairing faulty tools, taking consideration of health for planning work, maintaining safety in working process and environmental ergonomics.

They have to pass special tests to satisfy qualification for special jobs. Their theoretical and practical courses teach them to handle with their duties according approved ICAO standards and requirements for work instructions which they follow during maintaining operation to serviceability of aircraft. Among a long list with job positions in aviation it is stated all positions are quite important to provide service for customers but such positions as aviation maintenance technicians are worth of considering more close [2].

Due to improper replacement of any spare part in some aircraft unit the malfunction of the latter can bring a catastrophe in the air. To prevent lost of human lives and aircraft the aviation authorities have implemented the replacement procedures, associated regulations for handling proper maintenance practice.

The most significant place in this chain possesses the role of human factor in aviation. The problem is being studied since the beginning of the 20th century till nowadays. Even in 1956 the Human factors society was founded in the USA which tasks were dealt with understanding and realizing human characteristics that can be applicable in three components system model of interdependence as people, machine and environments. The information was gathered about human abilities and limitations, searching as a goal how to apply it for producing safe and productive human use of devices, machines, task strategies with crew and maintenance resources in their working environment.

The objective of nowadays human factor study is to diminish human errors and prevention them through managing system improving safety and performance with provision training process for updating knowledge and needed skills. In the latest decades of twentieth century the ICAO implemented a so-called SCHELL model to present human factor pattern. Each component of this model follows a special goal to benefit company success. So, software as a component stands for operational procedures. Such component as culture optimizes interactions in organisations. Hardware is responsible for equipment and technology for work, environment stands for working conditions, live work force deals with human aspects in system working operations and the last component, live ware stands for interpersonal relationships in working environment [3].

The research of human factors influences on accidents, workers injuries, wasted time in aviation industry is being considered steady by aviation authorities of leading aviation companies and airlines. All the cases were investigated by aviation inspectors and government commissions according to the standardised practices of ICAO. The studies and investigations of aviation accidents found that near 80 percent of accidents and incidents happened due to different components of human factors. According to human factors studies the reliable functioning of all aviation branches depends on such human factors components as mental, emotional, physical states, human capabilities and limitations, environmental conditions. All these are dealt with human errors. It was documented that human errors are the most significant contributors of aviation accidents [4].

To recognize and realize human factors for fruitful usage in aviation industry the researchers studied a lot of subjects that have been incorporated in human factors technology. This technology has combined interdisciplinary ties from different sciences and especially with different branches of Psychology. Clinical, Experimental, Organisational, and Educational Psychologies are in favour for such studies. The received knowledge can deepen the understanding human capabilities for operation as aviation engineers or maintenance technicians, focusing on physical, psychological, physiological and psychosocial components of human factors.

To prevent consequences as from unintentional or intentional errors as from active and latent ones that can be done in aviation, Transport Canada authorities developed a list with twelve human factors in 1990s. Research of each of them gave fundamental basis for training aviation personnel. Each of these twelve human factors can affect safe functioning of aviation industry. Numerous of them depend on many characteristics, conditions of work, health state of crew engineers or maintenance technicians. The task of air companies personnel to learn these factors participating in special training. They have to recognize these factors, to prevent and avoid accidents and incidents in aviation industry.

Human factors specialists can suggest even aviation professionals with graduated degree on Good2 or even Excellent 3 and having basic knowledge on technical subjects and such subject as Human Factor for aviation colleges must have competency-based trainings for updating knowledge and skills to handle proficiently with new equipment and spare parts, requirement for maintenance of new models of aircraft, new regulations and documentations.

Along with proficient courses the ICAO regulations for operators (CAO 82.3 or 82.5) requires to provide regular special trainings on human factors to skilled level for aviation safety-critical personnel (pilots, cabin crew, maintenance technicians, dispatchers) to prevent human errors and manage consequences of human errors. The aviation authorities provide crews with crew resource management programs and maintenance technicians with maintenance errors management programs. The objective of human factor training is to teach aviation personnel with non-technical skills such as a decision making and social skills. Using Information technology the training programs are accompanied with DVD for ensuring recall information at working place in office after training [5].

The useful thing for better apprenticeship that learning process is supported with simulators, trainees have access to virtual maintenance trainer, virtual test equipment and practical assessment tools. The advantage of nowadays proficiency training and human factor training programs includes WEB based training and virtual instructor courses to reduce training costs. Such WEB trainings have aimed to refresh trainings, recurrent trainings and continuation trainings.

Conclusion

Study of analysing productive experience of aviation human factor training for various air services has suggested the fruitful results from such training. Due to close attention of aviation authorities to specific human factors errors, aviation personnel have opportunity to participate in practical training to improve proficient skills and human factor capabilities to ensure success operation of aviation teams. Taking various kinds of airworthiness measures the aviation industry has maintained reliability and benefits of air transportation.

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Crew resource management in aviation

The article investigates the question of formation, development, influence and practical value of one of the components of the holistic process of securing the aviation system in the process of aircraft operation – Crew Resource Management. It analyses CRM training, taking into account the concept of human factor in aviation.

The airline industry, perhaps more than any other, has throughout its history been subject to cyclic variations of the world markets. Some of these have been quite spectacular and damaging for the industry. However, these crises do not mask the underlying growth trend.

Flying operations is not a one man show, rather a managerial process shared by the regulators, operators, flight training organisation, airplane manufacturers, and pilots. Adequate crew coordination and teamwork is thus crucial for providing a safe operational environment.

Today’s tasks range from pure handling of the aircraft, to managing the whole event of a commercial flight which requires a completely different set of skills. While much of the work is procedural in nature, pilots have to be trained to be able to depart from linear thinking and quickly shift to “thinking outside the box” in order to deal with unexpected and undefined events. This is a key ability to prevent an accident from happening.

Therefore, being a professional pilot requires very specific skill sets and competencies meaning that professionalism can only be created by combining a thorough education with a constant development throughout the entire career of a professional pilot.

Most pilots are aware that human behaviour and performance are cited as causal factors in the majority of aircraft accidents. While the aviation industry has benefited from technology, with hardware and software becoming more reliable, human operators still continue to make errors. We cannot eliminate human error, but we can catch and minimise errors before their consequences become unacceptable. One of the best ways to do this is to train pilots so that they have the necessary human factors skills to cope with the risks and demands of flying.

Crew Resource Management: fundamental concepts

Crew Resource Management (CRM) training for crew has been around in different forms since the early years of aviation. It has been introduced and developed by aviation organisations including major airlines and military aviation worldwide. CRM training is now a mandated requirement for commercial pilots working under most regulatory bodies worldwide.

Crew Resource Management can be defined as a management system which makes optimum use of all available resources – equipment, procedures and people – to promote safety and enhance the efficiency of flight operations. CRM is a safety barrier against human error by managing resources within the flight crew team.

CRM historical background. Historically, the question of crew training arose in the 1970s. Investigators discovered that more than 70 per cent of air crashes involved human error rather than failures of equipment or weather. A NASA workshop examining the role of human error in air crashes found that the majority of crew errors consisted of failures in leadership, team coordination and decision-making.

The aviation community responded by turning to psychologists J. K. Lauber and R. Helmreich to develop new kinds of psychological training for flight crews. That training focuses on group dynamics, leadership, interpersonal communications and decision-making and is known nowadays as crew resource management.

John K. Lauber, a former member of the National Transportation Safety Board, defined CRM as "using all available sources – information, equipment and people – to achieve safe and efficient flight operations". More specifically, CRM is the process used by crew members to identify existing and potential threats and to develop, communicate and implement plans and actions to avoid or mitigate perceived threats. Using CRM methods, airplane crews can avoid, manage and mitigate human errors. And as secondary benefits, CRM programs improve morale and enhance efficiency of operations [5; 6].

Six generations of CRM. *Since its introduction in the early 1980's, there have been six generations of Crew Resource Management. Each successive generation was enhanced to build upon the successes and lessons learned from the previous generations. The following are overviews of each generation [7; 8].*

First Generation: Cockpit Resource Management. With crew-based training validated in concept, United Airlines (UA) initiated the first formal CRM training course in 1981. This initiative followed the alluded to rash of serious accidents, none of which were attributable to a specific problem that would have prevented a safe flight.

UA developed its program with the input of experts on improving business management. Other airlines took the same management-focused approach in their early CRM programs. Some of them included full-mission LOFT training in addition to classroom work. UA made its C/L/R program available to other carriers, but they were slow to respond. However, UA continued to fine-tune its program, making it an integral part of UA's own flight officer training. Consistent with the FAA recommendations, the main tenets of the program were to institute:

- A comprehensive system for improving crew performance.
- An operational focus on safety improvement.
- A study of how team member attitudes and behavior affect safety.
- A training method using the team, not the individual, as the training unit.
- Active training where the participants experience and participate.

In retrospect, the business management focus of these first-generation programs proved unduly narrow. Virtually all of those programs emphasized correcting deficiencies in individual behaviour such as a lack of assertiveness by juniors and authoritarian behaviour by captains. The programs featured psychological testing and explored abstract concepts such as leadership. They advocated general strategies of interpersonal behaviour but did not clearly define appropriate cockpit behaviour.

Overall, despite these shortcomings, the early Crew Resource Management programs were generally well received.

Second Generation: Crew Resource Management. During the middle and second half of the 1980's, many commercial airlines, domestic and foreign, developed and implemented their own CRM programs. By the time NASA held its May 1986 industry workshop, a new generation of CRM courses had emerged. These newer programs expanded the scope of the first-generation efforts, embracing more modular, real world operations.

Second-generation programs emphasized cockpit group dynamics and led to a name change, from Cockpit to Crew Resource Management. The expanded training included new topics such as team building, briefing strategies, situational awareness, and stress management and featured distinct modules on decision making and breaking error chains that can cause catastrophe. These refinements were intended partly to address pilots' resistance to first-generation programs, but also to translate abstract concepts into everyday operational tools.

However, in order to teach CRM concepts, many of the second-generation courses still relied on exercises and games unrelated to aviation. Therefore, although the new courses were better received by trainees than those of the first generation, the criticism persisted that the training was heavily laced with psycho-babble.

Third Generation: Further Expanding the Scope. In the early 1990's, the CRM training began to aim at increased relevance. CRM was integrated with technical training, focusing on specific skills and behaviour that would help pilots function more effectively in actual flight deck operations. Several airlines introduced modules connecting CRM and flight deck automation.

Significantly, third-generation CRM programs also expanded to address:

- Issues related specifically to the aviation system in which crews function. This included the elements of organizational culture that affect safety.
- The recognition and assessment of human factor issues.

As the name change suggests, training in Crew Resource Management was extended to other groups that shared the responsibility for aviation safety, including flight attendants, dispatchers, and maintenance personnel. Many airlines, in fact, initiated joint cockpit-cabin CRM training. A number of carriers developed CRM training specifically for captains, related to the leadership demands that accompany command. Advanced Crew Resource Management training was given to check airmen and others responsible for training and evaluating crew members.

Third-generation CRM programs filled the identified need to expand the emphasis on, and the definition of, the flight crew. But they may also have had an unintended consequence: diluting the original Crew Resource Management mandate to reduce human error.

Fourth Generation: Integrating Crew Resource Management and Establishing Formal Procedures. In 1990, the FAA issued an advisory circular on Crew Resource Management; comprehensive Crew Resource Management training became a not only a reality, but a regulatory requirement. The FAA also introduced another major change with its Advanced Qualification Program (AQP).

AQP allowed carriers to develop customized CRM training for their own organizations. In exchange for this greater flexibility, carriers would be required to:

- Provide both CRM and LOFT for all flight crews.
- Integrate CRM concepts into technical training.
- Create detailed analyses of training requirements for each aircraft.
- Develop programs for addressing human factors in each aspect of training.

Most major U.S. airlines and several regional carriers chose AQP. A consensus found that the AQP approach improved flight crew training and qualifying.

To assimilate Crew Resource Management into actual operations, airlines began to formalize CRM concepts by adding specifically prescribed behaviour to their checklists. This was done to ensure that decisions and actions would be informed by bottom line considerations and that the basics of Crew Resource Management would be observed, particularly in non-standard situations.

By making Crew Resource Management an integral part of all flight training, the fourth generation of Crew Resource Management made progress in solving the persistent problems with human error. But even more progress was needed.

Fifth Generation: Error Management. The fifth generation of Crew Resource Management aimed at resolving reported deficiencies in the previous iterations.

Dr. Robert Helmreich and his colleagues set out to fix the education shortfall by defining a single, universal rationale that could be supported by pilots worldwide. They circled back to the basics: returning to the original concept of Crew Resource Management as a way to avoid error, we concluded that the overarching justification for Crew Resource Management should be error management. Effective error management is the hallmark of effective crew performance and the well-managed errors are indicators of effective performance.

The Helmreich team advocated sharply defined justification accompanied by proactive organizational support. The fifth generation of CRM would:

- Introduce and emphasize the concept of error management: managing and living with human error.
- Flow from the recognition that human error is ubiquitous, inevitable and a valuable source of information.

Therefore, Crew Resource Management would concentrate on error countermeasures that would apply to each situation:

- Avoiding error altogether. (For example, advance briefing on landing approach procedures and potential pitfalls, combined with intra-crew communication and verification.)
- Identifying and trapping incipient errors before they are committed. (For example: cross-checking navigation information before executing on it.)
- Mitigating the consequences of errors that do occur. (For example, remembering to fly the plane after a warning alarm sounds.)

Fifth-generation CRM would include formal instruction about the limitations of human performance, including the nature of cognitive errors and slips and the performance-degrading effects of stressors such as fatigue, work overload, and emergencies.

Fifth-generation Crew Resource Management posited that in order for the error management approach to achieve full traction, organizations should (1) affirmatively concede that errors will inevitably occur and (2) adopt a non-punitive approach to all errors (except for wilful violations of rules or procedures).

As suggested above, fifth-generation Crew Resource Management also stressed data gathering and reporting. Doing so would advance deeper understanding, but also help gauge program success. The FAA took the cue and, in 1997, enacted Aviation Safety Action Programs (ASAP), intended to encourage aviation organizations to take proactive safety measures and freely report incidents. American Airlines (AA) was an early adopter, working in cooperation with both the FAA and the pilots' union. Through

AA’s confidential, non-punitive reporting program, pilots reported safety concerns and errors. The AA program was a resounding success: during its first two-years, nearly six thousand reports were received. The data generated by its ASAP helped AA refine and improve its Crew Resource Management training program.

Although each ASAP requires delicate negotiation among the carrier, the FAA, and the pilots’ union (which seeks to protect the confidentiality and non-punitive nature of incident reports), ASAP continues today to be a vital element of airline safety.

Sixth Generation: Threat Management. Crew Resource Management has evolved to a sixth generation, which builds on the fifth generation’s error management theme. The sixth generation recognizes that the fifth generation’s focus on pilot error was appropriate; it further addresses the reality that flight crews must not only cope with human error inside the cockpit but also with threats to safety arising from the work environment as a whole.

Thus, in the sixth generation, the Crew Resource Management lens has been widened from error management to threat management. These days, traditional Crew Resource Management skills and methods are applied not only to eliminate, trap, or mitigate errors, but to identify systemic threats to safety.

CRM significance. CRM alerted the aviation industry to the human interactions that are an integral part of any team performance. This training has the potential to save lives and money, as well as prevent accidents and lawsuits.

While no one can assess how many lives have been saved or crashes averted as a result of CRM training, the impact has been significant. The Line Operations Safety Audit (LOSA) data demonstrate that 98 per cent of all flights face one or more threats, with an average of four threats per flight. Errors have also been observed on 82 per cent of all flights with an average of 2.8 per flight. Consistent with the outstanding safety record of commercial aviation, the great majority of errors are well managed and inconsequential, due in large measure to effective CRM practices by crews. LOSA provides organizations and regulators with a valid means of monitoring normal operations. By understanding what crews do successfully as well as where things go wrong, researchers can help develop more effective training and safety initiatives.

One of the basic underlying premises of CRM is that a team can, and should, perform successfully. The aim of CRM is to ensure that team performance takes precedence over individual performance. CRM principles may also extend to situations where ATC, maintenance, company experts, etc., are considered to be part of the team especially in emergency situations or in a single pilot environment. Thus, it is concerned with the cognitive and interpersonal skills needed to manage the flight within an organised aviation system [1].

CRM practical application. Based on the evidence that CRM is effective, the International Civil Aviation Organization, a regulatory component of the United Nations, began requiring CRM programs for member countries. CRM also informed the development of maintenance resource management, an effort to improve teamwork among aircraft maintenance workers.

CRM training is also being used in air traffic control, fire fighting and industrial settings, including offshore oil operations and nuclear power plants. The training helps workers in control rooms and emergency command centres avoid making operational errors that may lead to accidents. The medical community is also responding to findings of human error and failures by adapting aviation's approach to crew coordination.

Crew Resource Management Training: brief overview

CRM training encompasses a wide range of knowledge, skills and attitudes including communications, situational awareness, problem solving, decision making, and teamwork; together with all sub-disciplines which each of these areas entails. A high level of proficiency in CRM requires continuous training, evaluation, and feedback. CRM is concerned not so much with the technical knowledge and skills required to fly and operate an aircraft but rather with the cognitive and interpersonal skills needed to manage the flight within an organised aviation system and to complete the missions successfully. CRM training includes the following integrals [2; 5; 6]:

- Information processing.
- Human error, reliability and error management.
- Fatigue and workload management.
- Situational awareness.
- Communication and management.
- Automation.
- CRM for single pilots.

Information Processing provides an overview of mental human performance characteristics which flight crew use, it examines the way in which information gathered by the senses is processed by the brain. The limitations of the human information processing system are also considered. The basic theory of decision making is also covered, although not in depth.

Human Error, Reliability and Error Management addresses both types of mitigating strategies, but concentrates particularly on error detection, especially in the multi-crew situation.

Fatigue and Workload Management deals with 'readiness to cope' in some sense, in terms of an individual's physical and mental ability to cope with work demands, and how he manages those work demands. CRM aims to help flight crew to plan their workload as far as they are able, making best use of the team, and taking into account the fact that some individuals may be performing below peak levels (e.g. due to fatigue, etc.). It is also important for managers to be aware of such human performance issues when planning (rosters etc.).

Situational Awareness is a knowing what is going on around you recognising "the big picture". It's is fundamental to correct decision making and action. Information processing tends to be the term used for the psychological mechanism of receiving and analysing information; situation awareness is a description of an individual's – or a team – understanding of the aircraft state and environment, based on perceived and processed information.

The aim of SA training should be to ensure that all flight crew members have good SA and a common (and correct) perception of the state of the aircraft and environment. This can be achieved by good team working and communication.

Breakdown of situation awareness is the root cause of so many aircraft incidents that eliminating it would dramatically reduce the accident rate. SA is, therefore, an important element of CRM.

Communication and Management is one of the basic underlying premises of CRM which lies in understanding that a team can, and should, perform successfully in the cockpit. Good CRM is getting the balance right as a team. The emphasis in CRM is primarily upon the cockpit crew, and how they work as a team.

Automation in the aviation domain has been increasing for the past two decades. Pilot reaction to automation varies from highly favourable to highly critical depending on both the pilot's background and how effectively the automation is implemented.

Modern aircraft feature a variety of automation technologies to help the pilot with such things as checklist execution, navigation, descent planning, engine configuration, and system monitoring.

One of the goals of automation is to improve the pilot's situational awareness. A related goal is to decrease the workload required to maintain a given level of awareness.

Technologies assist the pilot with awareness of position, terrain, traffic, fuel usage and remaining aircraft range, engine operating characteristics, etc. Pilots have various reactions to automation. CRM in highly automated aircraft presents special challenges, in particular in terms of situation awareness of the status of the aircraft.

Conclusions

Aviation industry today as ever before is subject to cyclic developments: either damaging or prosperous. In the course of its development lots of problems have been successfully tackled. Still, the human capabilities aren't almighty, we need clear minds, necessary resources, and scientific researches and, definitely, time to investigate the problem(s) in this domain and minimize errors. Effective good human factors can reduce the likelihood of error and resultant accidents/incidents.

Thus, today professionally-minded pilots are trained to use crew resource management as a vital decision-making tool meaning that the CRM concept goes beyond seeking input from crewmembers; all resources at the airline pilot's command are tapped to help manage the flight with sound decisions. Crew Resource Management becomes a natural part of pilots' lives aloft.

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Multicultural orientation of modern Ukrainian higher education (based on National Aviation University)

In the article the features of native system of higher education orientation in Evrointegration's conditions are defined. It operates on the base of European multicultural educational space principles.

On the European continent some processes and transformations based on the integration which comprises all areas of personal, social, educational and professional life and cause deepening of globalization phenomena, formation of information society, improvement of the labour market mobility, strengthening of migration have been observing during the last decades. These changes affected the development of the national higher education system, which has been the official component of the Common European Space of Higher Education and Science since 2005. Under these conditions, there is a need to reinterpret the paradigm of formation of the future specialist's identity in the higher educational establishment, whose society has been extended and went beyond the traditional, state, national, ethnic or individual. Objectively, the need to "live together" has been arisen. Its implementation in the future will be inevitably associated with *multiculturalism:* the recognition of European political and cultural traditions, focused on the fundamental values of Western civilization and human virtues. In the territory of the European and global social space these values are the primary measure of worth of human's thoughts, views, actions and behaviour. These human values are the basis for further reforms in Ukraine.

The process of identifying himself / herself with the European multicultural educational environment, in our opinion, should occur on the basis of deep love, respect and understanding of the values of the state, its people, ethnic community. In other words, we can reach multiculturalism by means of the high level of national self-identity. These are the main principles to form a new generation of specialists in higher educational establishments which are involved into the multicultural European Educational Space.

The aim of the paper is to determine the peculiarities of the national system of higher education orientation in terms of the European integration.

Educational sector, in particular the area of the national aviation professional and technical education, is involved into the all-European integration process, including the "Europe of Knowledge". The basis of this substance is «lifelong education» – education during life. The students' and teaching staff's mobility which has been proclaimed by the Bologna Declaration is a key principle of the formation and becoming of the Common European Space of Higher Education and Science. At the same time, mobility contributes to meeting the national interest, not only in higher education but in many other areas of public life as well. Migration processes in the field of professional education is a natural and common phenomenon. It is a real indicator of the European

Space of Higher Education existence, which brings together national educational systems of different levels and types. These educational systems are different in philosophical and cultural traditions, the level of the objective and tasks of their quality status. It is a formed integrated organism that can be characterized on the basis of representation in each of its components of some global trends and tendencies to preserve variability. During the period of its intense formation (the first decade of the XXI-st century) the number of foreign students in Europe as well as in the world, significantly increased (since 2000 their number has increased by 64, 5 %, and their part in the total number of students today is about 3 %). In the world the major countries-respondents are the USA, UK, Germany, France, Australia, Canada [1].

Ukraine is among the top ten countries according to the number of international students. Currently in our country, more than 200 higher educational establishments are licensed to realize their professional training. This makes it possible to study more than 44 thousand students (the number compared to 2000 has been doubled) from 133 countries. It brings to the state budget on average 80 million annually. A large number of foreign students studies at higher educational establishments of Ukraine is from China (6.7 million), India (2, 7 million), Jordan, Iran, Syria, Pakistan, Iran, Malaysia, Nigeria, Congo, Nigeria, Egypt.

According to the number of international students, the leaders are the major cities – Kharkiv and Kyiv (17 thousand foreign students in 69 universities). In Odessa 18 higher educational establishments and in Dnipro 16 higher educational establishments have licenses to train foreign students. The most popular are the following specialties: medicine, engineering, economics and finance, social sciences, linguistics. The largest number of foreign students study in Vinnitsa Medical University, Kharkiv National University named after V. Karazin, at the National Aviation University. In particular, 1200 foreign students from 49 countries study at NAU.

Principal mechanisms of attractiveness of national higher educational system for foreign citizens is the power of research schools, providing of quality education that meets the international standards; the cost of education that is lower than in other European countries; optimal amount of living expenses. However, in our opinion, the main reason is the traditional Ukrainian hospitality, which is the leading feature of the Ukrainian nation's reputation as a tolerant nation.

Under conditions of deepening integration processes in higher education, enabling national students to develop their language skills of international cooperation during training is getting of special importance. The means of this improvement is the English-language project implementation. At the same time, migration causes increase of a number of foreign students who have chosen Ukraine as a destination for getting higher education, where the training under the English-language project facilitates the process of obtaining their profession. The choice of foreign language as a learning tool causes some changes in the methods of teaching, since the peculiarities of its organization in a multicultural and multinational environment; the different levels both knowledge and speech training; the peculiarities of objects’ of study motivation as to career choices and the conditions of its obtaining must be taken into account [2, p.14-15]. Systematic, purposeful work with the students of English-language project is focused on improving of oral and written English level, dosed complications of contextual and process loads, enabling confident public presentation of acquired academic performance in English promote high-quality professional training of the students and create comfortable conditions for their further study at universities abroad, participation in international students' societies and forums, and the most important thing is that it will help complete the personal and professional self-actualization.

Youth of Ukraine actively migrate to other countries primarily for mastering master programs, getting the scientific degree of PhD, internships, practical training. According to the survey of graduating students of the aviation university, *the main motives of their mobility are:* getting in European universities quality education which is demanded by the market of professional services; obtaining of additional diploma (diploma of European standard) to increase the competitiveness of employment in Ukraine and in other countries; mastering the new information, educational technologies and advanced production technologies; language and speech self actualization, knowledge of the culture and history of the country-destination.

Working with the students who become proficient in terms of Magistrate specialty, we have established the certain regularity. It largely contradicts the predictions of the initiators of the Common European Space of Higher Education and Science as to improving the attractiveness of European education. Master students – are people who have basic higher education. In accordance to the current Law of Ukraine "On Higher Education" and branch instructions, they are entitled to implement their professional activity according to specialty in the primary positions. In our opinion the difficulties in entering the university (conditions to realise the school graduate's right as to the choice of future profession according to the "abilities, aptitudes and vocation" are not always available because of the limited opportunities of the training on public order or the lack of financial support for getting higher education by contract), no real job prospects after graduation which would contribute to the dynamics of personal and professional components of professional competence and prospects of qualified activity have caused the formation of the following students' volitional traits: purposefulness, persistence, patience, ability to overcome difficulties, deal with complex psychological and social problems, belief in the possibility of personal and professional plans implementation. At the same time, in recent years the process of finding some additional opportunities to enhance the capacity of employment: training courses, participation in trainings which are organized by the institutions, companies – potential employers; obtaining of the additional specialty along with the basic one in a system of post-graduate education; mastering several foreign languages.

There is no doubt that the student who is seriously concerned about his / her future, personal, professional, career, does not look for easy ways to obtain higher education abroad. He / she does not have any illusions about the reality of finding a promising job and complete satisfaction of the social needs in another country. Most students tend to live and work in Ukraine. In other systems of higher education the simplified conditions of enrollment at the educational institutions, the ease of the procedure of transfer results of educational achievements in higher educational establishments of the country-origin do not attract them. For further study they choose those systems which provide an extremely high quality of training and access to which is difficult.

Conclusion. Ukraine as a full member of the European educational community, preserving its national self-identity, updates the human values in the professional training of different sectors. The human values are the foundation of multiculturalism. Its base principles are human centrism, dynamism of contents, methods and forms of students' education; mobility, the priority of competence and contextual paradigms.

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Features of aviation experts training in the system of "people-machinery"

A new approach of aviation specialists training based on using the entropic principle of optimality is proposed. It covers the principles of the information technology use for control of education quality. It has been found that the use of the subjective analysis's methods in higher technical education efficiently influences professional development of specialist aviation specialists, it also shapes personal and professional qualities, promotes self-development and self-realization.

The development of higher technical education depends on global challenges, as well as on the information technology revolution. The development of knowledge and the concentration of the acquired skills and the abilities amount should take place by a continuous way according to the laws of nature and reflect the processes of natural laws as the laws of world order have a cyclic structure and they reflect the fundamental laws of nature. Prominent scientists in educational psychology note that complications met by young people in understanding and interpreting technical texts, are currently unsettled matters in the process of students educational activities of in higher education institutions in content communication between teachers and students.

The aircraft has been by the series of passenger airliners air crashes lately caused by the human factor. These crashes has been related to aircraft designing and/or manufacturing defects, complicated meteorological conditions, collision with other aircraft or birds, strike by anti-air missile. Behind all of these situations there is a person's workplace negligence, wrong assessment of the actual situation while choosing flight mode.

According to the statistics analysis of aircraft crashes, 80-85% incorrect crew actions count for professional negligence and inadequate psycho-physiological characteristics of the people, violation of the professional regulations and lack of personnel qualification.

Despite all the difficulties, ICAO, applying the accumulated experience of air accidence investigations and accidence prevention, has worked out a range of concepts which prove that the human factor is essential to any discipline by its nature. The applied character of the human factor causes rather a problem than a subject of study; its conceptual relation to the psychology is similar to the relation between the designing and Science. There comes to life a variety of combined methods and techniques of human influence on the efficiency of ergonomic system, as in the familiar case of the technical applied sciences tying the Science with its practical application. Complex character of human factor which is characterized by overlapping of constituent disciplines can be seen as a system of scientific knowledge about the human life and work environment, their relationship with machinery, rules and regulations, the environment as well as the interrelationships in professional activities. In other words, the human factor is the combination of personal, medical and biological factors which determine the efficient conditions of aircraft flight exploitation and control of air traffic.

Training of a new generation of highly educated personnel, able to gain and imply up-to-date knowledge, is hardly possible without significant changes on the university level. The solution of this complex of tasks is connected with the reforming of national technical university system and creating effective continuing education in Ukraine which would meet world standard requirements and demands the introduction of integrative educational courses.

At the same time, pedagogic interaction can be efficient only if a student has adequate, appropriate understanding which is respondent to the teacher's intention of design that is not distorted with wrongly perceived information.

One of necessary modern means of improving the quality of higher technical education is the systematic use of new innovation techniques during a course of studies of general and special subjects, and especially in solving applied problems, carrying out research work. Efficient students training of higher technical schools can be achieved by implementation of a systematic and comprehensive approach to the educational process. As a result of these innovations the evaluation will be reduced to the systemic automated collection of information in each structural research element, the information consolidation with its further handling by information technologies.

We have set the goal – to establish the characteristics of algorithmic models of learning activities in higher technical education.

The object of the study is the process of evaluation of higher technical education of aviation specialists.

The actual education of the student is not possible without understanding of his personal role in the world around us, without understanding the role of the future profession, as well as appropriate knowledge and competence, which he has mastered, for his own future career. We believe that the man is an instrument of knowledge and it is obviously the main essence of its existence. Synergetics, as a science that studies the processes of self-organization in animate and inanimate nature is able to answer the questions related to the individual's preferences. Indeed, the main result of the educational process – is the ability to produce new knowledge and to educate themselves throughout their lives.

A content rearrangement of regulatory information and the database formation based on monitoring studies which are performed on a regular basis, allow the use of more efficient means of monitoring the status of training activities.

As a result of monitoring studies arises the problem of optimal decision-making process, which requires the establishment the automated working places for the interpreters of the monitoring studies results on the basis of modern computer technologies and their systems. It allows involving specialists (experts) in the decision-making process in the on-line mode and, based on current intermediate results, use prior information and expert evaluations; initiate problems to the experts in a form common to their subject field; refer to the experience of before solved problems and reference information banks.

The previous investigations in this field have shown [1, 2] that the use of information technology for the automated evaluation and the information processing, which has been obtained in the monitoring process, significantly improve the inspection quality of the object.

The monitoring of learning activities requires creation of a hardware-and-software complex (HSC), which should be adapted to the specific conditions of functioning. This complex must be provided with the necessary mathematical, software and hardware as well as teaching materials.

Software for the monitoring system is advisable to form on the principles and methods of stochastic information processing under conditions of incomplete information and its uncertainty. It is necessary in order to find optimal solutions using stochastic processes, the theory of risk and the theory of subjective analysis.

At the initial stage of these monitoring studies can be used the standard packages of statistical information processing SPSS or STATISTIC [3-5].

The main blocks of the algorithmic model system for the training activities monitoring will be the following blocks of:

- Previous mathematical modeling of learning activities which are based on the models;
- The learning activities decomposition based on their certain kinds;
- Classification, collection and monitoring of information;
- Initialization, control and adjustment of the monitoring system;
- Mathematical research and prognostication of the current state;
- Modeling of possible control solutions and their effects;
- Developing the recommendations based on the projects of ready alternative control solutions, involving in the process of the alternative development the representatives of the scientific and educational community;
- The final making of control decisions based on the alternatives' analysis and the current state of the investigated educational process.

One of the principal results of the monitoring investigations is predicting of the educational activities' state. The efficiency of the prognosis based on the monitoring system can be estimated by probability, the period of prognosis and the cost of its implementation.

When functioning the monitoring system of educational activity is actively using: the procedures of sequential analysis when selecting the monitoring parameters; technologies and computational approaches for processing the current information; standard, predicting mathematical methods of educational activities; the system of the on-line receiving of information; the multi-stage system analysis of the current information; the concentration of the current research information as a PC database.

In general, the essence of the sequential analysis method for organizing the expert system for the results' analysis of these monitoring investigations consists of a multi-stage procedure for the final decision adoption.

At first, by means of mathematical modeling, on the basis of the previous data, the current state of the educational activity is being evaluated in general and its individual kinds. Thereby is determined the equivalence of education in accordance with the requirements of a particular educational institution.

If it is not possible to establish, the collecting of data continues by means of the monitoring system with additional studies, mathematical methods and technical means. It gives a possibility to obtain some additional information in terms of incomplete and unclear input information. At this stage, together with quantitative data and the qualitative information is being taken into account, at the same time additional information resources are being attracted.

A necessary condition for increasing the accuracy of the educational activities' evaluation which is carried out with the use of probabilistic methods is the consideration of temporal and spatial information correlation that is obtained in the monitoring process.

As a measure of the system's diversity, which is characterized by a probability distribution $p_1,..., p_N$ in the information theory, statistical physics and thermodynamics, the entropy $H = -\sum_{i=1}^{N} p_i \ln p_i$ is commonly used, which represents the assembly average of the logarithm of the probability of the system's stay in a free condition, taken with the sign "-".

If for some number condition *i* a corresponding probability $p_i = 1$ (i.e., to the set of alternatives is included only one type of the technical education training), so the entropy of this training plan equals zero. This value is a minimally possible (the entropy cannot be negative) and is describes a complete lack of variety in such time distribution for all types of training (in practice, of course, impossible). If for all types of training of technical education has been determined the same quantity of academic hours, that is $n_i = n/N$, so the entropy of this distribution is $H = \ln N$. This value is a maximally possible, it corresponds the largest possible variety of educational process.

It is clear that the actual process of educational activities according to their diversity should be placed between the minimal and maximal allowed values.

In addition, using the subject's advantages on the set of alternatives and on the methods of subjective analysis in the higher technical education system influences efficiently the professional development of aviation specialists, forms personal and professional qualities, promotes self-development and self-realization.

For the currently-operating normative rules, which define and regulate the educational activity, correlations between the control system and the object's response to these control actions, one can take them into account by means of the correlation analysis.

The most accurate results for determining the correlation coefficient between two random variables can be obtained from the data processing as time series which are based on the Bayesian approach. In this case, the correlation coefficient is defined by generally accepted methods and numerical algorithms.

It is possible to evaluate the reaction of the educational activity delay during the changes in the management system, if this delay can be considered as a quasi-stationary random process. Thus one of the principal tasks is to determine the degree of correspondence between the theoretical curve of probabilities distribution, its type (normal distribution law, tapered-shaped, deltoid-shaped, angular) and the statistical distribution of the obtained data, and the characteristics of this distribution: mathematical expectation, dispersion, the coefficient of variation.

The use of monitoring allows monitoring of the task carrying out from its formation to the results presentation, changing or modifying the solution codes, expanding the automation area owing to the ability of people who make decisions and affecting the course of the problem solving.

Based on these results, the appropriate organizations and the personnel of training and analytical units make proper conclusions about the nature of possible management decisions, the period of their decision and completion. These decisions should stimulate the student achievements, the teaching quality, as well as reducing the number of expelled students by the results of current control.

According to the science-based structures and the content of model operators of particularly complex control systems (GN Makarov, LV Gerasimenko) a present-day pilot, receiving a higher technical education, should possess: functional and psychological readiness for professional activities; developed heuristic components activities; working memory and thinking; the ability to solve problems; analyze and correctly estimate the situation in stressful conditions; competently and reliably implement decisions in critical situations, etc.

This is the reason why the following professional qualities: the capability to make contacts, the art of communication, the ability to achieve targets, competence, creativity, talent for organization, analytical thinking, are among the most important ones in training aviation university professional.

The didactic principles of knowledge generalization of provides the expedience of linking of variable partial and specific knowledge to the general knowledge about classes, types and objects as well as the processes with which the given branch of education deals with. The application of the active systems theory where the core and, the main element is the man – the subject, which allows identify the priority areas of technical education as the object of scientific study.

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Ecologization of Cosmos: problems and perspectives

The article discusses the problem of social and environmental risks of cosmic activities. The strategy of ecologization of the cosmic sphere in the context of technological and social realities at the beginning of the XXI century is analyzed.

The technical and social reality of the XX-XXI centuries demonstrates an important role of space technology as a powerful instrument for civilization's development and prevention of potential catastrophes. However, the practical results and consequences of development of cosmonautics are controversial and wide off the ideal becoming themselves a source of global risks [1, 2, 3, 4]. They regret to state that at the turn of the XXI century the balance of space activity and environmental safety is obviously disturbing. It makes actual the attention for a strained problem of the impact of cosmonautics on the environment and social surroundings.

All the works dedicated to the named issue can be divided into three groups. The first one advocates for cosmonautics, justifies cosmic expansion using mythology, and idealizes the positive opportunities, ignoring or underestimating environmental and other problems. The second one defends the opposite position, firmly criticizing the cosmic mythology, cosmonautics and cosmization [4, 5]. The third group provides a balanced assessment of the opportunities, limitations, environmental problems and the consequences of space exploration [1].

Let us briefly review the problems and perspectives of the ecologization strategy in the space sphere in the context of technological and social realities at the turn of the XX-XXI centuries.

The development of space, as well as any other technology is determined with three main factors: 1) the gained social, scientific and technological progress (pre-history); 2) the quantity and share of resources allocated to its development; 3) the efficiency, i.e. correspondence between positive and negative effects of use of space technics (aimed at increasing of "behoof" and minimizing of the "damage" in view of the back-story and constraint of resources).

Summing environmental consequences of the use of space technics in the XX century, we note that, along with a significant positive contribution to the development of space-faring states and the word community (a spacewalk, a permanent man's presence beyond the Earth, construction and use of communications, telecommunications, monitoring the Earth), there are increasing environmental risks and damage to nature, massive breaking of environmental rights of citizens [4, 5].

Relatively speaking (by the criterion of environmental effects) the history of space technics can be divided into two stages: 1) pre-ecological (till the mid-80s); 2) ecological (since the mid-80s). According to the system approach it will be efficiently to examine and predict the ecological threat and safety of space technics during the life cycle of objects and technical systems (i.e. the development, production, testing, maintenance, elimination of technology and wastes).

The harmful effects of modern space technics involve the surface, the ground and the upper atmosphere of the Earth and near-Earth space. The main negative impacts on the system "man – society – nature" can be grouped as follows:

1.Pollution of the environment with harmful emissions of gases (rocket fuel combustion products and residues of fuel in areas where rocket stages are falling; fuel spilling, fuel atomizing in the atmosphere as a result of incomplete combustion and subsequent releasing to the surface; space debris in near-Earth space; falling of technics fragments from space to Earth after the term of functioning, etc.);

2. Prolonged staying of people (cosmonauts) in an artificial environment, in conditions of complex harmful factors as: weightlessness, radiation, toxicity, microbial contamination, electromagnetic fields, noise, vibration, changes of ambient light, a strong psychological stress, etc.;

3. A high level of professional diseases of the personnel caused with space technology, the risk of long-term adverse consequences for the life and health of the population;

4. Consequences of crashes;

5. Contamination of environment as a result of military use of space technology;

6. Contamination of wastes, environmental damage in case of liquidation and elimination of facilities (including military technics and weapons).

The current state of space technics and its anti-ecological character is the result of fatal errors in forecasting. For example, the single one problem concerning pollution of near-Earth space was foreseen in the 60-s of the XX century. The rest of environmental problems in fact virtually were neglected.

What are the origins of the problems of inefficient use of space capabilities and environmental irresponsibility? We suggest they could be found in excessive politicization and military genesis, technocratic management practices and thinking, as well as in corporate and institutional secrecy of the cosmonautics sector. Initially aimed at solving global problems of survival and development, space activity has turned to an unrestrained and wasteful race for ambitions and records, realization of myths and social utopias in the absence of adequate public scrutiny. Society comes off a loser because of the authority of cosmic mythology, gaps in the law, powerful lobbying of monopolies and space agencies, environmental illiteracy and irresponsibility of professionals, concealment and distortion of information.

Having inherited extremely low environmental characteristics of space technic systems the implementation of global space colonization projects is practically impossible. Made and prospective space projects and programs, as a rule, are extremely wasteful (especially those related to man’s flight into space). For example, the international space station project is estimated at $ 90 billion, and here the planned expedition to Mars is estimated at 500-1000 (!) billion [1]. All of this would be enough to solve with an excess the most pressing problems of the mankind such as the lack of drinking water and food in underdeveloped countries, where most of the world's population are living.

The process of tough economic, social, environmental critics, the expertise of space technology projects and programs will inevitably approach. The rapid ecologization of space technology and activities is an objective need. This sector has been developing yet by inertia in the paradigm of scientific and technological revolution, while in the world in response to increased environmental disaster the environmental revolution is coming.

The successful development of space exploration for the benefit of the mankind, in our opinion, is not possible without a radical improvement in ecological characteristics of space technologies and activities. It requires:

- systematic studies of historical experience and scanning of the real situation, the inherited problems and trends;
- strengthening the law regulation and control for space activities initiated by the civil society with the active use of all democratic institutions, and international cooperation, taking into account the experience of social technologies application in other areas;
- development and implementation of environmental policy through an environmental management system in accordance with the strategy and principles of sustainable development;
- concentration of resources in the first place in order to minimize harmful impacts on the environment. The problem of the urgent importance is to increase the general efficiency of space technology to a higher level: up to 10-30%;
- the implementation of social technologies (human rights, the principles of bioethics) in relation to man’s flights into space.

It is also needed: quotas for the number of launches; limitation of carrier rockets with low efficiency, with high risk of accidents; prohibition of fuel-super toxicants; fees for wastes and other measures [1].

Changes in the training process of space professionals’ environmental education should play a key role. After the conference, "Rio-92" a "silent" environmental revolution started in the world. Its legal basis is the new international standard ISO 14000 "Environmental Management Fundamentals", which gave impetus to the development of national standards [6]. The environmental management includes: development and implementation of environmental policy, an independent environmental assessment of decisions, projects, technologies, processes and products; information transparency and access to environmental control. Environmental information should be neither state nor commercial secret.

Environmental management encompasses a range of mechanisms of legal regulation (environmental licensing, certification, insurance, inspection, audit) with the use of economic criteria, requirements, standards, spatial and temporal restrictions and prohibitions for equipment, technology, products, services (space technology and space-related activities), developed on the basis of modern scientific methods (assessment, environmental risk management, etc.) [Ibid].

Space technics and activities of the XX century, in practice, have confirmed the law of techno-humanitarian balance – the technics in its development goes ahead of humanitarian awareness of its consequences, leading the society to the destruction. The basic methodological and practical issue of technical reality of the XXI century on the brink of ecological disaster is the shift from the techno-control of natural environment to humanitarian mastering the Cosmos.

Conclusions

The general results of the passing XX century testify the deployment of environmental problems caused by the rapid scientific and technical progress, an extensive industrial and economic activity, and the aggressive absorption of the space environment.

What is the forecast for the XXI century? The global environmental problem seems to remain the basic one. The alternative to super-industrialization and resource exhaustion of the Earth's biosphere, global catastrophe and the destruction of the mankind (pessimistic scenario) is the ecologization of technology and human activity, the environmental limitations of spatial expansion and the transition to an integrated environmental management (optimistic scenario).

Technical reality of the XXI century requires searching for the "golden mean", i.e. the new strategy of space activities to realize the potential of cosmonautics in the aid of survival and development of civilization by achieving the balance of interests of man, society, states, multinational corporations, and the world community. It will require the realization of environmental policy, based on knowledge of the pre-history and reliable ecological foreseeing, which correspond to the principles of environmental management aimed at ecologization of technics. The humanity has a chance to survive due to ecological education deliberately limiting and overcoming the defects of techno-centrism; the process of humanitarian and technical synthesis, using social technologies of the civil society and the possibilities of international cooperation; an increasing responsibility of the professionals answerable to application of constructive potential of technologies with minimum harmful influences and consequences.

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Aviation security as a social and cultural issue

The article discusses the issue of transformation of social space of the globalized world, which takes place under influence of the development of aircraft industry and civil aviation. The opinion on the fact that the prerequisite of aviation security is establishment of global consciousness as a sociocultural practice is substantiated. Basing on the analysis of the ICAO's documentation in the sphere of aviation security, there is an assumption made with regard of lacking consideration of the cultural and civilizational aspect of the issue.

The modern phase of development of the humanity is referred to as informational. The researchers highlight its definitive role in availability of information, technologies, network services, etc. There is an impression that informatization and computerization of social practices is a sufficient condition for emergence of information era. At that, the transformation of infrastructure of social networks that formed in course of history and exist beyond the virtual space remains unnoticed by the representatives of the human and society sciences. Nevertheless, the social reality (as actuality) is the main source of hazards generated by the so-called human factor. Therefore, without the analysis of establishment of the urban architectonics, it is impossible to perceive the prospects of aviation development as practical implementation and material base for globalization processes of information society.

Since the middle of the 18th century, owing to ramification transport communications system and growing scopes of industrial production, urban infrastructure saw permanent changes. Cities, and further megapolises, started to acquire universal characteristics, which became the first tangible sign of world's globalization. Not only did the urban landscape become universalized, but also the urban culture, way of reasoning, methodology of decision-taking, etc. That led to perception of the world's integrity, global relations, risks, collective responsibility, and also formed common needs, interests, values and aesthetical preferences of the people, raised the level of their social mobility.

The second half of the 20th century and the beginning of the 21th century marked the vigorous development of civil aviation. As a result, the preformed sensation of integrity of the humanity gradually found its practical embodiment. It was embodied in rearrangement of transport routes, urban architecture, change in the lifestyle, social and cultural rapprochement of social groups, broadening of outlook, raising the level of awareness, education, etc. As a result, not only did the physical space become more complicated and differentiated, but also the cultural one.

Consequently, the domain of aviation with all its infrastructure has become more significant driver of the referred processes, and it transformed into the sign of reality of the theoreticians' dreams of global society. The global consciousness transformed from a theoretical concept into the prospect for transformation of the social space and social time. Therefore, one may agree with the opinion of some researchers who reason that it is a cosmic civilization that opened for the humanity the path to self-organization as a way of self-regulation of social relations [1, p. 86]. That is, the domains of aviation and space have catalyzed the formation of ontological, informational and organizational integrity of the planetary society.

This objective became the most relevant in the information society that was the first to attribute the status of programmatic and conceptual social project to the issue of providing the integrity of the society. The successful implementation of a series of innovative decisions in the end of the 20th and the beginning of the 21th century transformed the borders of the countries of the geopolitical West into conventional lines of distribution of the spheres of influence. The resulting acceleration of the integration processes in the economic, cultural, legal, educational and military domains showed their both positive and negative sides. The destruction of cultural identities, the world's leading countries' implantation of the rules of production, exchange and consumption, which are favorable to them, subordination of the political establishment to the transnational corporations and centers of political influence, manipulative technologies and other factors testify to the hazards of destruction of the integrity and stability of the society.

Considering the above, we believe that it would be ample and timely to introduce the notions of "global reasoning", "global consciousness", "global identity", "collective mind", etc., into the notional and categorical base of social philosophy. They are intended to describe the social space as consolidated, capable of overcoming the internal conflicts, racial, religious and other forms of hatred. In other words, understanding the global consciousness as social and cultural practice, the society must find the sources and mechanisms for complementing the social space with a planetary, global dimension.

The aircraft industry and its corresponding infrastructure are intended for solving the referred issues. Owing to the civil aviation, human is capable of disobjectifying the globalization as a social and cultural phenomenon and economic and political project. The aviation laid the objective basis for identification of the humanity as a global society, perception of its integrity in the civilizational dimension. In contrast to the times of Socrates, Leonardo da Vinci, G. Galilei, J.-J. Rousseau, G. Hegel, K. Marx, O. Comte, when the idea of total integrity had the theoretical character and was not supported by the social facts, in the modern world, each event immediately impacts security and stability of individuals, groups and countries.

Furthermore, the focus on the cosmic and aerial space is characteristic of the function of bringing human to a level of global consciousness, distracting them from wars, reallocation of resources, obtrusion of subordination, etc., which were inherent in the previous historical epochs. The opinion as for the necessity of the departure from the planetary scopes was substantiated by the thinkers as early as in the beginning of the 20th century. Thus, M. Kholodnyy supported the opinion concerning the cosmic origin of human intelligence. The convincing argument of the "organic relation of mind with the entire space is the efficiency of applying the methods of mathematical analysis to precise description, explanation and forecasting of natural phenomena" [2, p. 146]. Regardless of the fact that the ideas of relation between human and the Space, which were proposed by M. Kholodnyy, are far from the status of instrumental knowledge, they bear methodological prescriptions which are important for the modern age, as the globalization, being accelerated by information networks and aerial communications, now provides human with grounds for perceiving themselves as a citizen of the world. Therefore, once they achieved a high level of social self-organization and explored its globalization potential, introduced information networks, humanity should depart from religious, ethical, aesthetical, judicial, educational and other kinds of confrontations. The peculiarities must be an adornment of the nations and countries rather than their burden, reason for conflicts, deaths and suffering. It is evident that such changes require evolution of the social consciousness, its departure for a global level which will be indifferent to differences as for its essence. However, on a level of of individual consciousness, such cautions are perceived as nothing more than moral prescriptions, and sometimes as an element of political struggle. Considering such statements appropriate, fair and important, human still does not take enough tangible measures for their implementation. And the problem consists not only in a lack of social confidence in the media of such information. Another hindering factor is also a lack of mechanisms for instituting social and cultural practices that would show the advantages of collective care for the future of the civilization.

An undeniable and evident argument in support of such conclusions is the increase of the social gap worldwide. Whereas the globalization processes partly cover negative social trends, the escalation of local conflicts and their destructive potential cannot be offset by the benefits and advantages of social, political, economic cooperation and that of other types. Therefore, "theoreticians and scientists gradually realize that, at the turn of the 20th and 21th centuries, one should be oriented towards new ways and samples of social development, basing on the available historical experience" [3, p. 401], searching them in the plane of social and cultural practices. Obviously, the development of aviation, space technologies, and their safety to the humanity is one of such practices, and social agents worldwide are involved in it now. However, even the interpretation of aviation as the world's peoples' requirement is challenged now by terrorism, financial crises, armed conflicts, etc.

From this prospective, the ICAO's activity is characteristic, as this organization set the objective of ensuring safe and well-ordered development of aviation as a global phenomenon. However, the analysis of the ICAO's documentation [4, 5] shows the inconsistence between the flight safety parameters with the challenges that the modern world is faced with. At present, we believe that aviation security cannot be reduced to a number of requirements to the equipment, pilots and air traffic controllers. We must admit that the globalized world is unified only on a communications level, while it is far from integrity in the plane of culture. The latter defragments the social reality, quite often reversing the efforts of air security experts.

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Airport as aesthetically organized living space

In the article the problem of the necessity of involving spiritual and aesthetical components into the structure of modern air-terminal is raised. The territory of the airport beyond its utilitarian and technical role should also become a space for the formation of human ideological culture, where an important role is played by the aesthetic and artistic component.

The emergence of aviation and the first flights marked not only the beginning of a new astronomical time – the twentieth century, but also a new social space-time continuum, a new space-time of human existence. For thousands of years people surveyed, experienced, learned and made habitable new lands, from the height of a horse or a camel, which they ride during military campaigns or caravan transitions. Created by human talent and creativity "winged horse" – an airplane for the first time raised man up to the celestial sphere. For centuries, the seemingly impossible flight on the winged car has become a reality. The distancies have reduced, time has shrunk and man's mentality has been changed. Man has become closer to the stars.

In the early twentieth century, new words were born and become actual that is "aviator", "airplane", "plane", "terminal", "airport", which were filled not only with the scientific and technical content, but also they were endowed with mythological, aesthetic qualities, inspiring to new horizons of creativity of not only scientific and technical thought, but also an artistic one. "I am all-powerful – I am an aviator!" – a futurist Igor Severianin wrote in his poem "The Aviator." "I broke the blue shade of color restrictions and came in white, follow me, aviators ..." – Kazimir Malevich called for avant-gardist artists. Alexander Blok emphasized that "the noise of the propeller has introduced a new sound into the world" [1, p.110].

The aesthetic factor is becoming an integral part of project design activity in the aviation industry. Our outstanding aircraft-designer O. Antonov has repeatedly stressed that "over the years some purely technical, computational and experimental, proven solutions were evolved. With this, sometimes even unconscious, information, the designer can often go from beauty to technique, from aesthetic solutions to technical ones. Here comes the designer-artist or artist-designer. In general, it is in a sense, a physicist – a lyricist" [2, p.48].

The outstanding designer 'words refer directly to the process of designing aircraft, but with good reason they can be attributed to the entire complex aviation complex such as the airport.

Even the appearance of the first airplanes made necessary the appearance of such area of aviation activity as a ground support of their flights. Today this function is performed by airports, which were called air stations at the dawn of civil aviation.

Modern airport in civil aviation – is a compound, unified complex of buildings, rich of technological equipment for adoption and maintenance of air transport including the runways, which is located between the service – technical and passenger areas. The central link of this complex technological body is the terminal. The air terminal is a kind of epicenter of the airport, a visible map showing both its advantages and disadvantages.

More recently, advantages and disadvantages centered on the solutions of comfort problems, convenience, speed of passage of the technological chain before boarding an aircraft. But over time, there appeared new problems that require timely solution.

These problems were caused by the way of modern life in a complex globalized world. Business travels, love to travel, overcoming of great distances, bound transfers from one aircraft to another, force many people to spend a lot of time in airports. It often excludes the possibility to leave the airport. Passengers had to look for ways to fill the void of time and to search for fun in the long periods of expectations and unanticipated delays in flights.

Passengers polls carried out in various airports around the world have shown that people, being surrounded by the most advanced modern technology, experience the deficit in cultural and spiritual components – the lack of recreation areas with elements of natural gardens, art projects that can restore and maintain emotional and spiritual state of man.

Gradually, starting from the middle of the twentieth century the aesthetic factor begins to actively influence the whole process in the airport, and air-terminal in particular.

This moment is marked not only in the aesthetic organization of the internal space of the terminal, but also in the architectural design of the exterior of the building, which is to express and create a special atmosphere to air passengers before the flight or upon landing. With confidence we can state that air terminals of the best airports in the world, such as terminals Kansai International Airportand Osaka in Japan; Marrakech in Morocco; Sondika Bilbao in Spain – are not only the top of technical design ideas, but also the works of high architectural art, solving an important aesthetic problem – the formation of the artistic taste of a person, preservation and augmentation of human in man. Modern airports are rightly called the visiting card not only of a city but also of the country.

It is pleasant to realize that now they begin to use the territory of the airport as a space for the formation of human ideological culture, where an important role is played by the aesthetic, artistic component. In the airport terminal areas art projects are organized: art exhibitions of paintings, sculptures, works of decorative art, artistic photos, viewings of films, "live" concerts of symphonic, jazz and popular music. These art projects have a wide resonance not only with the public, who will soon take their seats on the plane and leave the airport, but also for art lovers, who specially come to the airport to meet with one or another art project.

Despite the economic crisis, complicated political and military situation, which had a direct impact on the life activity of the whole complex of Ukrainian civil aviation, the head of the International airport "Borispol" Evgen Dykhne believes that "the idea of creating an art space in the framework of the country's main airport arose from the desire to show our passengers, especially from foreign countries, – versatility and originality of the Ukrainian culture. Airport, – said the head – is not just the aircraft maintenance, but

7 million passengers from around the world annually and approximately 17-25 thousand daily. As you know, the art speaks the universal language that needs no translation"[3].

The modern world is too full of communication and the whole communicative flow often turns into a monotonous or protocol chatter and society is deleted into silence and inaction. But in any negative phenomena there always seen a positive moment of the formation of something new, and in this case, it is the process of forming a unique culture of silence and action. Such action is carried out primarily in the art, using a variety of its forms and directions.

Airport space granted for aesthetical aims is a field of live communication for artists, poets, performers with the audience, where cultural dialogue, personal exchange of ideas, world outlooks and emotional mood take place. And for the airports themselves such art projects enhance their prestige and contribute to obtaining of financial investments.

Therefore, modern airports have become a phenomenon of intercultural communication, where the aesthetic and artistic tastes are formed, the practice of tolerance, mutual understanding and the development of new cultural traditions are carried out.

Training specialists in the field of aviation, in particular the personnel who guarantee smooth operation of the airport, it is to be taken into account not only their technical skills, but also worldview guidelines in the field of aesthetic and artistic culture.

We consider this aspect an important and urgent one, because the social space and time proper, the dynamics of the globalized world economy, the growth of free competition in the world markets, including the air passenger transport, in particular, toughen the requirements for the aviation industry of our country both as a whole and to workers in all its structural units.

ICAO forecasts, over the next fifteen years, airports have to be ready to double the amount of passenger traffic. Undoubtedly this is a positive tendency for the industry. But the question remains: "Will Ukraine be able to take its place in this process?" One of the decisive factors in a positive answer to this question is still the same "human factor".

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Information technologies and human factor in civil aviation

The article makes the philosophical analysis of correlation of information and communication systems, modern means of communications and navigation, and the role of the human factor in increasing the safety of aircraft flying in civil aviation.

At the beginning of the third millennium the information technology as an innovative form of communication, penetrate into all spheres of human activity and provide the expansion of information flows in society. New information technologies provide new forms of relationships between people, change the scheme of social interdependence, and become an integral part of education and science, and they intervene in every aspect of our personal lives. The origin of technical means that provide access of the biggest part of human to the information reality enables us to characterize this process as an intellectual "information and communication revolution" [5]. Of course, the aviation industry, which has always been at the cutting edge of high technology, could not avoid the "information and communication revolution".

When the first aircraft soared into the air, communication between pilots and ground services was not possible due to lack of appropriate technical means of communication. The process of human interaction with the aircraft was limited by simple pilot`s movement responses. However, today because of permanent development of aircraft, the pilot has to work with complex information system. This system combines the operation of all aircraft maintenance services and the airport together. Nevertheless, the role of information technology in the aviation industry is not restricted by this factor, especially when we talk about the civil aviation. However, if transportation services are offered by the airlines identical, the introduction of new services, that enhance passenger comfort, is impossible without the use of advanced information technologies. They are the automated sales and booking of air tickets through the Internet and registration system, and even the possibility of mobile communications on board. However, the usage of high-tech information systems, as well as in the area of safety and creation of comfortable conditions for passengers does not diminish the role of human factors in aviation.

In the aviation industry the concept of "human factor" includes many elements related to human behavior and his/her efficiency, the ways of decision-making, uninterrupted information operation of navigation systems work and others. According to the definition adopted by ICAO "human factors is about people in their living and working situations; about their relationship with machines, with procedures and with the environment about them; and also about their relationships with other people" [6]. One definition of Human Factors, as proposed by Professor Edwards, declares that "Human Factors is concerned to optimize the relationship between people and their activities, by the systematic application of human sciences, integrated within the framework of systems engineering. So, if the quality of passenger service is low (e.g., lost luggage, delayed flights, service on board and so on) none of the newest information system can`t change the negative passenger impression from the flight caused by human factor. Therefore, the safety of flights and handle of emergencies depends on the human factor, the understanding and communication between crewmembers, the organization of work of ground services. Thus, the origin of the information and communication systems in aviation requires the availability of professionals, which corresponds to the level of new technical capabilities of modern aircraft. These professionals throughout their professional activities must be able to work with high-tech means of communications and navigation, to learn quickly and use their new knowledge, to be able to handle large amounts of information and so on.

The usage of ground and airborne information satellite vehicle for communication and multifunctional space systems, avionics, that is based on satellite technologies for communication, navigation, control and organization of air traffic will improve the level of aviation security in several times in future [3]. As you can see, information and communication systems are closely related to flight safety. And such qualities as: the ability to communicate, to cooperate in a team, the responsibility and the initiative are necessary for aviation industry professionals, especially for pilots and flight operations officers. The crew members, flight operations officers and pilots must be quick to understand each other, because their interaction, intuition and ability to resolve conflicts can save many lives. Therefore, all messages should be clear, understandable and unambiguous. And the cultural differences, language barriers, inattention, fatigue, stress and so on can prevent this. In this regard, some researcers have noted the need not only the professional, but also psycho-physiological and mental training of professionals.

We should not underestimate the special place of information technology in the training of aspirant pilots. In particular, when we talk about professional language training of pilots for conduction of the radio communications on international routes; the development of new methods of training of the aspirant pilots of flying aircraft operating on international routes; about the methods of training aspirant flight operations officers of air traffic control in extreme situations on international air routes and so on [2]. The above-mentioned abilities reveal some aspects of usage of information and computer technologies in aviation industry training, including air comunicators. It is referred to the field of aviation industry where engineers work and their activity involved to the development, production, testing, repairing or disposing of aircrafts; the design engineers that design aircraft and aircraft engines, mechanical engineers which are responsible for production, maintenance and repair of aircrafts; wireless engineers which are the specialists in the field of development, production and operation of aircrafts etc.

Among these are aviation specialists and operators – pilots and air towermen, and from their ability to work with information systems, the possessiveness of the necessary communication skills depends not only the success of professional work and career, but also the safety and life of the participants of the communicative process. Because flight activity is one of the most difficult, and the modern aircraft crew managed "not the physical object itself, but its information model" [2]. Therefore, the safety of flight depends on the reliability, accuracy and efficiency of receiving the information by aviation operator and reduces the risk of accidents, related to the human factor. As V. Tsvetkov noted, the missunderstanding of the information and its transmission can cause many difficult situations in the air, which can cause the accidents [8]. We can find the confirmation of this point of view in B. Alyakrynskyi`s works, who notes that the lack of practical skills and abilities during the providing of wireless communication, bad articulation, lack of literacy teams, the using of words in the message, that allow semantic distortion, is one of the causes of aviation accidents [1].

To sum up, we can conclude that aircraft operators often have some lack of needed skills while working with the newest information and communication and navigation systems, and it negatively reflected on the safety of aircraft flights. Today one of the most important component in the providing of the security of planes overhead lines is highly professional activities of air carriers. The effective and reliable pilot`s communication with the flight operations officers who accompanying the aircraft in all phases of flight, from the moment of takeoff to the moment of landing, is one of the factors of flight safety. In addition, according to statistics, the most incidents of aircraft in international air routes happens because of poor cooperation between the flight operations officers and the pilots of aircrafts. Therefore, some scientists offer to examine the pilots` professional reliability through the prism of aviation system, each of its component, which has its own specific characteristics. Thus, the scientists focus on one of the most important features of the pilot profession, namely that the pilot`s activity in normal situations and in extreme cases, are two different activities. As in "... an extraordinary situation not stereotypes are needed, but new forms of reaction" [7]. The hope that only pilot`s own experience will allow him to cope successfully in difficult conditions of the flight is almost reasonable. However, the complexity and diversity of the human factor cause the need to explore everything ... in philosophical analysis of the interaction between human and technical devices [4, p. 31]. Taking into consideration that flight safety is largely dependent on flight operations officer`s and pilots` language training and training skills in information and communication systems, the special attention to the problems of communication in the air are taken not only by the scientists, but also by the world organizations, such as the International Civil Aviation Organization.

Conclusions

The aviation industry plays an increasing role in the system and passenger carrying operations in the world. The quality of provided services and the level of safety of passengers depend on the spread of information technology in the aviation. Because the way of their usage ensures the implementation of communicative exchange between airports, access to global aviation systems and networks for information exchange that contributes not only the increasing of flight safety, but also the improvement the passengers` level of comfort. We talk about the using of the Distributed Control System SDCs, the SITATEX (the leading operational mail service in the air transport industry) delivery, the World Tracer (the *world's* only global bag-tracing and matching system) and others.

The improvement of the technical capacities of flight, the emergence of *Airplane Information Management System* does not completely eliminate the risk of dangerous accidents. New information and communication technologies and satellite-based aviation communication system modify qualitatively the whole process of pilots` professional activity; change the mechanism of interaction between machine and human. As a result, the using of multimedia resources in training of aviation professionals, including interactive tools and software, Internet resources and simulators, will have a positive impact on the level of training of airline operators. Although we can't certainly predict the pilot`s reaction in situation, we do not have to forget that the current level of technology doesn`t completely eliminate human intervention at the stage of decision-making and any computer can`t replace the human being.

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The safety of aviation industry in terms of modern challenges and promoting the aviation education

It is noticed that aviation is a strategic sphere of each country. It is the prestige, security and wellbeing. It is considered that threat prevention, establishment of appropriate level of safety and comfort is the goal of professional management in any field, but the most important is this problem in aviation.

The aviation industry is sensitive to changes in the economy, but it is sensitive to the political situation. Status of hybrid war with neighboring countries can not affect the expectations and fears of the risks of air travel. Affect it, and the threat of international terrorism, which became a significant risk factor for the global aviation industry. And although Ukraine did not know high-profile cases of this format, the idea of international terrorism, its forms and scenarios have long attracted the attention of the world, where there is no exception and the Ukrainian community. Threat prevention, the establishment of appropriate level of safety and comfort is the goal of professional management in any field, but the most important is this problem in aviation.

In the context of overcoming the current challenges in the field of air services we need to develop a theory and strategy for the development of safety aviation industry. The theoretical security of the aviation industry should implement the following steps: – to study the principles, patterns and features (conditions) of the aviation security need to use the methods of scientific analysis, as they themselves only empirical methods and they do not provide the ability to penetrate deeply into the essence and genesis of security and problems of its protection;

– need to carry out in-depth philosophical and political analysis of the process of ensuring aviation safety;

– need to conduct a study of normative and value the essence of aviation security;

– need to analyze regulatory aviation security.

Using a philosophical-political analysis provides an opportunity to consider the process security from different angles, primarily noting its focus on the protection of the rights and freedoms of citizens, their life and health, to protect the interests of life of large social communities and to protect and support the security of the state. Legal analysis will find out the specifics and limits of legal regulation of activities of subjects and objects of aviation safety in the framework of current legislation. Analysis of the results of the study of moral-axiological essence of security will provide an opportunity to clarify the appropriate ethical norms-constraints that can influence the choice of forces, means and methods of security, and therefore on the nature of the interaction of subjects and objects of security.

But for a comprehensive and thorough analysis of aviation security at all levels (individual, national, international) should use a systematic approach taking into account the whole range of modern processes, among which we can name: – the increasing role of transport factors, in particular flights in the sphere of ensuring global and national security;

– increasing interconnectedness of the global security with security systems of nation and states;

– the formation of new parameters of international security in the conditions of growth of terrorist and asymmetric threats;

– the emergence of modern methods and principles of safety at various levels, aimed at the achievement of harmonious interaction of social, economic, political relations and relations in a particular community.

Analysis of all the above-mentioned trends will give you the opportunity to find out the dangers and threats that exist in the aviation sector and identify ways of overcoming threats in this region.

Analyzing the security Strategy of the aviation industry, it should be noted that it should have the following main directions:

1) continuous monitoring of threats and challenges in the aviation industry with analysis of the level of danger of such threats [2];

2) developing programmes for aviation security in the short, medium and long term; 3) development of legislative ensuring of aviation security [4];

4) preparation of the structures and bodies that have to implement aviation security; 5) appropriate financial, logistical, and staffing structures of aviation security. In a practical implementation for the implementation of aviation security requires a differentiated approach. This should take into account the political situation in any particular country, the socio-historical features of formation of the country, demographic and migration processes, cultural characteristics, ethnic composition of the population, the ratio of titular and non-titular nationalities, religious characteristics, etc.

Developing ways of optimizing aviation security in the context of national security as a whole, need to promote the formation of national security not only as the characteristics of threat protection, as it is regulated by law social relations, reflecting the state of national security. And the important role it has to play and civil society. So the researcher G. V. Novitsky believes that the key components of national security should be the analysis, forecasting and control of civil society the status of national security [3, p. 143]. With this approach, all the activities of the state may be regulated and assessed through the prism of national security by the gradual establishment of the relevant branch of law in the legal system of Ukraine. This will contribute to the formation of a contract (security) state model in Ukraine. Of course, policy-making aviation security it is necessary to consider international experience in this area, analyzing relevant international legal norms and acts.

Professional management involves conducting professional policy, quality of recruiting personnel. Here, important areas are issued by professional selection of specialists in civilized countries and are in different directions. Unfortunately our country is not yet realized the need, which in most cases is not even conscious. So, according to sociological research of public organization "Democratic initiatives of the youth" almost 45% of HR medium and large enterprises in Ukraine are not only used for recruiting special tests, but did not even see the need in it. Testing when applying for a job in airline industry in the West takes place in several stages and in a number of areas

[5]. And this applies not only to assessments of professional competence and psychological relevance of the posts and most importantly – the general level of erudition, of philosophical attitudes and level of personal development. The man who works at the airport should be aware of the whole spectrum of risks, understand human psychology and have an idea of how behave in different situations. It is important to understand the ethno-cultural specificity of the passengers, their cultural differences, religious beliefs. And this is important not only from the standpoint of maintaining a high level of tolerance in such places as airports, but directly related to transportation safety and the image of the country. Knowledge and awareness with the political situation of the country is also crucial for employees of the airports. This knowledge is acquired the system of higher education for courses of sociology, political science, philosophy, religious studies. Promoting the quality of aviation education is a question of the image of the country and state security because the transit of narcotic substances and smuggling of large batches of the aircraft, and a powerful political terrorist threats are often just a strategic point as the airport [1, p. 34].

Analysis of the results of the study of moral and value level of personal development will give the opportunity to clarify the appropriate ethical norms-constraints that can influence the choice of profession, tools and methods of professionalization, and therefore on the nature of the teaching profession, familiarization with security skills [6].

But for the comprehensive and detailed testing of personnel at all levels (psychological, professional, ideological) we should use a systematic approach taking into account the whole range of modern processes, of which has to be a knowledgeable employee of the aviation industry among which we can name: – aviation security issues;

– ethno-cultural specificity of passengers;
– political processes and phenomena;
– social phenomena and social behaviors
– crowd psychology.

In a practical implementation we should have appropriate knowledge or wide experience, or differentiated approach of teaching. This should take into account the political situation in any particular country, the socio-historical features of formation of the country, demographic and migration processes, cultural characteristics, ethnic composition of the population, the ratio of titular and non-titular nationalities, religious characteristics, etc.

Developing ways of optimizing aviation education in the context of national security as a whole we need to promote the formation of philosophical ideas and develop their personalities not only as knowledge for the protection against threats, but humanistic picture of the world. And the important role should have the public policy, understanding the role of politics and values. With this approach the whole education of aviators can be resolved and evaluated through the prism of national security by the progressive humanization of professional education of aviators, creating appropriate educational programs. This will contribute to the formation of a contract (security) state model in Ukraine.

Conclusions

Summing up, it should be noted that more relevance will be an understanding at the state level and we need total modernization of the system of recruiting pilots, borrowing the best global practices, forming a complete system of personnel selection. But we should start with the modernization of education in general. Summing up, it should be noted that the implementation of these measures will allow for the proper level to provide the level of aviation security.

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Human factor in aircraft maintenance

The article deals with issues concerning aviation human factors and aircraft maintenance. We know that research in normal operational environments indicates that the formal requirements for the aircraft maintenance system are frequently not fully or effectively implemented in practice.

The maintenance technician operates under a set of approvals to undertake maintenance work on specified aircraft types, and to certify that the work has been carried out according to the correct procedures. The basis of this is the certification of competence in compliance with the requirements of JAR 66. The ADAMS project provided the opportunity to study the functioning of four European aircraft maintenance organisations Auditing practices vary widely between different maintenance organisations and national aviation authorities. While all organisations place emphasis on effective auditing of documentation, some audit fixed facilities and resources, but few attempt to audit how work is actually done. There are no common auditing standards. Few quality-reporting systems work as they should, particularly in dealing with human factors information. Some organisations are only starting to implement a quality discrepancy reporting system, and either it only covers part of their operation or many technicians are not aware of its existence. For some it is not seen to be sufficiently independent of the disciplinary process to be fully trusted. For others there is a large volume of reports which give rise to a backlog and long delays on responding. Part of the problem is reported to be getting managers to take responsibility for dealing with reports when they have other more pressing matters to attend to. Organisations are not learning from their incidents. Following incidents or accidents, it is critical to future safety that organisations learn from what has happened and implement change to prevent similar incidents occurring. This is particularly true of the human and organisational factors which contribute to incidents. It is hard to find information on cases where learning and change has occurred. The Case Study on "Organisational learning from incidents" demonstrates that, often, despite focused efforts to solve the problem, incidents may have to occur several times before effective change happens. Organisations are rarely systematic in their follow-up to non-technical aspects of incidents, specifically the implementation of recommendations, the monitoring of their effectiveness in addressing the problems they are designed to change and ensuring that knock-on problems are avoided. Maintenance engineers completed 286 questionnaires after they had completed a task. The questionnaire sought primarily to discover the normative level of deviation from task procedures, as well as inquiring into the reasons behind this non-conformance. 34% of respondents reported not-following the official procedure for the task. The most common reason given was that there was an easier way than the official method (45%) followed by 43% saying there was a quicker way. A number of factors which were related to increased likelihood of non-conformance were identified. Those individuals who consulted the manual but did not follow the official method were significantly more likely to report that: "the task card was unclear;

- the necessary steps to complete the task were unclear;
- to have employed guesswork or trial and error;

Increasingly, evidence from major incident and accident enquiries is implicating failures at an organisational and regulatory level. Of particular concern are situations where there have been a series of incidents exhibiting similar underlying organisational problems, while the immediate characteristics of the incident might be quite different. For the official investigators and the authorities, it is difficult to know whether the recommendations from investigations have been implemented and, if so, whether they have been effective. The development of design for maintainability guidelines and the integration of these guidelines into design tools and standards is one of the main strands of the work-programme of a new project under the CSG Aeronautics programme – ADAMS-2 – Human centred systems for aircraft dispatch and maintenance safety. Training to develop human factors competence is, of course, one of the elements which is critical to successful implementation of the different components of a human-centred management. Building on the initial findings of the ADAMS project, initiatives to develop, implement and evaluate training have been pursued at three levels:

- a core human factors training programme adaptable for training technicians, trainers, supervisors and managers has been completed in the STAMINA project (Leonardo programme);
- a cost-effective approach to ensuring effective human factors training requires the integrating human factors into technical training. AITRAM (1ST programme) is developing a virtual reality environment to demonstrate how this should be done; developing competence in-depth for human factors specialists is critical to ensuring that the opportunities for change are taken, and that human factors programmes are effectively managed. The STAMP project (Leonardo programme) is developing accredited training courses for such specialists.

If human factors programmes are to be more successful in the future than they have been in the past, then they need to offer a strategic vision not only of what benefits thy can bring to the organisation, but also of how to achieve these benefits. A major strand of the ADAMS-2 project is to develop an organisational model of the implementation process for the tools and methodologies developed in the projects described here. In parallel with this a strategic cost-benefit model will be developed. Both the organisational and cost-benefit models will be tested and elaborated through implementation case studies.

Conclusions

Coming to the end of my presentation, in which you were briefly introduced to human systems and aircraft maintenance, the ADAMS project has documented major deficiencies in how the aircraft maintenance system manages non-technical (human factors) information. These deficiencies can be characterised as a double standard – an official way of working, which is publicly acknowledged, and an unofficial way in which much maintenance work is actually done. Breaking down this double standard will require a comprehensive systems approach.

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Physical education syllabus optimization for students with poor health

Physical exercises used in the course of physical education of students with disabilities, increase the body's resistance to various stress factors by creating psychological relaxation and improve emotional state, contribute to the development of physiological functions and motor characteristics, thus improving the level of mental and physical health of students.

Latest research and publications review. One of the mainissues in the focus of modern pedagogics is the development of current educational and preventive healthcare technologies that promote and maintain the health of young people and the development of body potential. The system of higher professional education prioritizes the intellectual development of students at the expense of physical development and health. Therefore, a recent increase in the number of students with diseases can be observed, more than 50 % of students have poor health, and 80 % suffer from hypodynamia.

There is a dissatisfaction among the students' community with the content of the Physical education academic studies, which has a negative impact on the level of physical development and health condition. Consequently, the search for effective ways of revitalizing the students, improvement of their physical development and training, introduction of a healthy lifestyle become topical. One of the most effective ways of solving this problem is the optimization of Physical education syllabuses for students by introducing new types of physical activities.

Cardiovasculardiseases are the most common not only among adults but also among students. One of the reasons for the increasednumber of cardiovascular system diseasesamong students is the reduction in the level of their physical activity.

Physical exercises play a key role in the prevention of cardiovascular systemdiseases, as they compensate the lack of students' physical activities. Activation of motoring mode through exercise improves the function of various kinds of systems that regulate blood circulation, improves myocardial contractile properties, reduces blood lipids and cholesterol in blood, reduces hypoxia due to the development of collateral vessels and eliminates all manifestations of the majority of risk factors for diseases of the cardiovascular system.

Following the above-said, we draw a conclusion that it is very topical to systemize the means of the classes, particularities of employing them at physical education classes, depending on the nosology of the disease, and to study contraindications while doing exercisesby the students with cardiovascular system diseases.

The objective of the research is to identify the ways of optimizing the physical education curriculum for students with poor health as a result of cardiovascular system diseases.

Materials and methods of the research. Thefollowing methods were employed for achieving the set objective: analysis of scientific and methodological literature, syllabuses on Physical education for higher educational institutions, best practices ofadvancedteaching practice, analysis of medical records. The studies were conducted at the National Aviation University among the 1-st year students that have variations in health status (n = 386).

Results and discussion. The results of the study show that more than 10 % (386 people) of the 1-st year students at the National Aviation University have deviations in health condition. The majority of students (43%) have cardiovascular system diseases, 24 % suffer from diseases and traumas of the musculoskeletal system. 8 % of the students have various degrees of myopia and astigmatism, 6 % have diseases of the gastrointestinal tract. Students with kidney and urinary tract diseases occur in 5 % of cases, and with diseases of the respiratory system – in 4 % of cases.

Thus, all the students with deviations in health condition may be streamed into three groups for classes of Physical education (in compliance with recommendations, set forward by S. N. Popova).

The most numerous among the surveyed students with deviations in health condition wasa group, composed of students with diseases of cardiovascular and respiratory systems (47%).

The second group (29%) included the students with diseases of other internal organs (gastrointestinal tract, genitourinary system), with impaired metabolic processes, myopia.

Students with diseases and traumas of the musculoskeletal system, osteochondrosis, scoliosis and flat feet make up the third group (24 %).

The specificity of the educational process of this contingent of students is determined by a number of specific features. The most important of them are stiffness and self-absorption, discrepancy betweenlarge amounts of technical information and the physiological state, low motivation to physical training. It is indisputable, thatphysical abilities of such students are severely limited; however, most of them are recommended to engage in physical exercise and therapeutic physical training.

Judging by the results of the present research, students with diseases of the cardiovascular system account for 43 % of all the students in the special medical group. The most common diseases are hypertension, essential hypotension, acquired valvular defects.

Classification of physical exercises class facilities for the students with major diseases of cardiovascular system are shown in Table 1.

Table 1

Systematization of physical exercise for students with diseases of the cardiovascular system

Characteristic	Disease		
	hypertension	Neurocirculatory hypotension	acquired heart valvular disease
Tasks of the class	to improve peripheral circulation and blood flow to the coronary system, to enhance reductive-oxidative processes in myocardium		

Main techniques used in class	breathing exercises, coordination and balance exercises, dosed walking, even running at a slow pace, skiing, swimming, hiking, rowing	breathing exercises, relaxation exercises, exercise with accessories, wall-bars exercises, simulator exercises, walking, skiing, cycling, action-oriented games, elements of sport games, swimming, rowing	coordination exercises, reaction rate exercises
Contraindi-cations	exercises which require maximum stress; exercise, requiring intense concentration and situational change reaction time;body shaking exercises, abrupt movements exercises, exercises with deep bents	breath-holding exercises while doing power training	exercises which set high requirements on the circulatory organs and the body as a whole; exercises with power training loads and nervous-and-emotional tension

Doing physical exercises in the case of cardiovascular diseases can involve the following mechanisms of therapeutic effect: tonic effect, trophic activity, compensatory mechanisms of activity and functions resetting. Aerobic exercises improve heart blood supply due to the disclosure of reserve capillaries, the development of collateral circulation, activation of metabolic processes. Exercises aimed at small muscle groups improve the veinbloodcirculation, acting as a muscle pump, cause dilation of arterioles, reduce peripheral arterial resistance to blood flow. Breathing exercises facilitate the flow of venous blood to the heart by rhythmic changes in intrathoracic and intra-abdominal pressure.

With the aim of increasing motivation to physical activities it is necessary to integrate different kinds, means and methods of physical fitness in the process of physical education of students with poor health (table 2).

Table 2

Innovative types of motor activity, which are recommended for students with diseases of the cardiovascular system

Orientation training	Innovative forms of motor activity
Aerobics	Low, Latina, Funk, Jazz
Aerobic exercise	Nordic walking, recreational swimming, cycling
Aqua Aerobics	Aqua Gym, Aqua Swim

Strength training	Callanetics, Fit-ball, Wellness Training (Light Training), Stretching-press
Mind & Body	Pilates, Yoga, Fitness Yoga
Special classes	Stretching, Body Balance, Power Flex, Relax (breathing exercises, relaxation exercises)

Atclasses of Physical education for students with poor healthit is recommended to use: recreational walking and jogging, medium – and low-intensity aerobics, fitness programswith elements of eastern recreational gymnastics and martial arts, fitness programs with power training, breathing exercises, stretching, relaxation exercises.

Conclusions

1. To summarize the above-mentioned, we can state that the usage of different types of fitness in the process of physical education of students with poor health helps to increase students' motivation to different kinds of motor activities, to introduce the healthy lifestyle with the aim of improving students' bodies adaptation to workload in the process of studying and in their future professional activity.

2. The process of physical education of students with diseases of cardiovascular system requires the use of special techniquesin class depending on the disease nosology with the aim of normalizing the cardiovascular system adaptation processes, impact enhancement of energy and regenerative mechanisms, recovery of impaired functions and structures. Physical exercises, which are used in the process of physical education of students with physical impairments, increase the body resistance to stress by means of creating psychological discharge and improvement of the emotional state, promote the development of physiological functions and motor characteristics, thus improving the level of mental and physical efficiency of students.

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Social work with airports passengers

Social work at the airport is in to offer to passengers social services. The main methodological position is that people are under stress, which characterized by a particular set of characteristics in appearance and behavior. In such circumstances passenger attracts in his actions some attention. Only person whom he trusts can help him with the documents or psychologically.

Relevance of the study of the topic determined by the realities of the current situation in civil aviation. Nowadays, the problem of stress state of fear of flying, flight safety and the possibility of accidents has been and remains one of the most serious problems of modern society.

Worldwide the budgets of the leading countries support with the huge amounts of money the safety of passengers at airports. Heads of many countries call the fight of terrorism as one of the main directions of their policy.

Social Work at the airport is to offer passengers of the airport social services. The main methodological position is that people are under stress, that characterized by a particular set of characteristics in appearance and behavior. In such circumstances, a passenger in his actions attracts the attention and to help him with the documents or psychologically can a person whom he trusts.

The study and systematization of these features gives an opportunity to create passenger profile, under which a person can be classified as dangerous. Accordingly, the whole passenger flow is analyzed under a certain scheme that can detect signs and prevent crises.

At the airport, where the situation itself provides an increased level of responsibility, a passenger in a stressful condition become automatically dangerous. Stress and anxiety heightened state may intensify human's behavior to a critical level.

The impact of stress on consciousness, human activities, its ability to control own actions and finally, the effects of stress – one of the most pressing problems of our time. It attracts the attention not only of psychologists, but also experts in the field of social work.

In literature the term "stress" (or "emotional stress"), "mental tension" is often used interchangeably. These terms describe the features of mental activity, the functioning of the human psyche in difficult, extreme, unknown, unusual conditions.

Arising, stress initially mobilize to certain limits internal resources of the psyche, the whole human body, its adaptive capabilities, strong-willed, physical, cognitive activity and therefore is a kind of stimulating factor, which positively affects the efficiency of life. Due to this, especially at the first beginning, indicators of person's performance of simple and also more difficult tasks are certainly improved. It manifests the mobilizing effect of stress.

However, prolonged impact of adversely conditions such as aviation flight delay for some reason, as the depletion of the protective, adaptive reserves of the body and stress can lead to the opposite (negative) results and provide disruptive, disorganized health effects, human psyche that often leads to its frustration, negatively influencing the behavior.

The rapid changes of the social environment, extreme conditions of activity significantly contribute to the subject's position: acute shortage of time, efforts and resources; uncertainty, incomplete awareness of the situations; high-conflict selection of decisions, especially with inconsistent motivation; excessive motivation of social origin; high self-esteem of the subject in the absence of real opportunities, stay at the destination according to the scheduled traffic. Strong stressors can be a threat to life, health, welfare, and a similar threat to his family and friends, a sense of helplessness, physical or mental helplessness because of the attack, environmental disaster and so on.

State of short-term stress by passenger is marked with a sharp quickening and violation heart rhythm and respiration, also copious sweat, abrupt changes in pupil diameter, vasomotor reactions on the face. All these objective changes find its reflection in the subjective feelings of the person, who experience stress during passport control at airports or waits for plane delaying for a long time and absence of information. A person in a state of psychological stress usually feels different negative emotions standing in line or waiting for the flight. Especially when you have to answer questions not knowing the language or not understanding the question of border guards. Possible reaction of the body to stress could be: pain in the heart and other organs, difficulty in breathing, muscle tension, discomfort in the digestive organs, and others.

Factors, which are contributing to the emergence of emotional stress in these situations may be: insufficient information to passengers, its contradictions, excessive diversity or monotony, and also assessment work that exceeds the capacity of the individual in scope or degree of difficulty. Controversial or uncertain border requirements, critical circumstances or risks for possible future decisions, answer on questions about purpose of entry or exit, refusing to cross the border, lead to stress. Not every passenger (customer of social work) refers to the Information Centre under stress, it is necessary to detect.

Thus, the problem of mental adaptation of social work client (passenger) is important in the sphere of scientific researches, which locates at the junction of various branches of knowledge that obtain in the current conditions more importance. In this regard, the concept of adaptation can be considered as one of the most promising approaches to the complex study of human Aviation passenger.

In the case of a flight delay for a long time psychologists or social workers of social service at the airport assume responsibilities in detection of passenger's behavior, assisting, mediation in checking documents, and further supporting of provision of social assistance. External signs will help to create a complete picture of the passenger and to decide about social assistance in a difficult situation at the airport.

The situation at the airport can be daunting during the cancelling flights, secrecy of information, and lack of understanding of the circumstances. Long-term stay of a large number of passengers at the airport could lead to unpredictable consequences.

Social workers being in the halls of the airport with special distinction in clothes such as tie, scarf, badge, pleasant appearance and so on will attract the attention of the worried person and that will help to receive social services.

Also the great importance play the behavior of a person who is in stress, or passenger who is trying to carry on board any of the prohibited items, materials. Their withdrawal may create a situation of stress.

In general, the concept of stress of passengers at the airport is specific to the security service of the transport sector and requires a specific study. This article aims to reveal and identify opportunities to create social service at the airports and support the importance for social work.

The very definition of potentially dangerous passengers includes to the concept of so-called “profiling” – a method of combating acts of unlawful interference with psychological methods. Profiling is the main tool of psychological department of airport security, which require more detailed consideration.

It should be noted that at the airports one can observe the work of employees of airlines and border guards, who check luggage, documents, goal of passenger’s traffic, etc. Thus, during the formal passport control of passenger is minimized and often leads to internal and external stress.

We reviewed the question of fear aviation flights. We must consider that people do not fly by nature, so many people, in one way or another, experience inherent fear of heights. In some cases, the fear is based only on this natural component, while thinking ascribes the fear of disaster and so on. D. The key of positive thinking should be educated by each person.

Like any fear, concern of flights can happen due to stress-filled experience, for example, from an unsuccessful trip with great turbulence or through the stories of experienced seemed.

Thus, the experience and own imagination build a variety of pictures that support a strong feeling of fear of flights by the airplane. Exactly social service professionals can help passengers to cope with the emotions caused by the danger.

One of the ways to calm passenger is communicating with social worker from the social office of airport, who will provide such assistance if possible: firstly, the discharge of cell excitation; secondly, to switch to an interesting topic; thirdly, jointly to search for the way to solve the stress state, emotions, or at least to reduce its significance.

For reaching of an optimal effect in the activities and to eliminate the adverse effects of overstimulation it is desirable to relieve emotional tension based on attention concentration not on the significance of the result, but on the analysis of causes, explaining technical capabilities of aviation vehicles to passenger.

For creating an optimal emotional state are required: correct assessment of the significance of the event, sufficient awareness (diversity) on the subject, events, and spare compensation strategy. This reduces unnecessary excitement, reduces fear to get an unfavorable decision, and creates optimal background to deal with problems.

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Intellectual mobility of the flight crew members

The article deals with the problem of providing intellectual mobility of the flight crew members. It explains the essence of training and retraining these specialists of the quality. The definition of intellectual mobility as an integrated characteristic (quality) of a personality is given and its structure (motivational, cognitive, operational-and-technological, social and personal components) is also described here.

Taking into consideration a flight crew members's career, we should notice, that the world of aviation changes in so many aspects that it also affects his or her day-to-day work. Present system of air transport is undergoing fundamental transformation, flight crew members's operations and responsibilities also change as new technologies and new aircraft are being introduced, causing impact on the profession. Any time the flight crew member needs to stay proficient and fluent combining his thorough education with a constant development throughout the entire career of a professional flight crew member. This enormous challenge requires career long studying, training and even passing exams.

No two persons either students or trainees are the same. Initial experience and skill levels of flight crew members also may be different, as well as their individual ability to learn certain concepts and skills at different rates. Doubtlessly, there should exist effective training programs to provide the required flexibility to ensure each flight crew member's skill set meeting and exceeding the required proficiency and fluency to safely operate in the complex airspace environment, where the human factor issue is one of the most major problems. Human factor, essentially, combines mental, physiological, biomechanical, anthropometrical and other human features, determined by the criteria of human to machine compatibility [1, 2], representing the dependence of human activity on constructive and technological parameters of the machinery applied and involves all variables that influence the reliability and efficiency of pilot to machine integration [3].

Since the demand for flight crew members does incorporate not only the basic flying skills, additional skills and competencies certainly need to be taken care of. Flight crew member's technical knowledge and skills are not sufficient to be relied solely on to safely operate professionally. For them it is important to train both technical and non-technical skills. All positive and negative results of incidents and accidents in the aviation industry are directly traced to critical non-technical skills. Non-technical skills are represented in all pilot training courses, either initial training or recurrent training or requalification or initial operating experience. They are difficult to quantify concepts like motivation, social interaction, leadership and followership, common sense and logic, and communication skills.

One of the most important issues within the problem of professional reliability of the flight crew members is the ability to communicate skillfully in professional situations, to acquire interpersonal contacts, especially, to perform communication within the flight crew has become of crucial significance.It is understandable, that English is the aviation language, but as this is not the mother tongue for all of the aviation professionals there are two caveats that need to be taken into consideration. Firstly, flight crew member should all communicate in English fluently enough. This does not only mean being able to speak and understand standard phraseology within their profession. Secondly, the way people express themselves is different, which is caused by their own cultural background, even if all of them speak English. Cultural differences need to be taken into account to provide for a positive and safe working environment in the cockpit, in the cabin, on board the aircraft and within a whole company.

In this connection, the formation of intellectual mobility of flight crew members as an integrated characteristic (quality) of a personality is of great importance. Here one should mention that nowadays there is the transfer of understanding the concept of intellectual mobility: from intellectual migration and the exchange of thoughts to understanding this type of mobility as a personality quality which becomes the basis for general mobility of a personality. In modern scientific and educational texts there are a few terms for this or similar concept, namely “intellectual mobility”, “thought mobility”, “mobility of minds”, “intellectual flexibility”. All of them are related to the development of creative capabilities, innovative thinking and become the aim of training competitive specialists, geographical mobility remaining only the means.

We define intellectual mobility of the flight crew members as an integrated characteristic (quality) of a personality that ensures the readiness of a specialist to find and effectively apply required information, to generate new ideas and perceive innovations with tolerance, to act promptly and choose the best methods of solving both reproductive and creative tasks as well as change quickly the types of intellectual activity without reducing its efficiency.

The main invariants of readiness are considered to be personality and procedural components in their unity. On the one hand, readiness is related to personality (emotions and intelligence, will, motivation, which includes interest in activity, responsibility, confidence in success, emotional control etc.), on the other, it comprises professional’s tools (knowledge, skills, strategies etc.). Respectively, we distinguish the following components in the structure of intellectual mobility: motivational, cognitive, operational-and-technological, as well as social and personal.

Motivational component includes such features, as awareness of the significance of the personal intellectual development and availability of great interest in intellectual activity.

Cognitive component is comprised of: knowledge in intellectual mobility and personal individual psychological characteristics, the level of qualities of thought (flexibility, quickness, independence and profundity of thought), thought procedures, and manifestation of creativity in intellectual activity.

Operational-and-technological component includes instrumental competencies (ability to native and foreign languages communication, computing skills, information control skills) and the ability to use different techniques and strategies to perform intellectual tasks.

Social and personal component is related to the manifestation of qualities needed for proper adaptation (emotional endurance, business-like character, responsibility, and total activity), communicativeness and interactive skills, tolerance and persistence in goal achievement.

In our opinion, the pedagogical conditions of the formation of intellectual mobility of a future professional should comprise: the change in the function of a teacher / trainer when he / she becomes the moderator of the intellectual activities of students / trainees, but not only a knowledge transmitter; students' / trainees' motivation to the intellectual activities due to teacher's / trainer's consideration of their individual psychological features; integration of the vocational training and foreign language teaching, vocational orientation of foreign language learning with the use of distance courses, intellectual games and brainstorming tasks.

Conclusions

To provide professional reliability of the flight crew members it is essential to train specialists of a new quality – intellectual mobility. Firstly, it is an integrated characteristic (quality) of a personality that ensures the readiness of a specialist to find and effectively apply required information, to generate new ideas and perceive innovations with tolerance, to act promptly and choose the best methods of solving both reproductive and creative tasks as well as change quickly the types of intellectual activity without reducing its efficiency; secondly, it includes motivational, cognitive, operational-and-technological, as well as social and personal components.

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The factor of cognitive dissonance in the context of physical training of future pilots

The article considers the issue of cognitive dissonance in the sphere of physical activity as of a factor, influencing physical training of future airmen. The opposition of different types of knowledge about the physical activities and physical exercises and the subsequent choice of an individual predetermine the attitude of a person towards his own corporeity for the long run.

The structure and the context of the current concept of physical training of future airmen are defined by the requirements towards the level of physical and mental qualities development. Sufficient highly-developed level of airman’s motion functions is supposed to provide the physical reliability and readiness to work in different conditions and environments. Low level of modern students’ physical fitness of leads to the fact, that the majority of the graduates are incapable to work efficiently with intensity and effectiveness, required by the modern aviation industry demands [3]. The objective understanding and perception of all existing factors, influencing the process of physical training of the students, oriented on their future professional activities, stipulates further optimization of physical education in the higher education establishments.

The student period of the person’s life activities is characterized by the gradual completion of some natural processes. Among these processes we can single out the physical development of the body (development of body functional systems) and the formation of major mental functions of an individual (which is the nuclear of any personality). From this perspective Physical Education as a practical pedagogical subject lies on the border between the Humanities (ideals, values, social guidelines) and the Sciences (laws of nature – anatomy, physiology, biomechanics, and biochemistry of the human’s body). Thus, Physical Education, as an optimum alternative, has a beneficial effect not only on the physical fitness and the physical development of a person, but also on the formation of the specific individual’s attitude towards his own corporeity, motion activities with the focus on its long run perspective.

The practitioners of Physical Education during the physical education process as well as extra-curricular communication with the students face the fact that the majority of students know about the beneficial influence of physical activities on the person’s body and about the necessity of regular balanced physical loads in the individual regime of life functions. At the same time, less than a half of this contingent make themselves go in for physical training individually (in spite of the minimal number of the obligatory classes). The findings of the survey, conducted for the students of the 2-nd year of studies at the National Aviation University in 2015, testify that 100% of the respondents realize the necessity of having regular physical exercises. But only 45% of the respondents do some additional sports activities themselves (and only one-third of them do it more than once a week).

Knowledge by itself, which is some received information, does not necessarily lead to the expected action or result. It may be added, that the majority of children know ethic norms really very well but they consciously violate them at the same time [1]. The same refers to the physical activities, as the person very often consciously ignores important actions for his future life functions in favor of momentary pleasures and moods or interests. In the meantime the disastrous decrease of the individual's motion activities, within the framework of the environment, artificially created by the modern society, stimulates the search of actions for the improvement of the physical education system in the context of every individual's perspective.

The present article sets a **goal** to identify possible directions of cognitive dissonance in the individually-obtained student's knowledge about the motion activities and their own corporeity.

The current pedagogical constructs are void of a range of factors, which cannot be ignored or neglected in practice. These factors are not independent from each other and from other circumstances influencing the process of physical education; on the contrary they are the components of one integral system. The factors, which are traditionally ignored, are the following: laziness; different types of phobias; distorted perception of the present day realia; cognitive dissonance in the knowledge concerning the motion activities and physical loads [2].

It's commonly believed, that there is a body of knowledge about the objects, phenomena, subjects, people, which is symbolically called a "cognitive system". This complex, attached to the specific item, may be of a different complexity, coordination and interdependence. Leon Festinger suggests the following definition of the notion "cognitive dissonance": discrepancy between two cognitive elements – thoughts, experience, information at which denial of one of the elements occurs as a result of existence of another. In the meantime the conflict in the consciousness of logically competing knowledge about one and the same item (phenomenon, event or object) predetermines the existing discomfort for the individual. Cognitive dissonance creates special diseased mental condition, which the person subconsciously tries to get rid of. Such a mental condition is so unpleasant, that a person is ready to deceive himself by finding different justifications to his actions only to escape cognitive dissonance. Another postulate, connected with the presence of cognitive dissonance consists in the fact, that the person's actions, and the mode he does them, depend not only on his needs, aspirations and values, but also on the relatively changeable concept of reality, which is not every time adequate.

When we see that the students know (that is, they have the information), about the necessity for the body to have adequate physical loads, but the majority of them do not make any efforts to come into action, we may refer it to the "laziness" factor. But laziness is always seeking some excuse and in this respect these two factors (laziness and cognitive dissonance) are interconnected and very often they are interdependent [2].

In our opinion, in such a case the student's inner conflict may serve as an excuse; this conflict arises as a result of the theoretical knowledge, based in many cases on not quite distinct benefit of physical exercises and the knowledge about unpleasant feelings and negative emotions while doing these exercise (especially activities aimed at the development of kinetic efficiency of endurance and force). We may suppose, that in such a case it is mostly stipulated by the ambiguity of perception by the human brain of loads on the person's body (the state of tiredness, overstrain, exhaustion). At the same time there exists a contraposition between the knowledge of the pleasures of the limited in its real movement of the "virtual world" and complicated, unpleasant necessity to make oneself continue doing a motor activity, overcoming the growing fatigue. In the course of a lifetime a person accumulates different types of knowledge about corporeity and his own physical manifestations and the choice of the type of knowledge to be preferred is not every time univocal. An assumption may be made, that motor activity implies not only theoretical or practical knowledge, but also some implicit knowledge of the body itself. Such kind of "knowledge about the body" is closely connected with the individual's motor experience, but it is not his direct product. This knowledge about the conditions and individual abilities of the body within the period before, during and after the active physical activity, as well as the knowledge about the spontaneous body activities in emergencies is basically connected with the unconscious, but it seriously influences the choice of the activity (or inactivity) of a person and therefore this cognition cannot be ignored. In the sphere of motor activity the most widely spread natural form of a solution (or, more exactly, quasi-solution) of cognitive dissonance is procrastination. Morning exercises are shifted for the evening (at first, it's difficult to wake up, later you have got some business to attend to at once), a planned jogging in the park or at the stadium is postponed or shifted till Saturday, and later till Sunday, and gradually till another week and so on.

Conclusion

Many students experience uncertainty and ambivalence concerning their attitude towards motion activities, which may be viewed as a result of hidden cognitive dissonance; the issue of cognitive dissonance regarding the individual person's motion activity requires additional research in the context of interdisciplinary approach.

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Practical recommendations for cabin crew members dealing with unmanaged aircraft passengers

The paper considers the main aspects of psychological work with cabin crew members dealing with unruly passengers. These aspects are aimed at acquiring the ability to recognize one's own negative mental states, training techniques of self-regulation, mastering the method of establishing contact with unruly passengers, and developing an effective interaction style in conflict situations.

Nowadays, the personnel of airlines in Ukraine face the serious problem related to passengers violating the order onboard. This problem is for flight attendants to face and cope with. As defined by the ICAO, the term "an unruly passenger" refers to any passenger who fails to respect the rules of conduct onboard an aircraft or to follow the instructions of crew members and thereby disturbs the order and discipline. Examples of such violations include attacks on the crew and other passengers, refusal to follow instructions of the aircraft commander, illegal drug use, refusal to stop smoking, disorderly conduct, unauthorized use of electronic devices and any other actions that may jeopardize the safety of passengers, crew and aircraft.[2]

In order to determine the seriousness of the situation, 4 levels of unruly passengers' behavior are described as follows: level 1 – behavior that violates the order, including suspicious behavior or verbal threats; level 2 – physically abusive behavior; level 3 – behavior that threatens the life; level 4 – intrusion attempts or actual intrusion into the cockpit flight crew.

It is clear that the best option for preventing disruptive behavior onboard is to identify unruly passengers at the airport before embarkation, namely in the passengers registration area, at the check point, and at the lounge in front of the gate. Although, an inadequate behavior is not necessarily displayed during embarkation, because passengers often keep themselves under control, knowing that otherwise they cannot be permitted to get onboard due to the fact that they do not act normal, but once inside, they relax and often drink alcohol, which leads to disinhibition and outrageous statements regarding the cabin crew. That is why the aircraft crew should be able to identify signs of threatening behavior and be prepared to cope with some unruly passengers. Taking into consideration that flight attendants often communicate with passengers, to recognize unruly passengers and effectively deal with them is the priority task set to those who are on duty.[7]

An efficient strategy related to an aircraft crew's actions when dealing with unruly passengers has been developed. This strategy includes a detailed procedure to prevent the passengers who violate the order onboard, as well as measures that can be taken in case of incidents in flight and while landing. These measures comprise the delivery of a written notice to unruly passengers, the use of special means for restraining aggressive passengers and emergency landing at the nearest airport in order to disembark unruly passengers and transfer them to the police and other authorities.

However, in addition to the measures mentioned above, there are some situations where flight attendants try to cope without the involvement of the aircraft commander and sooth the conflict on their own. This problem requires the development and implementation of training and recurrent training courses aimed at psychological training of cabin crew members, using effective methods of interacting with unruly passengers in order to resolve conflicts onboard aircraft and improve flight safety. In this regard, the purpose of this article is to outline the main areas of training and psychological methods of improving the efficiency of cabin crew members' interaction with unruly passengers.

As specified in the ICAO documents [2], it is recommended to use the following methods of operation in the event of disputes: analysis of the possible causes of aggressive behavior displayed by passengers; verbal and non-verbal communication; action in the event of disputes; taking into account cultural differences and stress factor. To improve the interaction with unruly passengers, cabin crew members should be able to recognize and control their own emotional manifestations and techniques of psychic self-regulation. It is important to realize that most of flight attendants and passengers are in a stressful situation because of isolation from the ground, the limited space in the cabin, compulsory communication and others. Therefore, the first block of psychological operations with cabin crew members is dedicated to the diagnosis of their own emotional states, physical health, and mood in order to recognize and identify their negative states, targeted training aimed at managing one's emotional reactions, and methods of regulation of mental balance [4]. This block consists of training activities and includes the following techniques: managing unconstructive emotions (in the form of laughter, crying, swearing, active performance, drawing or describing their own emotional states in written); relaxation exercises to achieve inner peace and comfort (meditation techniques, autogenic training and relaxation skills); improving sense of energy and strength (exercising, "connection" of one's imagination to different energy sources, "reincarnation"); revaluation of negative feelings and thoughts (detection, fixation, searching for positive aspects of a problem, concentration on positive states, revaluation) positive attitude (faith is strengthened in its ability to solve a problem); playing roles (simulation of different situations for the development of effective behaviors in cases of sexual harassment shown by passengers, verbal aggression, etc.).

To effectively deal with unruly passengers, flight attendants should know the factors affecting passengers' behavior (alcohol and drug intoxication, fatigue, malaise, personal problems); kinds of inappropriate behavior (verbal insults, sexual harassment, physical assault), and mechanisms to resolve difficult situations. In our opinion, it is appropriate to start with the familiarization of cabin crew members with various types of unruly passengers and inadequate forms of their behavior, as well as training aviation personnel to realize the causes of such behavior and diagnose early signs that indicate the possibility of the order violation committed by passengers. Therefore, the second block of training activities is aimed at solving the following tasks:

1. To inform flight attendants about the possible types of inappropriate passengers' behavior associated with different psychological, physical and situational factors. It is appropriate to consider the mental, emotional and behavioral manifestations pertaining to the fear of flight, claustrophobia, alcohol and drugs, somatic diseases that can cause inadequate behavior, age peculiarities of passengers, different reactions to the

situational expectation and frustration, depending on the type of a passenger's personality, his/her temperament and so on. It should be noted that the stress factors in flight include the limitation of one's space and physical activities, inability to abort the flight and leave the plane, restriction of personal liberty, forced submission to the aircraft commander, insufficient choice of actions during the flight, reluctance to bear the environment of strangers, lack of movement, a fixed position of a body, financial costs on the ticket, and fear for one's own life [3].

2. The next task premeditated in the block of training activities is to inform the participants about external diagnostic signs of inadequate passengers' behavior, which are important for flight attendants to know, in particular the symptoms of drug and alcohol intoxication, as well as to be able to diagnose the manner of behavior, tone of voice and expression, hysteroid personality types, namely obsessive, compulsive and antisocial ones, which often causes conflicts and disputes. Also, it is necessary to pay attention to the verbal and non-verbal signs that indicate anxiety, stress and deception.

The third block of psychological operations with cabin crew members is focused on the development of an effective interaction style and methods to establish contact with conflicting passengers. First of all, flight attendants get familiarized with the signs of a confident and non-conflicting behavior. According to T.Filipyeva, in some situations, a flight attendant should speak "strictly, firmly and strongly, but politely and quietly"[3, p.150]. This implication means the main verbal and non-verbal manifestations of open and benevolent behaviors (gestures, facial expressions, body posture, tone of voice), and methods to establish contact with passengers considering their sensory modalities and elements of establishing rapport.

Special sessions are allocated for cabin crew members to get familiarized with assertive behavior which should be worked out in the role-playing games. It is necessary to clarify the difference between aggressive behavior and assertive behavior, as well as to determine their levels in each cabin crew members for the further correction of aggressive manifestations. To attain this goal, it is recommended to use the exercises with video capturing the interaction of participants in the role-playing games and their further analysis.

Particular attention is paid to the techniques intended to diminish conflicts, because a conflict can often be avoided owing to the fact that existing tensions or dissatisfaction of passengers are recognized in time. To fulfill this task, the following methods are applied: getting cabin crew members familiarized with existing strategies of behavior in conflict situations and psychological diagnostics of the dominant strategy of each member involved in the program; determining unacceptable and optimal strategies for conflict resolution onboard (strategies of avoidance, inaction and rivalry are inadequate, a more appropriate one is a concession, but the most effective ones are strategies of cooperation and problem solving).

It is also recommended to use professional trainings on conflict-free communication. For instance, there is a technique that is used in Cyprus airlines where flight attendants are taught to go up the ladder that leads out of difficult situations arising while communicating with passengers [8]. Ten steps (tactics) of the ladder:

1) listen actively;
2) ask forgiveness;
3) offer help;

4) think over and realize the situation;
5) provide information;
6) suggest alternative solutions;
7) get one's consent;
8) take action;
9) say goodbye sincerely to each person;
10) maintain contact.

In addition, it is recommended to consider the main strategies of conflict management (settlement, completion, avoidance, consensus-constructing, prevention, reducing, deferring) and develop methods of diminishing conflict situations (permanent attention to passengers, enabling passengers to speak their minds, friendly and respectful attitude, admitting the innocence of a passenger (if he is really innocent), patience, self-control, calm tone, appealing to facts, conciseness, explanation of the problem to a passenger, verbalization (specification) of a passenger's experiences and claims, the proposal to consider alternatives, demonstration of the interest in solving the problem, increasing the significance of a passenger and so on).[8]

It is necessary to emphasize the importance of information modules, developing skills of effective interaction in conflict situations, acquiring assertive behavior, and self-regulation techniques, which requires long-term and individual work with cabin crew members.

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Peculiar features of crisis conditions experienced by workers in special activities

The article presents the results of theoretical and empirical analysis of the crisis conditions problem experienced by workers in the special conditions. The empirical evidence suggests that these features of crisis states are: low reflection, high anxiety, low self-efficacy, social exclusion, the tendency to depression and loneliness.

Hope to live life without internal conflicts, sufferings, crises, losses would be too naive. After all, life is always preparing us more and more tests. Their length, complexity meets human capabilities, forces. We all occasionally find ourselves in such life situations that were specially designed to help us survive and realize something very important, which remained unnoticed in the routine of everyday life. It seems that these obstacles to the goal were invented to enhance the ability of self-exploration, self-development and self overcoming. However, "what does not kill us – makes us stronger" – said the great Nietzsche.

As you know, there are special conditions of professional activities that are directly related to the risk, overcoming obstacles. These include firefighters and rescue workers, pilots, sailors, law enforcement, specialized agencies, astronauts, miners, athletes, and others. Specific conditions are the conditions under which the individual activity takes place against a background of extreme factors that are occasionally or have a high probability of their occurrence. In the special circumstances of extreme intensity factors are insignificant and negative functional states arising at these circumstances are expressed moderately. Under such conditions of activity the reserve abilities of an employee are mobilized according to compensatory type.

The problem of maintaining the health and performance of those who were in special conditions, attracted the attention of such researchers as A.I.Vorobyov, H.S.Dunin, M.Ye.Zelenova, I.O.Kotenov, A.H.Maklakov, Yu.A.Oleksandrivskyy, S.V.Chermyanin and others.

Working in special circumstances implies an increased risk factor, lack of information and time for reflection, the need for adequate solutions, high responsibility for the task, the presence of unexpected obstacles. These factors put increased demands on the mental health of the individual. Strong emotional and physical activities create preconditions for the emergence of mental, physical disorders, and crisis states in the representatives of these professions.

As you know, the term "crisis" comes from the Greek krisis – decisions turning point result. This is a difficult transition condition caused by disease, stress, trauma and more. Thus, according to American scientists, researchers M.W.Seeger, T.L.Sellnow, R.R.Ulmer crisis means "the test" or "extraordinary event" [12].

According to definition by S. J.Venette, crisis – is the transformation of the old system, which cannot be controlled and organize themselves [13].

L.S. Vygotsky believed that the crisis – a turning point in the normal course of mental development, a chain of human internal changes with relatively minor external changes [2].

F.Ye.Vasylyuk, describing the critical situation, identifies four key concepts: stress, frustration, conflict and crisis. Under the term “crisis” scientist understood the critical moment and a turning point in life of the individual [1].

According to T.M.Tytarenko, in the state of crisis vision of the future becomes unclear, the person experiences fear of something new, unknown; there is a persistent feeling of unreality of what is happening, the person experiences grief, pain, resentment, depression, despair, etc. [7].

As to peculiarities of individual crisis states, A.A.Osypova notes, that according to changes in emotional sphere under crisis conditions the individual can feel one of the three dominant feelings: depression, loneliness or destructive feelings [6].

Long and difficult burdens, insurmountable conflicts can cause resistant depression (from the Latin depressio – suppression) – negative emotional and mental state, accompanied by painful passivity. In this condition an individual experiences depression, sadness, despair, detachment from life, the futility of existence.

Loneliness is expressed in such feelings as worthlessness, confusion, hopelessness, emptiness. A person in crisis changes the volume of communication: he/she either limits it sharply (a dive into personal world) or increases it sharply (loneliness in the crowd). An individual is seeking oblivion in the frequency of superficial contact with other people.

Social exclusion of the individual can be manifested in various forms: state of negativity, situational opposition of personality, social alienation (autism) of personality. Self-esteem is sharply reduced. The whole society is perceived as hostile; retreat from reality takes place that is the losing a sense of reality of what is happening or depersonalization – the individual loses the need to be presented in the life of others ideally; a person does not seek for self – affirmation and manifestation of the ability to be a person.

Psychologists distinguish the following main types of crises: neurotic, traumatic, professional and age. In terms of life expectancy crisis is divided into short and long term, and by the criteria of effectiveness – the constructive and destructive [8].

For our study young law enforcement officers were selected as their professional activity takes place in special circumstances. Age 23-35 was under observance. Among them, 57.0% were men, 43.0% – women. Analyzing crisis conditions of individuals, we have concluded that they were primarily caused by a common mechanism of reflection. As you know, reflection (from the Latin reflexio) – a process of internal mental acts and states directed into self-entity. Considering the crisis conditions of young law enforcement officers, we began empirical study, the first task of which was to evaluate the level of reflexivity using A.V.Karpov’s method [4]. We have the following results of research: high level of reflexivity was shown only by 10.0% of law enforcement officers; 50.0% of employees had the average level; 40.0% of the security forces demonstrated low level of reflexivity.

The obtained figures indicate relatively low ability of law enforcement officers to mental self-image content and its own analysis, and to understand the feelings of others, empathy, inability to put you in the others place. In our opinion, these low results are connected with the specific service activity in law enforcement. As it has already been mentioned, the police perform their duties and exercise the right to exclusively within its competence, in the manner prescribed by law (legal regulation). That is, it is a restriction of freedom of law-enforcement personnel, their activities are subject to clearly established rules of law. Secondly, there is a clear subordination, hierarchical (vertical strict subordination), the distribution of staff positions and team composition into high ranking and first line officials. Not following orders of the commander, freethinking may lead to liability under the Disciplinary Statute. Third, the service in terms of lack of time and information has psychological impact on people, making their work tenser as hesitation could cost lives. Finally, police officers often have to deal with not the best representatives of society. Among them many have immoral lifestyle. This "communication" is closely connected with negative emotions and eventually leads to a professional deformation, burnout, and cynicism and so on.

Thus, we conclude that the specificity of professional activity in special conditions includes: high risk, the need for great physical endurance, increased responsibility for decision-making, high concentration, often it takes place in an unfavorable socio-psychological climate that is directly affects the emotional state workers, and associated with feelings of crisis.

Special attention is given to how the individual reacts to the dangerous, risky circumstances that are threatening his life and health. Adequate individual behavior in special conditions depends on its strong-willed and forecasting abilities, behavioral skills, ability to recognize dangerous situations and adequately respond to them [3]. Anticipating a dangerous situation, one calculates its likelihood and potential severity of the consequences. The higher the risk situation is, the higher the level of anxiety and harder psychic self-regulation of the individual is.

Inadequate behavior in dangerous situations is usually caused by the high self-esteem of the individual, his self-confidence or self-doubt, mental demobilization, ignorance of optimal behavior system in some dangerous situations.

In M.I.Yenikyeyev point of view, in dangerous situations "narrowing of consciousness" takes place, arising neurohumoral changes that increase impulsive (often inadequate to circumstances) activity, reduced logic and critical thinking, the circumstances of threatening situation are inadequately reflected. Anxiety is hyperbolized and transformed into fear and even terror; emotions have asthenia character, manifested in physical weakness, real or chaotic movements. Hyper emotion blocks the perception of the real possibilities of reasonable adapted behavior. Often employees are seriously injured or even killed in an environment where salvation was objectively possible [3]. So, stress and adaptability of the individual are important factors of professional activity in special conditions, the absence of which can lead to the possible emotional burnout.

For carrying out professional responsibilities effectively, workers under special conditions should clearly see the goal, the achievement of its results. Thus, according to O.M.Kokun, self effectiveness is confidence (belief) of a person in the ability to organize and carry out activities needed to achieve a certain goal [5]. That is why the following procedure was to assess the level of self-efficacy using scales of self effectiveness by R.Shvartser and M.Yerusalem [10]. The results proved that high self-efficacy was shown by 12.0% of law enforcement officers; higher than the average – 24.2% of respondents; the average – 42.5% of employees; below average – 21.3%; low – 0% of the security forces representatives. So officers with high self-efficacy (12.0%)

and higher than the average (24.2%) perceive complex professional tasks rather as a challenge than a threat and set the target of reaching it.

Respondents with below average levels of self-efficacy (21.3%) are indecisive and inclined to retreat challenge. They cannot motivate themselves to perform complex tasks, disclaim effort while facing difficulties. In stressful situations, they focus on their own shortcomings, difficulties of the problem. They restore their own self effectiveness hard and slowly because they tend to diagnose failure as a lack of skills, thus, they are prone to stress.

Consequently, employees with high self-efficacy are less likely to experience crisis, compared to workers with low levels. However, the presence of high self-efficacy, i.e. awareness of their own competence, the belief in the possibility of successfully performing a task, expectations of success leads to the fact that people exert more efforts to get things done than those who doubt in their abilities. As a result, those who believe in their own effectiveness, make it possible to achieve better results, promote self-esteem. People who believe in their ability to solve problems, show greater persistence when facing obstacles. Psychologists say that the stronger the confidence in the abilities, the more prudent a person will be in his/her activities. Conversely, low self-efficacy, that is doubt in own competence, expectation of failure reduce the performance and lower self-esteem.

Conclusion

Thus, the specificity of professional activity in special conditions include: high risk, the need for great physical endurance, increased responsibility for decision-making, high concentration; it often takes place in an unfavorable socio-psychological climate and directly affects the emotional state of employees and connected with experiencing crisis conditions.

The special features of emotions in crisis state of employees, whose professional activity takes place in special circumstances, include: low reflection, high levels of anxiety, inappropriate emotional and behavioral manifestations, social exclusion of personality, predisposition to depression and loneliness, low self-efficacy.

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The human experience while decision-making

The article presents the theoretical analysis of the decision-making process of the subject's work activities, highlights the features of experience appearance, as a special form of activity, which helps to recognize the choice of available alternatives, make decisions, and assists behavior regulation of personality; considers the tolerance for uncertainty as a person's ability to resist contradictory information.

The decision-making – it is always a choice among available alternatives, however, if all of them do not fit, and decisions need to be made, the subject may experience certain feelings.

First of all, let us consider the difference between a choice and decision-making: choice is a process (short or long), decision-making is a moment, a very important moment for the subject that implements it. But it is necessary to immediately distinguish all decisions at least at three types: a) cognitive emotionally tense; b) vitally important; c) strategic life decisions.

In the first case, the subject must make a choice and take the only right decision in exceptional lack of time, when it comes, for example, to the professional activities of operators: pilots, divers, astronauts, etc., employees in extreme conditions and military activities. The tension in the moment of decision-making is caused by extraordinary responsibility (for ourselves, for other people, for job, etc), lack of time, the implementation of individual decision and so on.

In the second case, the vitally important decision is happening in the case of a great importance for life (personal or someone's). For example, when the subject sees the drowning man, or a man on fire, the decision (to help or not) is vitally important, firstly, for another subject (the hope for salvation), and secondly, for our subject, since the decision must be made in accordance with evaluated and specified price for oneself (the risk or the benefit for own life). These vitally important decisions can also be considered as the emotionally tense, which have to be made very quickly.

In the case of the strategic life decisions, to which the scientists (Abulhanova – Slavskaya K.A., 1991, Adler A., 1968, Ball G.A., 2007) include the professional self-determination, a choice of marriage partner, the determination of own life position (relationships with others), mostly the emotional component (like / dislike) is involved, the subject may experience stress and uncertainty for a quite long time (up to several years) [6; 7]. The burden for the responsibility for own life (and for lives of the inner circle) presses, because the construction of the entire life path of the subject depends on the decision made and the strategy of achievement chosen.

In all three cases, the process of decision-making occurs on certain, specified by scientists, stages, with the actualization of the leading psychological mechanisms, however, in a different time period.

The following discussion focuses on the decision-making in special conditions that are associated with considerable consumption of emotionally-volitional efforts, may be accompanied by the certain experience, and due to this, we believe, they require further research.

Studying the extreme activity I. Janis and L. Mann examined the decision-making process as full of certain experience by the subject. In particular, in the book "Decision-making. The theory of psychological conflict of choice and duty" the decision-making is seen as an emotionally intense cognitive process. However, the scientists attempted to uncover the deepest psychological mechanisms of decisions that they associate with the motivational conflict, the clash of emotively colored tendencies, and emphasize the subtle shades of emotional processes of the subject. Researchers examined the choice and decision-making without applying typical for this industry formalization. The researchers paid special attention to the issue of why it is difficult for people to make decisions, analyzing, above all, the motivational side of the process of making life decisions. It is important that they present the decision-making in the context of a temporal perspective, determining not only one moment, but the duration of this process, its distribution at some stages. Herewith, the number of stages and the distribution criteria are also not the same. Specifically, I. Janis and L. Mann associate decision-making with the risk assessment and the duty, and determine the next five stages, noting certain experience of the subject associated with doubt and fear [1, P. 81 – 104]:

1. Evaluation of the problem. – What happens if I do nothing at all?

2. Review the options. – Will a preferred option of actions help to solve the problem itself? Have I considered enough of options?

3. Evaluation of options. – What is the best option? What are the requirements it is connected with?

4. Notification of others about the selected action. Adoption of duty. – Do I need to notify the others about this decision?

5. The decision-making despite the risk. – Is the risk big, if I do not change anything?

The list of stages-questions indicates on the social indirect context of decision-making that involves their implementation under the pressure of obligations taken and in the presence of other people. However, not every decision the subject tends to tell others; a person can keep some decisions in secret even from the close people, until realizing them in practice. For example, the decision on the choice of its implementation can be hold by a person in secret until this person eventually is confident in its finality or expediency.

The modern researcher, Professor V.O. Kasyanov, conducting the deep analysis of stressful events in aviation, indicates that there are situations which he called "entropic catastrophes", when the subject can not make the right decision. Overlaps number of factors (lack or excess of alternatives, lack of time, lack of subjective resources, etc.) that lead to a critical increase of entropy and the inability to make the right decision [2, p.337]. To the such uncertainties result the abrupt changes, which are accompanied by the stress, and hence by the certain experience of the subject.

It is understood that, working in special and extreme conditions, the subject of work, above all, must have a high level of stress resistance. However, the availability of such professionally important skill does not remove the responsibility for decision-making, and also the experience related to the true / false choice made. So, along with the stress resistance it is necessary to create and explore the other qualities that help to overcome moments of stress situations with the lowest load on both the emotionally-volitional and the whole mentality of the subject.

In 1962. S. Budner conducted the research of tolerance-intolerance to uncertainty (Tolerance Ambiguity Scale), the results of which were summarized in the relevant diagnostic questionnaire. The tolerance to uncertainty by S. Budner was seen as an individual predisposition of the subject to evaluate uncertain situations as desirable or as threatening. It is a person's ability to accept the conflict and tension arising in situations of duality, resist contradictory information, accept unknown, not feel uncomfortable to uncertainty [5, P. 29-40].

Continuing these studies, T. V. Kornilova, M. A. Chumakova also conducted a series of experiments, identifying in decision-making the importance of this characteristics in human. Tolerance is seen by scientists as an integral personality characteristics and is studied in perspective of psychological stability, system of values, personality settings and set of various individual properties [3, P. 92-110]. As the researchers point, the tolerance to uncertainty is associated with high emotional intellect and high self-effectiveness, and, conversely, intolerance – with low academic intellect and low self-effectiveness. Conducting numerous studies, they noted the emergence of anxiety, and therefore a certain experience as predictor of intolerance of the personality to uncertainty.

What happens in the psyche of the subject when it comes to the choice of what decision to make? As we know, the decision is a complex hierarchical process of mental activity of the subject, during which the original uncertainty of the problem situation is reduced (Tihomirov A.K., 1977). To make a decision – means to select the specific purpose and the mode of action, to give them an advantage over others (Ball G.A., 2007). However, even when the decision is already made, anyway the subject can not sleep normally, keeps rethinking, pondering. What disturbs him? What does not give a rest? When we put these questions, we can hear the answer: "I feel the thoughts of others, they confuse me..." Again the question arises: in reality, are these the opinions of others, or own, subject’s? What feelings does the subject experiences, what experience, when he is tormented by the conscience?

At the end of the XIX century W. James deeply studied the human consciousness, creating his famous model, which to this day is the key to the cognitive psychology of consciousness. W. James devoted considerable attention to the decision-making process as a model of choice. The scientist believed that the choice is determined by mind, will, accidental impulse and fear, highlighting the types of decisions:

1. Reasonable decision. The subject considers the arguments for and against a certain mode of action and chooses one alternative; chances are rationally weighted, and the decision is made with a full sense of freedom of a human.

2. Volitional decision. The subject focuses on the intense sensation of "internal efforts". This is a "slow, deep movement of will". This decision option is quite rare, because most human choices are made effortless.

3. Drifting decision. In this case there are no decisive arguments in favor of a particular choice; Each argument seems good, and the subject is experiences fatigue or frustration from this decision. It seems that the decision, which was made, makes it possible to drift in the direction randomly determined from outside.

4. Impulsive decision. The subject feels inability to make a decision, and the choice becomes random. But the answer comes from within, not from outside, as it was in the previous case. Human perceives itself as one that operates automatically and often impulsively.

5. Decision predefined by the change of the angle of view. This decision often occurs suddenly and is the result of some important external experience, or internal state (for example, sadness or fear). It leads to a significant change of what human strives to, what desires.

The views of scientist are important for our research, because such decisions differentiation gives the opportunity to approach to the understanding of the processes and experiences that happenned with the subject, in particular, which include mental and volitional processes, random impulses and affective reactions (fear).

Let us consider the psychological meaning of subjective experience. As we know, experience in psychology is considered in the three meanings, that together make the understanding of this phenomenon. Experience is interpreted: as any emotionally charged state of the subject, and the phenomenon of reality directly represented in the mind as an event of own life; as the presence of aspirations, desires and wants, that reflect in the individual consciousness the process of selecting by the subject the motives and goals of own activities, and thus contribute to the understanding of attitude of the subject to events occurring in his life; as a form of activity that occurs when it is impossible to achieve the leading motives of the life of the subject, when there is a collapse of ideals and values, and is manifested in turning the psychological world, aimed at rethinking of own existence.

All these forms of experience act as internal signals which help to realize a choice of possible alternatives, to make decisions, and assist behavior regulation of the personality. As a special form of activity, the experience allows the subject to endure severe events in the critical life situations, to gain the meaningfulness of existence due to revaluation of values [1]. Therefore, experience – a form of expression of the attitude of the subject to the object, to the situation, to another person, to oneself, it is a form of emotional sensory reflection of subject's attitude to everything that surrounds.

The experience of the subject is caused, above all, by the mechanisms of reflection. As we know, reflection – the process of self-knowledge of internal mental acts and states by the subject. But reflection – not just knowledge or understanding of the subject himself, but also awareness of individual of how he is being perceived and evaluated by the other subjects; kind of knowledge, during which the subject becomes the object of his own observation; thinking, analysis of own mental state.

In psychological dictionaries states that reflection as a mental (rational) process aimed at analyzing, understanding and awareness of oneself (own actions, behavior, language, experience, feelings, states, abilities, character, relationships with others and to others, own tasks, destination) conceptually, procedurally and functionally linked to introspection, retrospection and self-consciousness. In our opinion, in the process of decision-making it is advisable to allocate intellectual and personality reflection.

As we know, the scientists define the intellectual reflection as the ability to select, analyze and correlate own actions with the subjective activity. It provides a general regulation of subjective-operating transformations of content of the decision-making process: a mechanism of generation provides the use and transformation of integrated orientation of mental activity – its semantic gestalts (models, tools, charts), and a control mechanism – specification and implementation in the thinking process of already present integrated functional elements of its content. The personality reflection involves the ability of the individual to comprehend own motives, to predict the consequences of own actions and deeds for oneself and other people, the ability to coordinate goals and own behavior with the means to achieve them. Thus, the combination of intellectual and personality reflections in the decision-making process contributes to their adequacy and is an essential condition for improving the efficiency of the subject's preparation to the aforementioned actions.

However, the presence of the subject's reflection mechanism does not guarantee the emergence of experience both positive and negative. Rather, there is a complex of mechanisms that involves, according to the stages of the decision-making [7], motivational, emotionally – volitional, goals-creating, etc. Thus, the problem of the subject's experience emergence in decision-making requires further research.

Therefore, further research is advisable to analyze the psychological principles of the personality readiness of the subject to decision-making, and on this basis, to distinguish from the general array the psychological mechanisms which can be used for the settlement of human experience in tense situations.

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Basic values of a flight attendant’s career

The article highlights a number of issues related to popular beliefs on a flight attendant’s career vs professionals’ understanding of their job, lifestyle and key notions of safety, fulfilling of passengers’ basic needs, and personal / corporate discipline.

The professionals’ discourse reflects the mainstream tendencies in and about the aviation industry. We have selected a range of articles from the Business Insider archive on the job of flight attendants. The texts exemplify typical aspects of the career, popular beliefs and insiders’ opinions.

The subject of research combines both linguistic elements and a wider context of social interactions, which suggests an interdisciplinary approach to be adopted. We have chosen Algirdas J. Greimas' narrative semiotics which differs from an exclusively linguistically oriented semantics, presenting a promising perspective as a relevant tool to carry out the study on the discursive level, narrative level, and abstract level of deep laying conceptual structures of a discourse.

The key concepts of safety, glamour, food, time, dream are represented either explicitly or implicitly on each of the levels mentioned. We are going to focus on the peculiarities of its representations in the form of semantic fields (isotopies) on the upper, explicit discursive level, trace the typical narrative programs and highlight the concepts representing the basic values of the sphere and their correlations on the abstract level. The complex study of different levels of meaning in the outlined professional segment of the media discourse will help us elicit the fundamental values of a flight attendant’s career.

We will start with the figurative component of the first, discursive level. The term covers all the text elements (figures) which refer to the external, physical reality open to the five human senses. This most explicit level of verbal textual representations is opposed in form to the internal, abstract reality of concepts on the most implicit, the third level of meaning. Successive interpretation of these consistent levels of discourse provides further detailing of particular segments of the linguistic view of the world (the English one) and adds to their better understanding. Here is a typical discoursive fragment under analysis:

How do those long-haul trips affect you?

"You're pretty beat up by the time you get home. You really are so tired, you can't even type on Facebook, 'I'm home now.' On the day after your trip you close the blinds, you may or may not answer the phone. You definitely won't answer the door. You're definitely going to cancel any plans you have with your friends because you were dumb enough to make them in the first place thinking you would go. But you just kind of come back into yourself and stay home because that's where you need to be.

"When I get home I plan on sleeping in as late as I can. Your time clock gets crazy. But you do the best you can, you sleep when you can."

The basic figures in the textual fragments under study include lists of words, which refer to:

a) actants:

people: *the world of commercial aviation, airline crew, people who ensure we do it safely, a flight attendant, sort of a policeman [a flight attendant], the vultures [when there's a first-class meal available], passengers, people [from all walks of life who are on the plane for different reasons], somebody*. A focused term *flight attendant* is opposed to rather unspecific references with gradual increase of vagueness: *passengers, people, somebody*.

profits (often outlined through vague and biased judgments)**:**

on-board: *a first-class meal available, the primo trips, we get what's left over of the fresh food [after the passengers have been fed], 'One girl's trash is another girl's treasure;*

activities during layovers: *go shopping, go relax, go get your hair and nails done and your back massaged, whatever you want to do there, stay in a really nice hotel*

b) place:

of destination: *flying to Beijing, to fly domestic, to fly international, [to] Beijing and Tokyo from Washington*; *Somebody may be going to a wedding. Somebody may be going to a funeral.*

of action (on board): *on a plane, down the aisle, first class or business class,*

background place-relevant information: *from all walks of life*.

c) time of action:

after September 11, Chinese New Year, it was a long time before the high flying time, 13 years as a flight attendant under her belt, [you're working] a lot of time in a short amount of days, laid over for 52 hours, a shorter layover, something like 24 hours, you fly there about 13 hours, you lay over for 24 hours it's a three-day trip versus ... a four-day trip." The group includes both specific dates and conventional time markers like national holidays etc., and regular/irregular spans of shifts and layovers.

The list of basic figures may be further subdivided into detailed groups according to the category of cooperation. We have elicited some of the isotopies in the selected discourse fragments, the dominant ones reveal relevant oppositions.

Popular ideas vs Insider's Understanding

• *being a flight attendant is glamorous*	• *the biggest misconception about the job*
• *"People think there's glamour associated with this job*	• *How hard could this job be?*
	• *to finally make her dream a reality*
	• *it's still a dream job for her*

From the professional's discourse one can elicit a strong determination to overcome unexpected hardships to do a dream job, nevertheless it is far from popular beliefs. From the linguistic point of view, the following sequence of gradual devaluation is particularly remarkable: *"But the job itself is far from glamorous," she continues.*

"Even if you're working in first class or business class, it's not glamorous at all." Many flight attendants don't realize just what the job entails until they're doing it, she says.

Passengers' Behaviour and Attitudes vs Flight Assistant's Duties

	vs
• *you're flipping your phone over*	• *Maintaining everyone's safety*
• *you don't want me to see that you're texting*	• *I have to be sort of a policeman*
• *you don't like me because I'm telling you the rules*	• *I'm telling you the rules*
• *you just never think about trash on a plane*	• *We deal with a lot of trash*
• *People just think we're floating through the aisles, saying 'coffee or tea?'*	• *Serving and cleaning food*
	• *all flight attendants want to be liked*
	• *we want everybody to love us and they don't*

Passengers' ideas of the glamorous dream job are mainly associated with an easy routine of offering drinks, whereas the professional admits the more down-to-earth routine like food serving, cleaning, the trash on a plane: *Serving and cleaning food is simply one aspect of the job, Long adds. "People just think we're floating through the aisles, saying 'coffee or tea?' but there's a lot more to it," she says.*

She relays a story about a new flight attendant on a recent flight from Beijing as an example: "We deal with a lot of trash – you just never think about trash on a plane, but there's so much of it. We had passed out for dessert little ice cream cups and were coming down the aisle picking these cups up. Some of them are half eaten and melted. The new flight attendant takes one cup and puts it in the other, and this green-tea ice cream comes splashing out all over her. I'm sure when she was going through the interview process, because I never thought about this. She didn't think that she would have green tea ice cream all over herself".

Currently various gadgets present an indispensable group of thing for the vast majority of airline passengers. Airlines take steps to make wireless Internet connection available and allow mobile phones on planes, so the cellphone-free space is shrinking. Strategizing on how to control social contacts has been increasing and widely debated for the recent decade with a special focus on the limited public space of an aircraft.

«Passengers are taking an increasing array of devices on board planes – cellphones, tablets, GPS units and more. Many of these devices transmit a signal, and all of them emit electromagnetic waves, which, in theory, could interfere with the plane's electronics. At the same time, older planes might not have the best shielding against the latest generation of devices, some engineers said» [3]. Meanwhile many passengers ignore the request to turn off all electronic devices, and there are various reasons they do not comply with the restrictions,

John Ratey, a professor of psychiatry at Harvard, coined the term *acquired deficit disorder* to describe the condition of people who are accustomed to a constant stream of digital stimulation and feel bored in the absence of it [1, 219]. Many people confess of being addicted to having constant mobile connections to others, even resenting it at the same time, thus the stress level is increasing for both the passengers and flight attendants, whose top priorities include safety and order on board.

Passengers' spirits and emotions vs Flight Assistant's ones

Apart from the unnerving duty of enlightening passengers about the safety rules, flight attendants are to communicate with passengers from various backgrounds, in different life situations, and in any spirits and emotions (*deal with people from all walks of life who are on the plane for different reasons*). The discourse under analysis reveals the feeling of self-control, self-awareness, high adaptability, as well as emotional isolation and detachment from the clients: *you have to adjust yourself to each of those situations and the emotions behind that," Long says. "Somebody can be super happy, and somebody could be dreadfully sad, and **I think** people think it's just walking down the aisle".*

Private life

- *you miss a lot of holidays*
- *you miss a lot of big things, like graduations*
- *she is on reserve and has to fly wherever and whenever the airline sends her*
- *she hasn't spent many Christmases at home with her family*

vs

- *my family is kind of used to it.*
- *they don't even expect me*
- *a guy could get jealous*
- *there could be a lot of opportunities for jealousy*

"I think when you become a flight attendant you kind of have to give up big holidays with your family, and you find other ways to celebrate them," she says. "You do what you have to do." The discourse modality varies from assumption to an obligation thus revealing a strong sense of corporate duty.

It has been reported by relationship experts that people with certain jobs are more likely to suffer lifestyle incompatibility due to "atypical hours and intense demands and responsibilities":

"Each occupation has a distinct way of life that goes with it… They all involve long hours, at least during certain seasons of the year, that may result in an inability to participate in the mainstream social activities of one's peers." [2]

Long says that flight attendants often find dating to be particularly tricky. "It could be difficult I think trying to explain your job, your schedule, and what going out means," she explains. "It's really not going to the nightclub. It's going out to dinner, maybe getting a cocktail, and then to bed."

Aircrew will generally do things together for the duration of a trip, she says. "But we're just a family for the three or four days we're working together and that's it. We're done."

Private life sacrifices are only partially compensated for with social activities among the aircrew on a trip, but otherwise, explaining the job to the family / a date is tricky, the routine living is simple, even simplified, and adjusted to the intense job demands and responsibilities.

Conclusions

On the part of passengers, a flight attendant's distinct way of life is often associated with the key concepts of *glamour* (stemming from the ideas of fancy layouts, global clubbing etc.), *dream* (easy, holiday-style duties, e.g. serving drinks), *force* (recognized rights to maintain order and safety), *predator* (suspected access to otherwise inaccessible joys on board, e.g. quality food).

The key concepts elicited from a professional's discourse present a dramatic contrast to the popular beliefs. Thus we may resume that the fundamental values of a flight attendant's career are rooted into satisfying passengers' needs of safety, food and water, as well as into strong sense of discipline, and a narrow choice of personal life activities. These are maintaining ***safety***, humble ***serving*** through servicing and adjusting to any kind of passengers' life situations and spirits, fulfilling other people's ***basic needs*** of food and water, personal ***discipline***, strict self-inflicted ***timing***, and private-life ***restrictions***.

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Human factor in aviation maintenance engineering

The problem of human factor and the peculiarities of the professional activity of the aviation specialists have been considered. The causes of aircraft maintenance errors have been analyzed. The SHEL model, the PEAR model, «Swiss Cheese Model» and Murphy's Law has been analyzed. The authors have considered the person and system approaches in the problem of maintenance human factors. The paper reveals the effective countermeasures to maintenance error.

A maintenance human factor is a thing of vital importance in aviation. It covers all areas of human involvement in the aviation industry. The human factors investigate human capabilities and limitations in the workplace. The human factors include the social and personal skills (communication, decision making) that compliment technical skills. Its goal is to identify and optimize the relationship between maintenance personnel and systems to ensure safety. Each error of maintenance technicians must be carefully examined to identify underlying organisational problems.

Many researchers investigate the problem of maintenance human factors. Two approaches are used to study the notion of the human factors:

- the person approach;
- the system approach.

The first approach is focused on the errors and procedural violations of people involved. Errors are considered as moral issues. This approach assumes that bad things happen to disorganized, irresponsible people. In psychology it is called "just-world hypothesis." The negative side of this approach is that it isolates unsafe acts from the system context. The system approach is focused on the circumstances under which people work and try to construct defences in order to prevent errors or mitigate their consequences.

This issue was discussed at the annual Human Factors in Aircraft Maintenance Conference. A. Hobbs and A. Williamson determined the types of human errors and contributing factors in aircraft maintenance (their research was based on the idea that human errors occur in the context of contributing factors) [3]. M. Masson and Y. Koning studied the problem of human error in aviation maintenance [6]. James Reason developed the model of accident and incident causation [8]. D. Lucas investigated the causes of human error [5].

Attention on human factors in aviation maintenance engineering was focused after the accidents of Aloha aircraft in the USA in 1988; the BAC 1-11 accident in the UK in June 1990 and the Airbus 320an incident in the UK in August 1993. These accidents involved maintenance human factors problems. We present you the description and the investigations results of these accidents carried out in accordance with The Civil Aviation regulations 1989.

On April 28, 1988, a Boeing 737-200, N73711, involved 18 feet of the upper cabin structure suddenly being ripped away in flight due to structural failure. There were

89 passengers and 6 crewmembers on board. One flight attendant was swept overboard during the decompression and is presumed to have been fatally injured; 7 passengers and 1 flight attendant received serious injuries. The flight crew performed an emergency descent and landing at Kahului Airport.

The Boeing 737 involved in this accident had been examined, as required by US regulations, by two of the engineering inspectors. Inspectors were experienced. One inspector had 22 years experience and the other, the chief inspector, had 33 years experience. They didn't find any cracks during inspection. Post accident analysis discovered over 240 cracks in the skin of this aircraft at the time of the inspection. Accident investigators identified many human factors-related problems leading to the failed inspections. As a result of the Aloha accident, the US instigated a program of research looking into the problems associated with human factors and aircraft maintenance, with particular emphasis upon inspection [1].

On June 1990 on a flight from Birmingham, England to Malaga, Spain, at FL 173, the left windscreen, which had been replaced prior to the flight, was blown out under effects of the cabin pressure. The decompression pulled the captain out from under his seatbelt. Despite trying to hold onto the yoke, the captain was sucked out into the opening. A steward in the cockpit was able to grab hold of his legs. Another steward was able to strap himself into the vacant seat and aid in holding onto the captain's legs. The co-pilot wearing full restraints made an emergency landing at Southampton Airport. The captain remained half way out of the aircraft for 15 minutes and suffered only frostbite and some fractures.

Accident investigators discovered that the engineer, working under pressure and without reference to manuals used improper bolts to refit the windshield. It resulted in the accident. In the final accident report investigators recommended to consider the need for the periodic training and testing of engineers and to ensure that, prior to the issue of an air traffic control rating, a candidate shall undergo an approved course including training in both the theoretical and practical handling of emergency situations [1].

An incident in the UK in August 1993 involved an Airbus 320 which, during its first flight after a flap change, exhibited an undemanded roll to the right after takeoff. The aircraft returned to Gatwick and landed safely. The investigation discovered that during maintenance, in order to replace the right outboard flap, the spoilers had been placed in maintenance mode and moved using an incomplete procedure; specifically the collars and flags were not fitted. The purpose of the collars and the way in which the spoilers functioned was not fully understood by the technicians. This misunderstanding was due, in part, to familiarity of the technicians with other aircraft (mainly 757) and contributed to a lack of adequate briefing on the status of the spoilers during the shift handover. The locked spoiler was not detected during standard pilot functional checks [4].

These examples of accidents demonstrate the importance of human factors to the aviation industry and the necessity to consider this problem seriously. It should be noted that ground personnel (maintenance engineers, technicians, mechanics), manager, supervisors involved into aircraft maintenance should always be reminded of their responsibility to be sure that they use the correct tooling and procedures and strictly follow the Maintenance Manual. It is obvious that all the mentioned accidents were preventable if any of the specialists involved had recognized the potential hazards. The examples of accidents reveal an error chain (a series of human factors problems). It proves the fact that if one of the links in the chain had been changed by built-in measures to detect the vulnerable area the accidents could have been prevented.

The examples of the accidents denied the idea that accidents only happen to irresponsible people. Even experienced, responsible human beings can make errors. But many individuals consider “It will never happen to me”. It is a kind of complacency. This belief is a great problem, because people do not want to recognize the risks of human factors issues. The awareness and understanding of Murphy's Law “If something can go wrong, it will”, may help human beings cope with the “complacency” and increase their awareness of potential hazard.

Human factors include organization, job and personal factors. All these areas influence on people at work. Human factors involve:

- human physiology;
- psychology (including perception, cognition, memory, social interaction, error;
- work place design;
- environmental conditions;
- human-machine interface;
- anthropometrics (the scientific study of measurements of the human body) [4].

To understand the human factors the SHEL model is used. It was designed by Edwards in 1972 and developed by Hawkins in 1975. It helps understand the human factor relationships between aviation system resources/environment (the flying subsystem) and the human component in the aviation system (the human subsystem). This model consists of the initial letters of its elements:

- **S**oftware;
- **H**ardware;
- **E**nvironment;
- **L**iveware

Each element represents a building block of human factors studies within aviation.

Software includes maintenance procedures, rules, instructions,, maintenance manuals, regulations, checklist layout, standard operating procedures, practices, conventions, safety procedures etc. If manuals are poorly written, computer software is untested or difficult to use, checklists are badly designed and procedures are misinterpreted it can result in aircraft accident. Software can be included in a collection of documents such as the contents of charts, maps, publications, emergency operating manuals and procedural checklists [9].

Hardware is design of flight decks, test equipment, the physical structure of aircraft, positioning and operating sense of controls and instruments, tools, etc. In case appropriate equipment is not available, aircraft design for maintainability is bad, there are not enough tools – the flight safety can be seriously damaged. **Environment** contains physical and work environment. Physical environment can be conditions in the hangar, conditions on the line, etc. Work environment includes work patterns, management structures, public perception of the industry, etc. If physical and work environment are not properly organised for example excessive noise, poor lighting, workplace is uncomfortable – it is also unacceptable.

Liveware is a human. It contains maintenance technicians, supervisors, managers, etc. Nowadays modern aircraft use the latest Built-In Test Equipment (BITE) which is controlled by computers but aviation maintenance tasks are performed by human beings. Nevertheless, humans have limitations. Liveware is the most critical element of the model. It closely interacts with the Software, Hardware and Environment. All these components must be thoroughly adjusted to Liveware to prevent possible failures in the system, to assist human performance and respect human limitations. It must be admitted that human being is not reliable, so to ensure the flight safety it is necessary to provide efficient training, procedures, tools, duplicate inspections. To reduce the possibility of making maintenance errors aircraft design is improved.

James Reason developed the model of accident and incident causation ("Swiss Cheese Model") [8; 2]. It illustrates that the typical accident occurs because several (human) errors have occurred at all levels in the organisational hierarchy. The model shows that accidents or incidents are usually caused by the actions of pilots or maintenance engineers. In order to understand and prevent accidents, it is recommended to trace the chain of causes including organisational influences. This is often called root cause analysis. The elements of the model are:

- organisation (company policies, resource allocation, and management decisions);
- local conditions (communication, workplace conditions, and equipment);
- individual actions (human error);
- risk controls (preventative controls and recovery risk controls: procedures, checks or precautions designed to manage hazards that threaten safety, engineered solutions, functional check, duplicate inspection, Self-check of work);
- incident or accident.

The model shows that accidents or incidents are usually caused by the actions of pilots or maintenance engineers. In order to understand and prevent accidents, it is recommended to trace the chain of causes including organisational influences. This is often called root cause analysis.

Dr Michael Maddox and Dr Bill Johnson developed the PEAR model. It is called the model of human factors in maintenance. According to this model the human factors is divided into four areas [7]:

- **P**eople (maintenance engineers who perform the work). It contains capabilities, limitations and interactions with other workers.
- **E**nvironment in which people work. The environment can be physical and organizational.
- **A**ctions they perform.
- **R**esources necessary to complete the job. Resources include tools, technical manuals, the number and qualification of people involved.

People include the following factors:

- physical factors (physical size, gender, age, strength, sensory limitations);
- physiological factors (nutritional factors, health, lifestyle, fatigue, chemical dependency);
- psychological factors (workload, experience, knowledge, training, attitude, mental or emotional state);

- psychosocial factors (interpersonal conflicts, personal loss, financial hardship, recent divorce).

Physical environment includes: weather; location; workspace; shift; lightning; sound level; safety.

Organizational environment includes: personnel; supervision; labour-management relations; pressures; crew structure; size of company; profitability; morale; corporate culture.

Actions include: steps to perform tasks; sequence of activity; number of people involved; communication requirements; information control requirements; knowledge requirements; skill requirements; attitude requirements; certification requirements; inspection requirements.

Resources include: procedures/work cards; technical manuals; test equipment; tools; computers/software; paperwork/signoffs; ground handling equipment; work stands and lifts; fixtures; materials; training.

The model of human factors in maintenance (the PEAR model) helps remember the four basic components of human factors program. It is used to identify, assess and mitigate human factors issues.

Aviation companies offer the Maintenance **Human Factors Training for the aviation professionals. The training helps recognise and aware** of the human factors that can potentially result in accidents and incidents, evaluate the situation and recommend solutions for reducing human error, learn the manage process to control the human factor. Its purpose is to reinforce safety and quality in aviation maintenance operations by decreasing human error and its influence on maintenance operations. The course syllabus meets the requirements of EASA regulations. EASA regulations require all Part 145 maintenance organisations to introduce a programme of Maintenance Human Factors training for all personnel involved in aviation maintenance activities. Following the course the personnel improves its practical skills, instructional techniques and feedback. They also develop their communication and interpersonal relationships.

Conclusion

The aviation industry cannot operate properly without the contribution of maintenance personnel. So, the maintenance error is a kind of potential threat to aviation safety. All employees involved in aviation maintenance activities should pay a considerable attention to all kinds of human attributes to ensure that they work safely and efficiently with minimal risk to others and equipment. There are seven critical human factors topics that need serious consideration. They are: hazard identification; procedural compliance and documentation; human factors training – evolution and reinforcement; fatigue risk management; human factors health and safety program; considering human factors issues in design and installation; measuring impact and return on investment. All these items contribute to the aim of creating and strengthening a safety culture at work.

To manage the possibility of maintenance error the organisational response must be available. A system-level response to maintenance error consists of two steps. The first one means that it is necessary to identify and counteract error-producing conditions in the organisation in order to reduce maintenance error. It involves a wide range of human factors which are associated with maintenance error, such as: fatigue management, maintenance human factors training, adequate tooling and equipment. The second step – the maintenance personnel must acknowledge that the threat of maintenance error cannot be completely eliminated, it can only be minimized.

The problem of human fallibility applies the person and the system approaches. The person approach concentrates on the errors of people. The system approach focuses on the conditions under which people work.

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The impact of cross-culture on airline pilots' safety performance

The article highlights problems of cultural diversity and its influence on ensuring safe airline operations. It gives a broad view of effective and efficient communication in high risk situations experienced by flight crews and analyzes the cultural significance of certain ways of interacting. Special emphasis is placed on behaviors that enable crewmembers to integrate their knowledge including non-technical skills and factors such as communications, decision-making process, workload management, teamwork, and situational awareness.

Aviation is a complex system that involves mechanical, human, and technological components that formulate the principal framework for operational integrity. In order to ensure optimum safety levels, safety programs must be developed to aid in identifying the hazards and risks that result in accidents and incidents. In order to mitigate the rate of pilot error, numerous training programs, such as Crew Resource Management (CRM), have been developed and infused into daily airline operations.

When analyzing pilots' behaviors and attitudes, it is necessary to explore their non-technical CRM skills. Non-technical skills are defined as "the cognitive and social skills of flight crewmembers on the flight deck, not directly related to aircraft control, system management, and standard operating procedures". They include communication, situational awareness, decision-making, leadership, teamwork, and workload management [1]. Incorporation of non-technical skills into CRM training is viewed as a positive move toward the understanding of attitudinal and behavioral implications by crewmembers. Despite the remarkable evolution that CRM has undergone, it still lacks a crucial cultural dimension that provides a clear two-way communication between superiors and subordinates.

High risk organizations, such as airlines, are highly dependent on the reliability of human performances and the effectiveness of their interactions. Studies have demonstrated that these non-technical skills are highly affected by cultural variations among employees.

Because homogeneous cultures share similar beliefs and values, the degree of consensus among their societies is stronger than in a cross-cultural (heterogeneous) society which involves diversified attitudes. Complex interactions among group members, such as pilots and ATC, are less effective in cross-cultural groups than in homogeneous groups. Variations in performances may be due to the differences in communication and behavioral skills that form the basis of non-technical skills [2]. Airlines operate globally and their operations involve cross-cultural interactions among employees. Thus, behavior-based interventions provide effective strategies when designing regulations and standard operating procedures.

Performing tasks safely in a cross-cultural flight deck depends on effective utilization of automation systems and efficient communication skills, particularly during flight phases that involve high workload, such as approach and landing. Consequently, a culturally influenced flight deck environment has led to further implications in important operational facets including communication skills and crewmembers' effective interaction with the aircraft's automation systems.

Communication is defined as a multi-dimensional process of exchanging information between individuals via verbal and non-verbal methods [3]. Cross-cultural communication can present challenges and barriers due to differences in beliefs, values, and languages [4]. Language diversity plays a prominent role in creating operational challenges in a cross-cultural environment. Ineffective communication due to language barriers may lead to inappropriate performance on the flight deck, poor situational awareness and lower confidence levels among crewmembers. Although English is the primary language in international businesses and organizations, it is often used as a second language, which creates a number of disadvantages:

1. Mental exhaustion;
2. Fluency in a second language may create an impression of competency in other aspects;
3. First-language speakers tend to slow down their rate of speech and simplify their sentences in response to second-language speakers;
4. Second-language speakers may pretend to understand first-language speakers to avoid embarrassment.

Cross-cultural communication is constrained by the cultural inputs provided by the speaker. These inputs are implemented unintentionally and are a byproduct of cultural influences [4]. In order to gain effective communication in a cross-culture environment, it is important to understand the different communication styles:

1. Direct versus indirect: the idea of speaking one's mind in a clear and concise manner is considered a direct style. In contrast, the context of the message in an indirect communication relies on the tone of the voice and non-verbal communication [4]. Non-verbal communication may create additional barriers to cross-cultural communication due to uncommon body language, movements, gestures, and postures. Nevertheless, non-verbal communication provides a higher level of trust [3].

2. High context versus low context: individuals with a high context style tend to demand a comprehensive explanation with explicit details concerning the information being exchanged, whereas low context individuals expect only the information needed to complete a certain task. More often a positive work environment is maintained as a result of cross-cultural harmony. However, communication differences may be perceived incorrectly and provoke an undesired work atmosphere [3]. Furthermore, cross-cultural interactions may negatively influence work performance, particularly when tasks are accomplished by means of effective communication, such as workload coordination and management.

Due to the existence of a cross-cultural work force on the flight deck with a multitude of linguistic abilities, ICAO has set the English language as the international language in aviation [5]. This standardization, known as Aviation English, involves specific phraseologies to simplify the communication process and eliminate potential errors between pilots, and between pilots and air traffic controllers. Communication problems still degrade safety levels, despite English being the required language of operation [5]. Since cross-culture has a strong influence on communication skills, airlines with a diverse international pilot population must dedicate special attention toward standardizing their pilots by providing Aviation English training courses.

A dependency on a diverse work force has evolved the nature of the work force and created a complex environment in which an organization must perform. Toward this end, culture has been viewed as the primary influence of an individual's attitude and behavior that directly influences his/her performance. Commitment to high safety standards and effective operations must be initiated from the highest point of an organization's structure. Therefore, establishing and maintaining a positive safety culture begins with the organization's management [6]. A positive safety culture requires the involvement and empowerment of employees as integral participants of the organization.

The absence of a healthy safety culture may lead to subcultures within an organization. The development of subcultures is a result of existing variations in risk levels and working conditions in an organization. A positive safety culture enables organizations to establish [6]: better communication among their employees, higher levels of assertiveness and employee-management trust.

Despite culture variations, pilots from across the globe are expected to aviate, communicate, and perform as an effective crewmember in any region of the world. However, airplanes are not manufactured to accommodate culture variations. Individuals from various geographical regions interact and perform differently. Crewmembers with diverse national cultures communicate with various styles and behave according to certain attributes that have implications on operational safety. Furthermore, situational awareness of cross-cultural crewmembers may be compromised due to ineffective communication as a result of language differences and behavior variations.

Culture can be viewed as the actions performed or omitted by commercial pilots as a result of norms, values, and beliefs adopted from their cultural backgrounds. The following four dimensions form the basis of their cultural model:

1. Power Distance (PD): Inequality between subordinates and superiors is viewed differently by various cultures. Consequently, societies accept and handle power distribution accordingly [7]. Organizations with high PD have centralized decision structures and authoritative management that creates inequality among the employees. Organizations with low PD refer to flat organizational structures with direct communication between employees and managers.

2. Individualism versus Collectivism (IDV): This dimension refers to the degree to which certain goals are pursued to achieve personal interests compared to a group to which that individual belongs. Societies can be divided into two categories: individualistic and collectivistic. In an individualistic society, individuals are inclined towards their own interests and taking care of themselves and immediate family/organization members. On the other hand, in a collectivistic society, the interest of group members is considered a priority over individual interests [7].

3. Masculinity versus Femininity (MAS): Members of a masculine society tend to be more assertive, ambitious, competitive, and reward-oriented. In contrast, members of a feminine society are expected to behave with modesty and interpersonal concern [7].

4. Uncertainty Avoidance Index (UAI): Societies tolerate future ambiguities and uncertainties differently. An individual not having control of the future may develop a sense of distress and fear. Crewmembers with a high level of uncertainty will not deviate from procedures since they provide a sense of familiarity and comfort. On the other hand, crewmembers from societies with low UAI are more likely to be relaxed and deviate from procedures with no sense of alarm or discomfort [7].

Every profession develops certain attitudes and behaviors that are expressed by members of the profession. Pilot uniforms and airline badges are physical characteristics from which pilots develop a strong sense of professional culture. These characteristics may create negative cultural aspects reflected by a sense of invulnerability, or, positive culture aspects reflected by good work ethics. Negative professional culture poses a threat to operational safety as pilots fail to recognize their limitations. Alternatively, a positive professional culture is reflected by a sense of pride and an overwhelming interest for the job. Pilots with a positive professional culture will demonstrate desirable leadership skills, establish clear communication, adhere to procedures, and obey regulations.

Organizational culture is an ensemble of complex cultural elements, infusing various beliefs, norms, and attitudes shared and expressed by members of an organization. Organizational culture can be viewed as a socially constructed system in which members of its organization are distinguished from members of other organizations [7]. Despite the presence of cultural differences, organizations tend to integrate their cultural diversity with common practices that shape the organizational culture by defining their own values and beliefs. Understanding the influence of national, professional, and organizational cultures on crewmembers is an important and complex task. Neglecting the impact of these cultures may lead to degraded operational performance and organizational implications.

In order to achieve the desired operational requirements, organizations must encourage adaptability and responsiveness toward certain aspects, such as regulatory obligations, that necessitate the implementation of safety programs. Management's involvement and commitment to operational obligations are an integral factor in determining the organizational culture and the overall safety climate. Moreover, organizational culture impacts the safety performance of an organization by shaping its members' perceptions about the importance of safety. Besides management's commitment to safety, an organization's communication style has a strong impact on members' attitudes toward safety. Three types of organizational communication styles are identified [8]:

1. Pathological: Information is treated with political sensitivity and resembles power. As a result, communication becomes ineffective and creates undesirable outcomes [8].

2. Bureaucratic: Minimal line of communication is provided between management and employees with a rigid relationship among team members.

3. Informative: An open line of communication between management and employees is established with a sense of equality. Members of an informative organization are empowered by partaking in decision-making processes [8].

Taking a proactive stance and recognizing the effects of cross-culture on operations is an initial step toward mitigating and managing the effects of cross-culture.

The addition of cross-cultural training would bridge the gaps among cross-cultural crewmembers to improve flight deck relations and flight operations.

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Anti-stress self-help of professionals in aviation industry

This article examines the content and ways of implementing anti-stress self-help experts. It also highlights the importance of knowledge and skills of self-help in career of professionals in aviation industry.

The term "stress" is a specific body response made on demand against it. Human life is closely related to psychological stress. This term is used to describe the state of mental stress arising in difficult conditions during the life. Depending on the level of demonstration stress can have on a person positive influence (stimulate its activity) and negative (destructive).

Aviation is a high-stress industry, given that it requires a high level of accuracy at all times. High stress levels can eventually decline performance and compromise safety.

Stress measurement in aviation seeks to quantify the stress experienced by aviators, with the goal of making needed improvements to aviators' coping and stress management skills [5].

Unlike the other professional aviation jobs, pilots are considered to be highly affected by stress levels. Professional pilots can exceedingly stress in flight, on the ground during work-related activities, and etc. An airline pilot can be an extremely stressful job due to the workload, responsibilities and safety of the thousands of passengers they transport around the world. Chronic stress can negatively affect one's health, job performance and cognitive functioning.

The anti-stress self-help is a promising way to prevent and overcome the stress of pilots and other employees of the aviation sector. It requires appropriate motivation and knowledge. The self-help is accomplished on the cognitive, emotional and behavioral levels. The success of anti-stress self-help of pilots depends on his psychological readiness to realization of stress influence, stress stability level and mental capacity for self-regulation.

There are two areas of successful stress management, such as enthusiasm of pilots and other professionals in aviation industry for his work and personal interpretation of existing problems, understanding of problems differently.

There are techniques that minimize vulnerability of specialists from the negative effects of stress, for example:

- person should first think appropriately and then act;
- You should know that Perfectionism is impossible, but each type of activity has its top and it worth of trying to reach it and be satisfied;
- appreciate the joy of true simplicity of life style;
- pay attention to pleasant things and to actions that can improve your situation and mental state;
- try to forget the ugly, hopeless and difficult situations, as random distraction – is the best way to reduce stress;

- you should remember that nothing affects person more than the failure;
- nothing encourages stronger than success;
- even after losing it's better to fight with the depressing thought of past failure using the best memories of past successes;
- deliberate recollection is an effective means of restoring self-confidence necessary for future victories;
- don't put aside unpleasant case if it's important for reaching the aim: instead of careful stroking that only prolong the period of disease, expand the boil to eliminate pain;
- knowing that the team has always its leaders and followers, remember that leaders are needed only insofar as followers need their help.

Learn to enjoy every minute an every moment of your life. Try to smile to your relatives and friends. Facial muscles remember your smile, which certainly will improve the mood. Don't waste the possibility to make joy to yourself: keep in a drawer your favorite joke, funny book, funny postcard or two walnuts: its manipulation, shifting from one hand to another, massage of fingers pads will promote calm.

Personalities have different tools to deal with stress. An effective response to stress, which follows to an adaptation, is to use such a strategy of interaction with stressors, which greatly reduces the experience of stress. Nobody can fully avoid stress. Stress in itself is not something bad. A certain amount or level of stress in our live is natural. It is often a natural consequence of the fact that we live in the real world. Use of ineffective ways of dealing with stress can deplete the body and lead to different diseases.

There are many psychological benefits of focusing on solving personal problems: promotion to improve self-esteem, increase efficiency of its activity, control of external situations.

The second group of methods for dealing with stress of pilots and other employees of the aviation sector offers another approach to solve the problem – to perceive problems in a new way.

There are several strategies for achieving this:

1. To make a new interpretation of the problem, its re-estimation with the slogan: „Everything is not so bad!" Cognitive reappraisal means rethinking of the nature of the problem so as to shed new (positive) light on it. So, how we feel us in this situation depends mainly on our querying estimation or approving of this situation. The strength of stressor doesn't depend on object characteristic, but on our subject attitude to it and follows: "Our life is so how we think about it!"
2. Social comparison is based on the installation: "I feel better than others".
3. Avoidance is based on guidelines "It's not the problem!", "Stop worrying!", "We need to put a limiter on the excitement".
4. Humor is based on installations, "This is ridiculous!" and "Smile and the joy heals the heart".

An expert, who is able to turn the "terrible news" on the absurd and funny less prone to depression, stress, anger than who perceives this news very seriously and is under the bad mood. Cognitive component of humor is very important. Mocking at the problem you insert it in a new perspective. A person begins to see it in stupid and anecdotal aspects and thereby acquires control over it.

To have a sense of humor is not always to laugh or walk with a cheerful mask. Sometimes behind the smile masks a sense of discomfort, helplessness and misery.

It is important to mention, that hostile and rude humor, which degrades others doesn't reduce stress. It often causes more tension and anger.

1. Use of medication (antidepressants) is a well-known way to reduce harmful stress.
2. Relaxation is the simplest way to reduce the signs of stress (high blood pressure, shortness of breath).
3. Physical exercises and vigorous activity, like running, dancing, cycling (physical exercises), crying, laughing are very important for maintaining health and reducing stress.
4. Fresh air and water contribute to effective stress management.

Conclusion

Stress is the nonspecific response of the body to any claim brought against it.

A promising way to prevent and overcome stress of aviation experts self-help. It requires appropriate motivation and knowledge. Self-help is provided by the person at the cognitive, emotional and behavioral levels, and with the creation of favorable conditions for professional in aviation industry activity.

The success of self-help expert of the aviation sector depends on his psychological willingness to accept stress influence, the level of stress and mental capacity for self-regulation.

There are two successful areas of stress management. They contain enthusiasm of aviation experts for work and personal interpretation of the existing problems, though realizing the problem in a new way.

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Results and evaluation of professionally applied physical training effectiveness of future bachelors in aviation and aerospace

The article discusses the results of the effectiveness of professionally applied physical training of future bachelors in aviation and cosmonautics. We analyzed the results regarding the development of professional qualities, physical and personal abilities of future engineers of the aviation industry.

When evaluating effectiveness, the quality of the organization and content of professional-applied physical preparation of great importance is the development of a criterial features of this process. We have justified the main criteria that determine the effectiveness of PPFP of future engineers – mechanics for maintenance and repair of aircraft: motivational, cognitive, realnosty, reflective. These criteria were the relevant indicators to identify the effectiveness of professionally applied physical training of future engineers in this specialty for the maintenance and repair of aircraft. We have identified three levels of professional-applied physical readiness: low, medium, high, which you can use to evaluate the well-formedness of the most important professional qualities of students, their motor skills.

The aim of the article is justification of results and evaluation of the effectiveness of professionally applied physical training of future bachelors in aviation and cosmonautics.

Our approach to PPFP describes not only the formation of knowledge, motor skills, organizational and methodological skills of students, it treats the person as a subject of professional activity, when the development of psychophysical abilities gives the ability to perform skilled work, to make responsible decisions in problem situations, to plan and develop actions that lead to rational and successful achievement of goals. Thus, PPP is not confined to knowledge and skills in any quantitative ratio and specific volume. The first criterion for determining the level of formation of motivational component of readiness of students to activities in the specialty was motivational. In the course of the study to identify the level of formation of professional orientation of future bachelors of Aeronautics and Astronautics, formation of motivational component of professional-applied physical readiness was used survey method (questionnaire)

Analysis of data indicates that fluctuations in the baseline level of the indicators motivational component of students control and experimental groups on average are the same. The students of the experimental group due to the implementation of the experimental procedure PFP increases the value of the indicators for all three types. In the experimental group resolved the contradiction between the awareness of the students of "health" as an absolute value (80 and 96%, respectively), and the value of practical activities to support it (follow the rules of healthy lifestyle and used in everyday life physical health-improving technologies 76%, formerly 32%). Significantly increased interest in information related to various aspects of physical education – 88% of students in the experimental group would like to increase the level of knowledge in these areas of physical culture (in ascertaining experiment, the group accounted for 55% of the students in Eg). With increasing grade of physical culture in the system of professional values (awareness of the need for deliberate creation of applied physical skills, psychomotor and moral – volitional qualities – for themselves and for others) has increased the need of students in psychophysical preparation for professional activity (optimal physical activity, methods of development of professionally important physical, psychomotor, strong-willed, leadership qualities, etc.).

Performance due to criterion was significantly higher in the experimental group. This confirms our assumption about the influence on the indicator of corresponding pedagogical conditions of the experimental programs of educational disciplines and techniques for implementing PPFP future bachelors in aviation and cosmonautics.

The second component PFP future bachelors in aviation and space exploration is cognitive. Experience shows that without knowledge of the organism, evaluation criteria of physical perfection, norms and modes of professionally-applied physical training, the basics of a healthy lifestyle is impossible to provide the students with strong interests and needs in purposeful physical education classes. As values is subject to the requirements of the future specialist, it should determine the content, forms and methods of professionally-applied physical training and development and mastering of a complex of means of training.

To assess the level of assimilation of knowledge, the degree of formation of which provides beyond the standard algorithms of activity, was used for quantitative parameters. In the form of quantitative measurement of theoretical preparedness of students was elected as the coefficient of mastering of educational material. Checked the quality of learning a set of basic concepts, definitions, which the student needs to keep in memory. Completeness of digestion was determined by means of tests of conceptual character (control tests with sample answers – one of which is correct and the rest incorrect or incomplete).

In the experimental group a high level of theoretical knowledge PPFP showed 54,0%. In the control group, knowledge of the high level remained unchanged at 0%. The average level was displayed is 38.0% in the experimental group and 32.0% in the control. 8,0% of students in the experimental and 68.0% of students in the control group in the survey showed low level of theoretical knowledge PPFP.

The third component is PPFP activity. It reflects the formation of motor skills and the level of development of professionally important qualities of students.

As a result of the pedagogical experiment we were able to reliably significant differences in the cognitive component PPFP among students of control and experimental groups. The largest increase occurred in the experimental group.

To determine an activity based component formation PPFG students, we used the following target physical exercises and techniques:

• general physical preparedness was determined with the exercise speed (running 100 meters), endurance exercise (running at 3000m..), exercises for agility (running 4x9м), exercises for strength (pull-UPS, bending and straightening the arms in emphasis lying, lifting the torso in gray from the prone position), exercises for speed and power (long jump from place), exercises of flexibility (torso forward from a sitting position);

• professional-applied preparedness was determined using typing test, the sample Romberg, dynamometry, push two weights, weight of 16 kg;

Figures were the basis for the assessment of the students. The number of assessments and their percentage in both groups is almost equal. High level shown by the students of the experimental group was 8.2%, control group to 7.6%. The average level of General physical preparedness demonstrated in the experimental group 27,6%, in the control of 26.2%. Low rates are found at 64.2% in the intervention group and 66.2% in the control group.

At the end of the pedagogical experiment was conducted final testing of General physical preparedness of students of experimental and control group. It showed positive dynamics of growth of level of physical preparedness of students of the experimental group and the smallest increase in students in the control group engaged in traditional programme and methodology. A high level of physical fitness showed 53.6% of students in the experimental group (in control group – only 6.5%), the average level in the experimental group to 7.1% in the control to 7.3%. Reduced the number of students in the experimental group with low level of 60.7%, the number in the control group was 13.8%.

The above indicates a higher level of General physical preparedness of students of the experimental group.

The next element of the action component ppfg was professionally-applied physical training of students. Methods of control were dynamometry, typing test, the Romberg test, the use of elements of kettlebell lifting. Obtained in the course of the study, the data were processed using mathematical statistics methods

As the findings in the experimental group there was a significant improved performance at high level (from 12.75% to 53.5%). In the control group respectively 12.5% and 22%. Positive dynamics was observed in the experimental group and the average: 34% – to experiment and 40.5% after the experiment. Decreased significantly in the experimental group after the experiment, the number of students with low level: 53,25% to 6%. In the control group it amounted to 46.5%.

At the end of the pedagogical experiment the final test showed a significantly significant predominance of high and medium levels in the experimental group and the pronounced predominance of a low level in the control group.

Analysis of the obtained data on the formation of reflexive component showed that after the experiment, 56.6% of students in EG had a higher level of development of the reflective component, students KG showed 17.8 per cent, at the stage of ascertaining experiment revealed 3.5% of students in EG and 2.2% KG with a high level of formation of reflexive component; 38.4% of the students in EG (was 27.8 percent) and 34.6% of the students KG (– 28,6%) – average level; 5,0% of the students in EG (was 68,7%) and 47.6% of the students KG was 69.2 per cent) is low. Comparative analysis of obtained experimental data shows that the number of students at the final stage of the study with high and medium levels of development of reflective component increased. The positive dynamics of formation of reflexive component ppfg future engineers – mechanics for maintenance and repair of aircraft indicates the presence of students with a high level of reflexivity after the experiment.

Conclusion

The results of experimental studies confirmed the effectiveness of techniques PPFP future bachelors in aviation and cosmonautics. This is evidenced by the results of the pedagogical experiment. Analysis of the obtained results shows a positive trend of all components in the structure of this phenomenon and reflects the efficiency of the developed technique.

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Variational principle of psychology

In this report we discuss subjective entropy paradigm as a tool of an active system control. Most of the problems we have dealt with in this area are connected with the human factor influence. Namely, we keep the work of psych in the course of decision making in mind.

In particular the human factor influence problems are connected with economy, sociology, education, taken into account in engineering, including when safety of such systems is considered.

In the last two decades the number of publications concerning the use of entropy methods has been growing with a very high rate – there are more than 70,000 publications in the named field.

In the report we are going to propose an entropy paradigm for psychological investigation. All questions connected with this paradigm have been conditionally named as *"subjective analysis"* [1-4]. The main postulate of subjective analysis is expressed with the following thought: *"development of the preferences distribution on a given set of alternatives is realized in an optimal way"*.

It is supposed that the optimization principle named above has been *"soldered"* into our psych *"priory"*.

The question about genesis of such a principle belongs to the domain of the evolution theory and neurophysiology.

Two kinds of preferences were introduced: *object preferences* $\pi(\sigma_i)$; $\sigma_i \in S_a$; $i \in \overline{1, N}$, where S_a – is the set of the object alternatives; $\pi(\sigma_i)$ – numerical measure of the *"force"* of the preference (they are normalized: $\sum_{i=1}^{N} \pi(\sigma_i) = 1$) and *rating preferences* with the measure of $\xi(j) \in S_\xi$; $j \in \overline{1, M}$; of the persons of the group S_ξ, also normalized: $\sum_{i=1}^{M} \xi(j) = 1$.

In the first case it is going about a choice of goods, in the second case – a choice of individuals: $j \in \overline{1, M}$, the member of the group S_ξ. They have to be chosen as actors of corresponding problem solution.

The important part of the postulate is the concept of an "individual carrier" of all information about problem situation. In order to realize a numerical description of the main principle of subjective analysis the Jaynes model [5, 6] was proposed.

It was introduced two kinds of entropy: subjective entropy of the object preferences $\pi(\sigma_i)$; $\sigma_i \in S_a$; $i \in \overline{1, N}$:

$$H_\pi = -\sum_{i=1}^{N} \pi(\sigma_i) \ln \pi(\sigma_i); \qquad (1)$$

and subjective entropy of the rating preferences $\xi(j)$; $j \in \overline{1, M}$ determined at the set of the members of the group S_ξ $H_\xi = -\sum_{j=1}^{M} \xi(j) \ln \xi(j)$.

It was also introduced different modifications of preferences, for example, conditional preferences. In accordance with the Jaynes scheme it is introduced a variational principle with the following criteria:

$$\Phi_\pi = H_\pi + \beta_\pi \sum_{i=1}^{N} \pi(\sigma_i) F_i + \gamma_\pi \sum_{i=1}^{N} \pi(\sigma_i) \qquad (2)$$

and

$$\Phi_\xi = H_\xi + \beta_\xi \sum_{j=1}^{M} \xi(j) G_j + \gamma_\xi \sum_{j=1}^{M} \xi(j). \qquad (3)$$

F_i and G_j are the so called cognitive functions that reflect the influence of some external factors and properties of the individual's psych itself. Parameters β_π, γ_π, β_ξ, and γ_ξ – bear information about the properties of the individual's psych.

As whole, the models of (1)-(3) have been taken as a useful *"wrapping"* of the *"subjective entropy maximum principle"*.

Solving this problem

$\pi(\sigma_i) = \max_{\sigma_i \in S_\sigma} \Phi_\pi$.

With functional Φ_π we found

$$\frac{\partial \Phi_\pi}{\partial \pi_i} = 0; \qquad i \in \overline{1, N}; \qquad \pi_i = \frac{e^{\beta_\pi F_i}}{\sum_{k=1}^{N} e^{\beta_\pi F_k}}. \qquad (4)$$

In the similar way we solve the problem for the rating preferences:

$$\xi(j) = \max_{j \in S_\xi} \Phi_\xi; \qquad \xi_j = \frac{e^{\beta_\xi G_j}}{\sum_{s=1}^{M} e^{\beta_\xi G_s}} \qquad (5)$$

and find models of the preferences distributions similar to Gibbs distributions of physical kinetics where $T = \frac{1}{\beta}$ is the absolute temperature. It gives us a possibility to introduce *"psychological temperature"*, (or *"emotional temperature"*).

In particular we can say about psychological overheating or psychological (emotional) super-cooling. Disposing with numerical models of preferences we can solve a lot of different problems. Especially it relates with the problem of choice (problem of decision making).

Generally, preferences are not probabilistic categories, although having formal similarity with them. It gives a possibility to use some models of investigations elaborated in probability theory. Some models of Bayes risk was proposed in work [7].

Subjective risk for object preferences $\pi(\sigma_i)$ is expressed, for a case of two alternatives σ_1 and σ_2 , by formula

$$R_{SB\pi} = C_{11}\pi(\sigma_1)\hat{P}(a \in A_1|\sigma_1) + C_{12}\pi(\sigma_2)\hat{P}(a \in A_1|\sigma_2) +$$

$$+ C_{21}\pi(\sigma_1)\hat{P}(a \in A_2|\sigma_1) + C_{22}\pi(\sigma_2)\hat{P}(a \in A_2|\sigma_2). \quad (6)$$

Subjective risk for rating preferences $\xi(j)$ is expressed by formula

$$R_{SB\xi} = C_{11}\xi(\Sigma_1)\hat{P}(\Sigma_1)\hat{P}(a \in A_1|\Sigma_1) + C_{12}\xi(\Sigma_2)\hat{P}(a \in A_1|\Sigma_2) +$$

$$+ C_{21}\xi(\Sigma_1)\hat{P}(a \in A_2|\Sigma_1) + C_{22}\xi(\Sigma_2)\hat{P}(a \in A_2|\Sigma_2). \quad (7)$$

Several conditions have been considered in the framework of subjective analysis. A conflict, in this point of view, is treated as a conflict of preferences distributions. In particular, inner and interpersonal conflicts are considered. Criteria of conflict direction of its strength are determined. Also, it is considered a transition of a conflict from one kind into another: namely, an inner conflict into interpersonal one, as well as a transition of a *"cold conflict"* into *"hot"* one.

Entropy thresholds serve for solving problems of decision making and a lot of other problems. The notion of the entropy threshold is an essential part of the general theory of subjective analysis. So, we can state that entropy space is not uniform but is divided with some borders. Crossing them puts an active system into a new state.

Some economic problems are being considered in the framework of subjective analysis, in particular, dynamics of Walras-Leontiev system, the problem of light and shadow financial streams separation, crisis dynamics of bank, economical dynamics with bifurcations. Hybrid model, joining Kolmogorov probability theory with subjective entropy maximum principle [8].

Conclusions

The main whereabouts of this work is a statement that a subject's individual psych (in the part connected with the preferences generation) works in an optimal way. Corresponding mathematical mounting if such a principle is given. Applications of the principle refer to the theory of active systems. In particular, problems of active systems safety, economics, sociology, theory of education, logistics and so on are the fields of the principle application.

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Finite Element Modeling of Concrete Airfield Pavement

Finite element modeling of concrete airfield pavement can be provided in program LIRA-SAPR. Finite element model of multi-slab jointed concrete pavement for program LIRA-SAPR allows analyzing pavement with or without separator layer and under impact of new aircraft main landing gears.

In Ukraine conventional airfield pavement of the international airports is concrete pavement on the stabilized base that's why finite element analysis is important for concrete pavement design under impact of the main landing gears of new aircrafts.

A concrete pavement system consists of a number of Portland cement concrete (PCC) slabs finite in length and width over subbase layer. When a slab is subjected to a wheel load, it develops bending stresses and distributes the load over the subbase. However, the response of these finite slabs is controlled by joint. Two methods are used to provide load transfer across concrete pavement joints – aggregate interlock and dowels. Aggregate interlock joints are formed during pavement construction by sawing 1/3 of the way through the pavement. Dowels are smooth rods, generally plainer epoxy-coated steel, which are usually oiled on side to allow the joints to open and close without resistance.

Finite element modeling of concrete airfield pavement can be provided in program LIRA-SAPR that is the general purpose finite element method software. Multiple-slab jointed rigid pavement model includes nine slabs. Longitudinal joint of pavement can include aggregate interlock or tie bars. Transverse joint include dowel bars. Joints between adjacent slabs are spring connection. The ideal spring connection would be one that provides a vertical spring force proportional to the relative vertical displacement between adjacent slab edges but does not constrain movement in any other direction.

The LIRA-SAPR finite element (FE) library contains simple spring model that is called FE 55 (fig. 1). FE 55 allows the user more control over the line of action of the spring by acting only a user-specified direction. The stiffness of the joint for rigid pavement analysis consists of springs which have stiffness in the vertical direction Z only. A shear modulus R_Z for the joint element can be calculated from the assumed joint stiffness.

For an aggregate interlock load transfer mechanism, the joint stiffness is prescribed by the parameter k, which defines the force transmitted per unit length along the joint per unit differential deflection across the joint. For the dowel load transfer mechanism, k is defined as

$$k = \frac{D}{s}\,, \tag{1}$$

where: the value of D depends upon the vertical stiffness caused by the support of the concrete, called the dowel-concrete interaction *(DCI)*, and a vertical stiffness caused by beam bending; s is the dowel spacing, m [1,2].

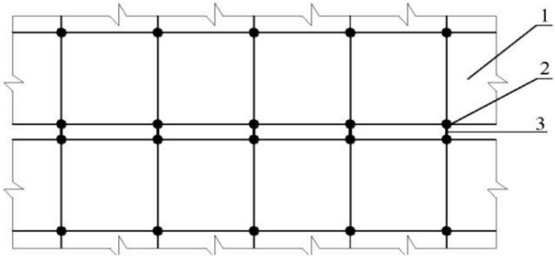

Fig. 1. Joint finite element model:
1 – shell finite element; *2* – node; *3* - FE 55.

Once k has been established, it is necessary to distribute the stiffness to the nodes along the joint in a rational manner. One method of allocating the stiffness to the nodes is by using the concept of contributing area, which is commonly used in structural analysis. In this method the stiffness values assigned to each node, R_Z (stiffness of FE 55), are determined based upon the length that contributes to the stiffness of the node. For equally spaced nodes in a 2D model, the nodes along a joint may be categorized into one of two types: interior nodes and edge nodes. Edge nodes are those which occupy the ends of the joint, while all other nodes are interior nodes.

Two-dimensional shell finite elements are used to represent the concrete slab and stabilized base. Subgrade model is Winkler foundation. Concrete slab and stabilized base are unbounded layers with or without the separator layer. Polyethylene sheeting, thin chip seal or slurry seals can be used as separators. Compression of interacting layers (concrete slab and stabilized base) of pavement is described by compression ratio. If the separator layer is located between rigid pavement layers compression ratio is defined by Totskyi [3]

$$C_i = \frac{2{,}4 \cdot E_i E_{i+1} E}{E \cdot (h_i E_{i+1} + h_{i+1} E_i) + 2{,}4 \cdot E_i E_{i+1} h \mu_1} \qquad (2)$$

where: E_i, E_{i+1} are the elasticity moduluses of a rigid pavement layers, MPa; E is the elasticity modulus of the separator layer, MPa; h_i, h_{i+1} are the thicknesses of a rigid pavement layers, m; h is the thickness of the separator layer, m; μ_1 is the reduced Poisson's ratio of the separator layer.

The reduced Poisson's ratio of the separator layer is defined by the relationship (Totskyi *et al.* 1982)

$$\mu_1 = 1 - \frac{2\mu^2}{1-\mu}, \qquad (3)$$

where: μ is Poisson's ratio of the separator layer.

Compression ratio of the separator layer between concrete slab and stabilized base is defined as

$$C_f = \frac{2{,}4 \cdot E_c E_f E}{E \cdot (h_c E_f + h_f E_c) + 2{,}4 \cdot E_c E_f h \mu_1}, \qquad (4)$$

where: E_c is the elasticity modulus of concrete slab, MPa; h is the thickness of concrete slab, m; E_f is the elasticity modulus of stabilized base, MPa; h_f is the thickness of stabilized base, m.

If the separator layer is not located between rigid pavement layers compression ratio is defined by Totskyi [3]

$$C_i' = \frac{2{,}4 \cdot E_i E_{i+1}}{(h_i E_{i+1} + h_{i+1} E_i)}, \qquad (5)$$

where: E_i, E_{i+1}, h_i, h_{i+1} are the same as in equation (2).

Compression ratio between concrete slab and stabilized base is defined as

$$C_f' = \frac{2{,}4 \cdot E_c E_f}{h_c E_f + h_f E_c}, \qquad (6)$$

where: E_c, h_c, E_f, h_f are the same as in equation (4).

The separator layer is proposed to model by FE 262 of the program LIRA-SAPR finite element library. Finite elements FE 262 model the separate layer as independent axial springs which have stiffness in the vertical direction Z only.

The stiffness values assigned to each node, R (stiffness of FE 262 of the program LIRA-SAPR finite element library), are determined based upon the area that contributes to the stiffness of the node. For equally spaced nodes of shell finite element mesh, the nodes may be categorized into one of three types: interior nodes, edge nodes and corner nodes [1]. Based upon the concepts of contributing area [4], the stiffness of the interior nodes R must be twice that of the edge nodes R_e; the stiffness of the edge nodes R_e must be twice that of the corner nodes R_c.

Multi-slab jointed concrete airfield pavement model allows analyzing the impact of all main landing gears of new large aircrafts such as A380. Nine-slab and twelve-slab jointed pavement models for A380 problem are shown in fig. 2, 3.

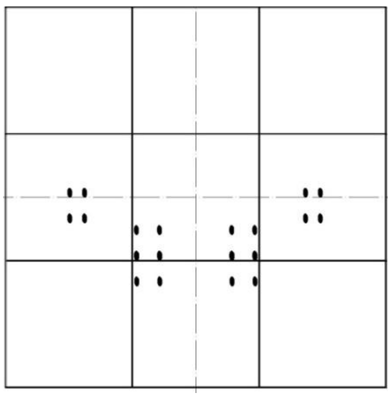

Fig. 2. Nine-slab geometry and load position for the A380 gears

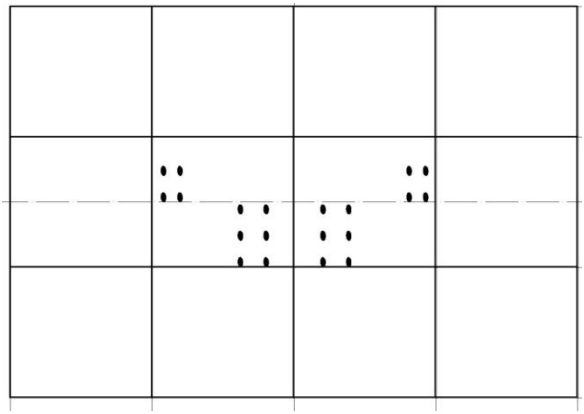

Fig. 3. 12-slab geometry and load position for the A380 gears

Conclusions

Finite element model of concrete airfield pavement was developed for program LIRA-SAPR by author. Compression ratio relationships of Totskyi were applied to the LIRA-SAPR finite element FE 262 stiffness calculation. The introduced finite element model provides a practical approach of computing concrete airfield pavement on the stabilized base in the general purpose program LIRA-SAPR and takes into account such factors as multiple-wheel interaction, finite slab size, variable joint stiffness and separator layer between concrete slab and stabilized base. The using of research results will have to improve concrete airfield pavement analysis and design.

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Project proposals for the construction of the passenger terminal at the airport «VINNITSA»

The results of the elaboration of diploma «Passenger terminal at the airport «Vinnitsa» educational-qualification level «Bachelor» in the field of training of 6.060102 «Architecture». The aim of the project is to create of the expressive architectural and artistic image of the Terminal throughput capacity of 400 passengers/hour.

Development of the Vinnitsa regional municipal enterprise «The Vinnitsa Airport» - a part of the complex of tasks of the State target development program of the airports for the period till 2023 [1]. Modernization of terminal and reconstruction of airfield should increase annual dynamics of a growth of passenger transportation up to 251,2 thousand people and servicing of air vehicles in 7,39 thousand flights.

Vinnitsa airport has been in use since 1982 for local airlines [2], in 1992 has begun to fall into decay, however in 2008 the airport have provided «second wind» with large-scale reconstruction and upgrade, its capacity has increased to the 400th pass/hour. Subsequently the airport has received the «international» status, though it is very small size and serves several flights a week. It has allowed not only to open new flights for ensuring the international air transportation (fig. 1), but also to solve strategic problems for the region [3].

Fig. 1 Scheme of the organization of passenger transportations

The purpose of the diploma was the creation of the expressive architectural and artistic image of the new passenger terminal, the space-planning, design and engineering solutions which should ensure the implementation of modern technologies of passenger servicing international and domestic flights [4].

Design process was preceded by an investigation of international and domestic experience of design of the airports, and also objects with the low level of energy consumption at construction and operation [3, 5].

The airport is located in 7,5 km from a railway station Vinnitsa and in 1 km to the southwest of the settlement of Gavryshivka. It is in the center of Ukraine and has a convenient traffic intersection for transportation of passengers and cargo, both across Ukraine, and across the border.

The territory of the airport is 6,1 hectares. Transport communication with the city runs part of the highway M12 of the international importance with a separate entrance to the airport (to fig. 2, a).

a

b

Fig. 2. Vinnitsa airport:
a - the existing air terminal, b - the passenger terminal (project)

A new solution of the Terminal (fig. 2, b) envisages the following organization of the General Plan (fig. 3). According to the technological processes of passengers service, passenger terminal is divided into two parts: a zone of domestic and international flights. Each of them lets you serve streams of passengers of different categories: departure, arrival, transit and transfer.

The zone of an arrival of the international and domestic flights is situated on the first floor, the departure zone - on the second floor (fig. 4).Entrance of motor vehicles from the city is on the level of the second floor (zone of departure), it arranged a flyover from two lanes.

The project decision is characterized by bigger, than existing, territory for placement of the passenger terminal, organization of the station square and the platform. At the same time, it allows to provide more comfortable service level (availability of a parking, parking for buses, telescopic ladders, trade enterprises, etc.).

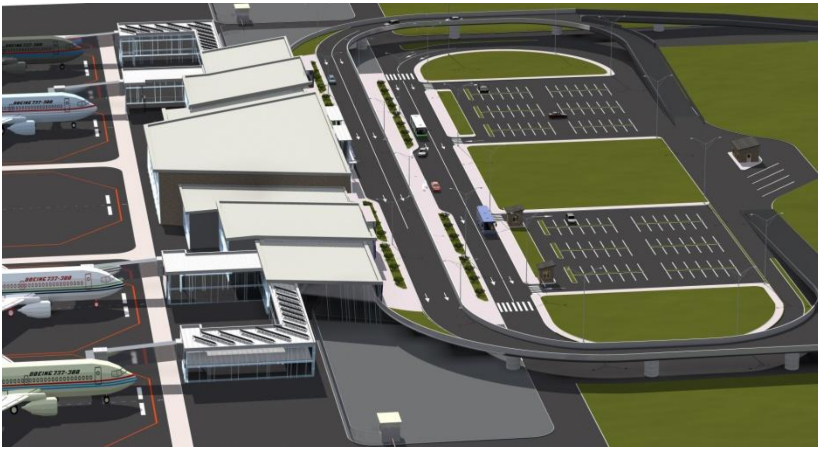

Fig. 3. Organization of the General plan

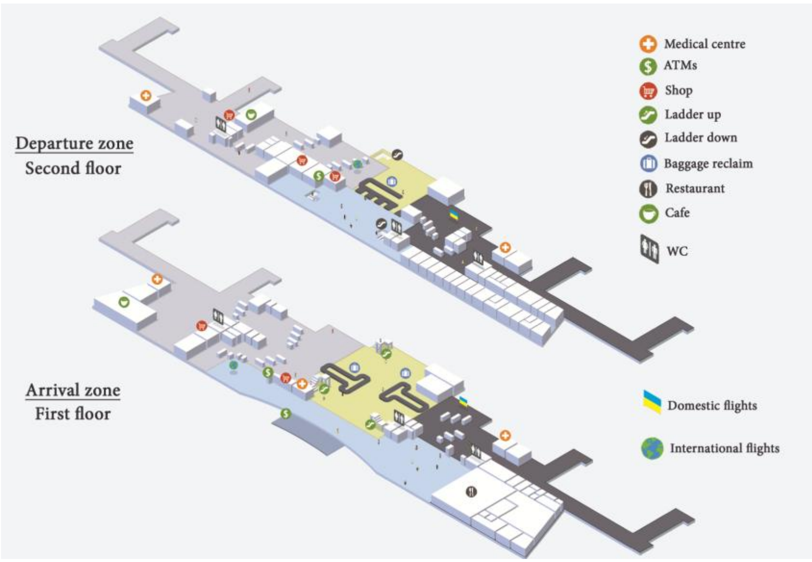

Fig. 4. Functional zoning of floors of the passenger terminal

Architecture-art image is expressed on the main facade in the form of the letter «V" is the initial letter of the name of the object's location.

Great value given to the geometry of the building plan, which ensures the integrity and efficiency of a phased construction (fig. 3), and the introduction of energy-efficient technologies [5].

Conclusions

1. The solution of perspective problems of the country on development of the regional airports and their inclusion in worlds transportation networks and requires a search of new architectural and planning solutions for buildings, including passenger terminals.

2. Solutions developed during the execution of the graduation project, reflects not only the level of acquired knowledge and skills, but also allows the soon-to-be architect to express their views on modern architecture of the domestic airports.

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UDC 556:628:2

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Considering the Loss of Precipitation on the Earth`s Surface in the Design of Culverts and Drainage System of Objects on Motor Roads

Analyzed the problem of accounting for the loss of precipitation on the Earth's surface in the design of culverts and drainage systems of objects on the roads. To account for the loss of the initial precipitation is proposed to use wetness index Iв which takes into account the type of soil and the initial level of moisture. To account for the magnitude of the loss of rainfall runoff asked to consider the type of expression of the soil of its land and the initial moisture level. The dependences of the intensity of runoff formation in time, which can be obtained for any hydrometeorological area of our country for different values of soil moisture capacity, wetness index and frequency of rainfall.

In Ukraine, natural meteorological phenome are annually registered in all districts, which covers large areas. The most common of these phenomena are heavy rains, which in some cases are catastrophic and cause major damage.

Hydrological engineering of drainage systems is based on calculation of the maximum expenditure of the integrated hydrograph, which shows flood peaks and volumes. Methods of design are usually based on assumptions that take into account the radio of rainfall and runoff. Two main methods of calculation exist:

a) The rational method, which only evaluates the maximum expenditure and accepts the flow rate and the rainfall intensity for any period of time as constants.
b) The method of calculation of the runoff hydrograph, which allows for determining the maximum and the volume of the flood. This method allows to perform calculations for large urbanized catchment areas and regulatory tanks as reservoirs and ponds etc.

There are many analytical expressions of the law of changes in the intensity of infiltration time. Most of them resemble the following:

$$it = i_0e\text{-}ct \qquad (1)$$

or

$$it, = k + i_0/t\alpha \qquad (2)$$

where it is the intensity of infiltration at a point in time t; i_0 is the initial intensity of infiltration for the air-dry condition of the soil; k is the coefficient of filtration; з and α are the parameters that depend on the nature of the soil.

One of the major factors that influence the formation of rainfall runoff is the nature of the surface, which defines the surface delay and the intensity of water infiltration into the soil. One can distinguish four infiltration phases in the natural conditions of rain irrigation:

1)Surface wetting and accumulation in rough areas of the soil as well as vegetation retention;

2)Leakage into large soil pores, cracks, and root paths under the influence of gravity;

3)Absorption in soil capillaries under the influence of molecular and capillary forces;

4)Filtration into the soil at its full saturation.

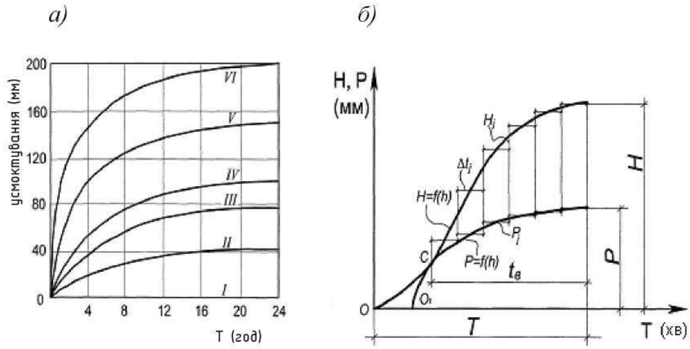

Fig.1 Schematization of the flow layer: a) dependence of the runoff loss on the absorption for different categories of soil in terms of absorption (*I – VI*); b) forming a runoff layer over time.

The natural moisture-holding capacity of the soil that which lies at the top of the earth`s crust is known to be mare or less constant depending on its type. These relationships allow obtaining the soil moisture-holding capacity index given the natural soil moisture-holding capacity $I_в^{ey}$ (refer to table 1)

Table 1.

Soil Characteristics of and Moisture Capacity Indices

Soil	ρ, кg/m^3	W, %	П, %	$I_в^{max}$, %	$I_в^{ey}$, %
Crushed-stone soil	1750	2	33,96	94,18	83,87
	1900	6	28,30	87,16	46,88
Gravel soil	1700	2	35,85	95,18	85,69
	1900	8	28,30	87,16	33,45
sand	1500	8	43,40	91,21	63,56
	1600	12	39,62	94,81	46,35
Sandy clay	1500	10	43,40	91,21	56,65
	1600	15	39,62	94,81	34,24
Clay	1500	20	43,40	91,21	22,08

	1600	30	39,62	94,81	0,00
Loam	1500	14	43,40	91,21	42,82
	1600	19	39,62	94,81	18,09
Vegetable soil	1200	20	54,72	65,01	21,15
	1300	25	50,94	75,61	11,82

We recommend determining the value of rainfall losses S at the filtration stage on the basis of the following dependence:

$$S_{\text{ф}} = \text{ПВ}\left(1 - e^{-\frac{P}{\text{ПВ}}}\right) \qquad (6)$$

The resulting ratio takes into account the type of the soil, its land use, and its initial moisture levels.

This kind of formation of the dependence of generation of the runoff intensity on time can be obtained for any hydrometeorological area of our country at different values of the moisture-holding capacity of the soil, the moisture-holding capacity index, and the frequency of rain fall.

In order to check the recommended equation, determination of the rate of filtration of water in the soil has been performed in laboratories conditions. The soil sample was sand with a density of 1600 кg/m^3 at the natural moisture of 10 pct. As a result of approximation of the obtained data, the parameters of the Horton`s equation has been determined, and the dependence of water absorption into the soil on time has been drawn (refer to Fig. 2)

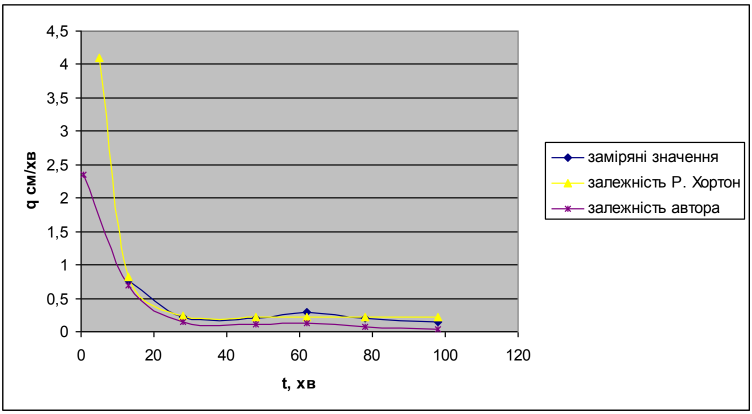

Fig. 2 Depedence of absorption of water into the soil (q, cm/min) on time (t, min).
Then, using the dependence

$$S = S_{в} + S_{ф} = I_{в} ПВ + ПВ\left(1 - \exp\left(-\left(\frac{P}{ПВ}\right)\right)\right) = ПВ * k \qquad (7)$$

, the layer of water that was absorbed by the soil and the absorption rate were determined, which allowed for obtaining the equation of the rate of ab Sorption of water into the soil depending on time.

As a result of this work, a model of loss of precipitation that falls on the earth`s surface has been developed and methodologically justified for further mathematical modelling of the surface runoff.

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Features of reinforcing materials for the layers of the road with increased roughness

In modern production has a trend for the use of new technologies improve the economic condition of coverage that will ensure an increase in terms of overhaul, pavement reliability, durability and improve safety of vehicles. There is a practice of choice the hard concrete pavement for roads with high intensity. Layer of cement paste with reinforcing fibers and small crushed stone material provides the necessary friction coefficient.

Road clothing that is designed and built in compliance with existing regulations, in most cases, cannot withstand the specified service life. This leads to the rapid destruction of the coating and pavement as a whole, rather than normative 16-18 years, 3-4 years covering work. The main type of covering on the roads is asphalt, which erased during service to form cracks and other deformations. Therefore, the development of which enhance its transport operational performance and durability are important and necessary.

In Ukraine roads used thin-layer coating-type Slarri-Sill on the existing asphalt pavement roughness to improve and increase the service life of overhaul [1]. But the main disadvantage of this technology is its high price in Ukraine. Therefore, in the present conditions of repair roads need not only a productive technology, but also economic efficiency.

There are quite a number of technology apparatus rough surface layers. These include the mechanical processing of existing surface, which often leads to even more destruction of the surface of the road with the times.

The modern concept of operation roads involves the repair early damage of surface layer the coating. The modern concept of operation roads involves the repair early damage of surface layer the coating. The primary means of enhanced adhesion is formation a rough surface that will provide the required performance properties of the road, including unfavorable condition coverage. Much of concepts to ensure the roughness of road surfaces is reduced to that the upper layer coating is a self-important constructive element road. This layer is designed to enhance comfort and safety, ensure the required speed.

In the semi rigid road surfaces asphalt concrete and cement solution combined to bring together the benefits of both materials. Due to the effects caused by viscosity, hardness and ductility of asphalt cement provided the opportunity to cast placement, a strong and durable coverings in comparison with the coverings material hydraulic binders are also economical.

Maintaining safe, comfortable and durable surfaces on heavily trafficked motorways has long been a major challenge to road owners and their operational units, who manage the construction and maintenance of their roads.

Rigid concrete roads are often chosen for roads with much heavy traffic as they offer high strength and durability, but modern requirements for comfort and noise generation imply a limited initial macro texture, which may lead to low skid resistance after some ten or twenty years of traffic.

Comfortable and safe traffic, surface durability on heavily trafficked roads are major challenge of road organizations who responsible for managing exploitation and are the need for drivers.

The thin layer coverage that is applied to the asphalt should ensure equality, strength, cover small cracks, and provide the necessary friction coefficient for the duration of road exploitation.

These are the characteristics of thin-layer coverage from cement paste that applied on the surface of the asphalt pavement. This cover is a thin layer of cement paste, composed of Portland cement, sand, reinforcing fibers (basalt fiber), water plasticizers and apply on top of crushed stone, which provide the necessary coefficient of adhesion [2].

Cement-concrete has a breaking strength at a bend almost an order of magnitude lower than compressive strength. Reinforcement and disperse reinforcement of continuous fibrous reinforcement changes the behavior of cement and other artificial stones, giving it a high resistance to cracking on bending and discontinuous loads, to create the necessary margin of safety, while maintaining the integrity of the construction, even after the cross cracks.

As a result of the introduction of fiber-reinforced cement mixture obtained in the so-called fiber concrete, which has a high crack resistance, tensile strength, impact strength, abrasion resistance [3].

In the last 30 years began the widespread use of steel fiber-reinforced concrete. Its best qualities are in high tensile resistance and high resistance to fracture because fibers create effective resistance to disclosure cracks (in the core resistance to fiber direction). As the fiber is usually used thin wire diameter 0,1 ± 0,5 mm, divided into segments of 10-50 mm.

Also metallic fibers can be used glass, basalt and other fibers. Glass fibers typically have a diameter of about several tens of micrometers and a length of 20-40 mm. They have a high tensile strength (1500-3000 MPa) and modulus of deformation higher than cement. Temperature coefficient of linear expansion coefficient close to the fiber cement. However, glass is quickly destroyed by the alkaline environment of cement as necessary to provide the use of special measures to protect the destruction of the glass fibers in concrete from corrosion. These measures include the use of alumina cement in concrete, various additives in concrete, connecting the alkali impregnated of polymer concrete. Increasing fiber volume content more than 1.5% creep causes an increase in the compressed area and increased deflections element. In the stretched zone is a slow development of creep.

The introduction of fiber is essential operation because the mixture with fiber concrete is prone to clumping and fibers may form in concrete mixture lumps, which drastically worsens quality and cannot achieve a proper compaction of the material in the product. Considering such a thing to prepare a mixture using various methods: fiber injected least in the pre-mixed mixture of cement, water and aggregate or mixed fiber and filler first, and then add cement and water [4].

Studies performed were divided into several stages:

1. Gathering information about the possibility of placing the hard concrete thin-layer coating on the basis of non-rigid coatings on non-rigid framework, which is the existing asphalt surface;

2. Select the components concrete surface that is fiber, stone material and directly determining the optimal com-position of concrete mix;

3. Carrying out laboratory tests to determine the physical and mechanical properties of the concrete mix matched;

4. Development of technologies applied to the existing asphalt surface.

Basalt fibers have higher mechanical strength, elasticity and temperature resistance compared to glass. This would allow operation of compositions with their use in high humidity and significant temperature fluctuations.

The use of fiber diameter of 30 micrometers under the influence of aggressive environment of hardening of cement remained at least 22 micron of working fiber diameter that has almost no effect on its strength characteristics [5]. Application of fibers 12 microns in diameter, made of basalt roving without lubricant showed that over time it loses all strength properties and sometimes completely destroyed as fibers, after reaction with the aggressive environment of concrete are reduced in diameter up to 4 micrometers. Using a fiber made from basalt roving with a lubricant, adhesion to cement weight is practically absent. Results of the study to determine the loss of strength fiber made of continuous basalt fiber without lubricant, when it stays in the liquid phase hardening cement concrete under normal conditions are shown in Figure 1.

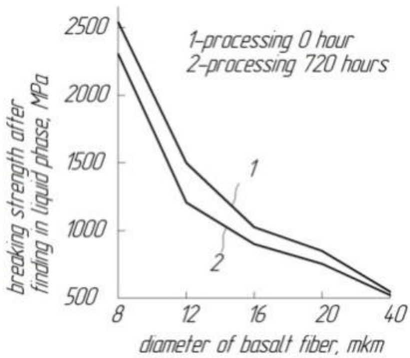

Fig. 1. Basalt fiber strength research

Selection of cement-concrete mixtures is that for material taken as directed cement-concrete, local conditions and economic considerations to set binding spending, water and aggregates and grain composition, providing the required volume weight and strength of cement-concrete at least of its value.

Selection is based on a method of trial mixes, with each sample which is manufactured and tested a series of samples. The optimal mix light concrete structure is the one that provides the required strength with minimal bulk density and cement consumption.

There are two most common technologies introduction basalt fiber into the concrete mix. First - fibers are introduced into the pre-mixed mixture of cement, water and aggregates in the least. Second - mix all dry ingredients first, then added water and plastifying admixture. To determine the compressive strength is making samples cubes 10×10×10 cm. To determine the tensile strength in bending are making beams 10×10×40 cm.

Conclusions

Conducted laboratory tests to determine the possibility of using basalt fibers to disperse (chaotic) reinforcing cement mixture showed that the material can be used as a reinforcing additive and this will improve the physical and mechanical properties of dispersion-reinforced materials.

The introduction of basalt fibers to the concrete mix improves the physical and mechanical properties (increase in compressive strength at 20%, tensile strength in bending by 20% - 25%, frost resistance and water resistance to 15 - 20%).

Conducted researches it is established the optimal number of input fiber, which is the mixture cement to 2.0% by weight. The introduction of technology has virtually no effect on physical and mechanical properties of the concrete mix.

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Analytical modeling of nonlinear problem bond armature with concrete

It is proposed the analytical model of nonlinear task of bond armature with a concrete, allowing to take into account elastic-plastic work of concrete, and also non-linearity of contact armature with a concrete. Nonlinear contact interaction of two materials is approximately examined as mutual relative displacements of armature and concrete. The offered model undoubtedly requires experimental confirmation by testing and numeral design more high level and degrees of working out in detail.

The bond armature with concrete is one of the most significant factors that provide a joint work of these multimodulus materials, allowing the reinforced concrete works as a single material. Therefore, the problem of bond armature with concrete is fundamental in the resistance of reinforced concrete constructions of force and deformation effects. This issue has received considerable attention for more than half a century in the work of leading scientists in the field and their schools (V.M. Bondarenko, A.B. Golyshev, A.A. Oatul, M.M. Kholmyanskii, G.N. Shorshnev and etc.).

In order to solve the various problems associated with bond armature with concrete conducted extensive experimental and theoretical studies [1–3 etc.]. However, analysis of research in the field of bond armature with concrete evidence of the ambiguity of approaches to solving this problem, and the lack of a unified theory, which based calculation method [1].

In recent years, studies of VM Bondarenko and VI. I. Kolchunova [2], NI Karpenko and GN Sudakova [3] bond armature with concrete and their relative displacement is considered taking into account the formation of the so-called radial and circumferential cracks. Reducing the bond armature with concrete leads disclosure to excessive cracking, reduced rigidity of and reduced bearing capacity of construction[1]. Thus, the elucidation of contact patterns of concrete and reinforcement in the transmission of tensile forces through the valve in terms of cracking is the great practical need.

The most complete, this pattern manifests itself in solving the problem of pulling rebar from the concrete block (prism), which is one of the most important tasks of reinforced concrete theory [4].

The analytical cored model of nonlinear problem of bond armature with concrete is worked out and analysed in this article by authors. Analytically rod bond reinforced concrete model is simulated by calculation scheme (fig. 1 and 4), and by the system consisting of the four equations, two of which are differential equations (DE) of first order (the boundary value problem Cauchy).

The model examines the reinforced concrete element with a single central reinforcement. The left end is rigidly fixed element of any movement, the right end – free. By reinforcing bar tensile force N_s is applied, the armature is pulled out of the concrete matrix. This effort causes a displacement and deformation of concrete reinforcement bar $\varepsilon_s(x)$ and concrete of reinforced concrete element $\varepsilon_c(x)$ over the entire length of of the squared beam. In the concrete matrix occurs due to force $N_c(x)$ interaction with armature in concrete beam contact region and the relative displacements of mutual reinforcement and concrete $\varepsilon_g(x)$. The contact interaction of the two materials is approximately regarded as a mutual relative displacement of reinforcement and concrete. The force $t(x)$ per unit length is acting on the direction of the current load in concrete along the entire length of contact shear, but in an armature, – oppositely directed (fig. 1).

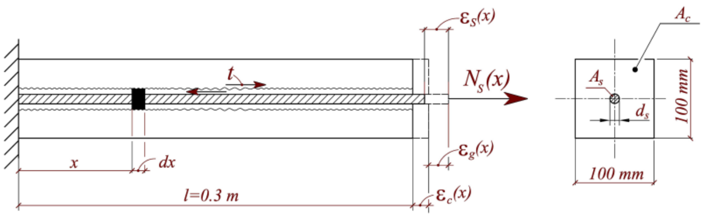

Fig. 1. The calculation scheme of the reinforced concrete element

The dependence of the tangential bond stress τ_{bond} from mutual relative displacement of reinforcement and concrete $\varepsilon_g(x)$, characterizes the bond of material is a bi-linear in nature (fig. 2.) and is presented below:

$$\tau_{bond} = k \cdot \varepsilon_g(x) = 0{,}4 \cdot E_{cm} \cdot [\varepsilon_s(x) - \varepsilon_c(x)], \qquad (1)$$

$$\text{if } \varepsilon_g(x) = [\varepsilon_s(x) - \varepsilon_c(x)] \le \varepsilon_g^*(x) = 4{,}95 \cdot \frac{f_{ctm}}{E_{cm}};$$

$$\tau_{bond} = 0{,}0232 \cdot E_{cm} \cdot [\varepsilon_s(x) - \varepsilon_c(x)] + 1{,}866 \cdot f_{ctm}, \qquad (2)$$

$$\text{if } \varepsilon_g(x) = [\varepsilon_s(x) - \varepsilon_c(x)] > \varepsilon_g^*(x) = 4{,}95 \cdot \frac{f_{ctm}}{E_{cm}},$$

where $\varepsilon_g^*(x)$ – the boundary relative mutual displacement of the concrete and reinforcement, corresponding to the end point of the first section bond diagram (fig. 2); f_{ctm} – average tensile strength of concrete in tension; E_{cm} – the average initial modulus of elasticity of concrete.

The bilinear diagram $\sigma_c - \varepsilon_c$ also describes the concrete work on this model. The expressions for each of the sections of the diagram included in the system of equations. It describes the deformation of concrete by next equations:

$$\varepsilon_c(x) = \begin{cases} \dfrac{N_c(x)}{E_{cm} \cdot A_c}, & if \ \dfrac{N_c(x)}{A_c} \le 0{,}9 \cdot f_{ctm} \\ \dfrac{18 \cdot N_c(x)}{E_{cm} \cdot A_c} - 15{,}3 \cdot \dfrac{f_{ctm}}{E_{cm}}, & if \ \dfrac{N_c(x)}{A_c} > f_{ctm} \end{cases} \qquad (3)$$

Using the equilibrium condition of the concrete and armature rods get the following two differential equations that relate the forces in the rods and shear bond stresses:

– for armature (reinforcment):

$$-N_s + N_s + dN_s - t \cdot dx = 0\,; \qquad (4)$$

– for concrete:

$$-N_c + N_c + dN_c + t \cdot dx = 0\,. \qquad (5)$$

After appropriate algebraic transformations, we have:

– for armature (reinforcment):

$$\frac{dN_s}{dx} = \tau_{bond} \cdot \pi d_s\,; \qquad (6)$$

– for concrete:

$$\frac{dN_c}{dx} = -\tau_{bond} \cdot \pi d_s\,. \qquad (7)$$

In the equations (4) and (5), $t = \tau_{bond} \cdot \pi \cdot d_s$, N_s – efforts in reinforcement, N_c – efforts in concrete.

For armature Hooke's law is valid.

$$\sigma_s = E_s \;\; \varepsilon_s; \Rightarrow \varepsilon_s = \frac{\sigma_s}{E_s} = \frac{N_s(x)}{E_s \cdot A_s}\,. \qquad (8)$$

Thus, a nonlinear boundary value problem is received. It consists of four equations, two of which control the first order, which is as follows:

$$\begin{cases} \varepsilon_s(x) = \dfrac{1}{E_s \cdot A_s} \cdot N_s(x); \\ \varepsilon_c(x) = \begin{cases} \dfrac{N_c(x)}{E_{cm} \cdot A_c}, & if \quad \dfrac{N_c(x)}{A_c} \le 0{,}9 \cdot f_{ctm}, \\ \dfrac{18 \cdot N_c(x)}{E_{cm} \cdot A_c} - 15{,}3 \cdot \dfrac{f_{ctm}}{E_{cm}}, & if \quad \dfrac{N_c(x)}{A_c} > f_{ctm}; \end{cases} \\ \dfrac{dN_s(x)}{dx} = \begin{cases} \pi \cdot d_s \cdot 0{,}4 \cdot E_{cm} \cdot [\varepsilon_s(x) - \varepsilon_c(x)], & if \quad \varepsilon_g(x) \le \varepsilon_g^*(x) = 4{,}95 \cdot \dfrac{f_{ctm}}{E_{cm}}, \\ \pi \cdot d_s \cdot \{0{,}0232 \cdot E_{cm} \cdot [\varepsilon_s(x) - \varepsilon_c(x)] + 1{,}866 \cdot f_{ctm}\}, & if \quad \varepsilon_g(x) > \varepsilon_g^*(x) = 4{,}95 \cdot \dfrac{f_{ctm}}{E_{cm}}; \end{cases} \\ \dfrac{dN_c(x)}{dx} = \begin{cases} -\pi \cdot d_s \cdot 0{,}4 \cdot E_{cm} \cdot [\varepsilon_s(x) - \varepsilon_c(x)], & if \quad \varepsilon_g(x) \le \varepsilon_g^*(x) = 4{,}95 \cdot \dfrac{f_{ctm}}{E_{cm}}, \\ -\{0{,}0232 \cdot E_{cm} \cdot [\varepsilon_s(x) - \varepsilon_c(x)] + 1{,}866 \cdot f_{ctm}\}, & if \quad \varepsilon_g(x) > \varepsilon_g^*(x) = 4{,}95 \cdot \dfrac{f_{ctm}}{E_{cm}}. \end{cases} \end{cases} \qquad (9)$$

The boundary conditions of the problem:

$$N_c(x=1) = 0\,, \quad N_S(x=1) = C\,. \qquad (10)$$

Implementations of this model is made with the assistance of symbolic mathematics software Wolram Mathematica package.

Varying the values efforts N_s at the end of a reinforcing bar distribution graphs were obtained of the desired functions $\varepsilon_s(x)$, $\varepsilon_c(x)$, $N_s(x)$, $N_c(x)$ along the length of the rod (fig. 2).

a) ***b)***

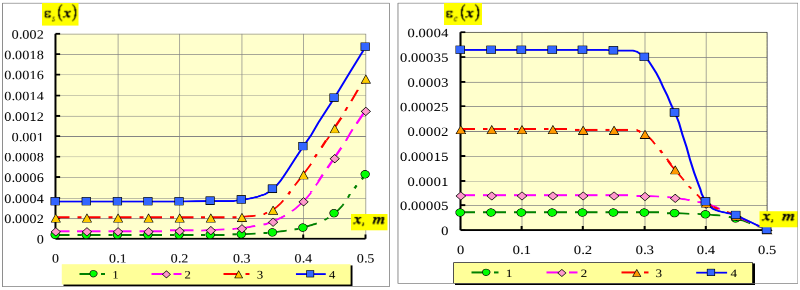

Fig. 2. The relative longitudinal strains in armature $\varepsilon_s(x)$ (*a*) and longitudinal strains in concrete $\varepsilon_c(x)$ *(b)* along the length of the rod, depending on the efforts acting on the end: *1* – for tensile effort at the end equal to 0.01 *MN*; *2* – the same, equal to 0.02 *MN*; *3* – the same, equal to 0.025 *MN*; *4* – the same, equal to 0.03 *MN*

Initial data for the build dependencies of the unknown functions with the effort at the end of the rod: $E_s = 2{,}04 \cdot 10^5$ *MPa*, $A_s = 7.854 \cdot 10^{-5}\ m^2$, $E_c = 2.7 \cdot 10^4$ *MPa*, $A_c = 0.01 m^2$, $d_s = 0.01 m$ (armature class A400C), $f_{ctm} = 1.9$ *MPa* (concrete class – C20/25).

The limiting factors in this case were: tensile strength reinforcement in tension f_t; the average tensile strength of concrete in tension f_{ctm}, which is determined by the stage of the work of the concrete section of the element; limiting the relative displacement of the armature with respect to the concrete at the end $\varepsilon_{g,\lim}(x) = 10 \cdot \varepsilon_g^*(x)$, in which there is a failure of reinforcement with concrete ties, according to the adopted work depending reinforcement contact with concrete; ultimate tensile strain of concrete in tension $\varepsilon_{c,2} = 10 \cdot \varepsilon_{c,1}$, according to the accepted depending on the concrete deformation.

From constructed graphs we have that for $N_s = 0.025 \ldots 0.03$ *MN* of stresses in the concrete exceed the tensile strength of concrete in tension $0.9 \cdot f_{ctm}$ and concrete starts to work on the second branch of the stress-strain diagram. The tensile load application area there is a sharp, abrupt increase N_s and U_s and decrease N_c and U_c (begins at a distance of 0.3m from the left edge and extends to the right edge).

Also, the results of the calculation of the analytical models were built unknown functions $\varepsilon_s(x)$, $\varepsilon_c(x)$, $N_s(x)$, $N_c(x)$ distribution graphs for different diameters of rebar from the concrete to pull out (fig. 3).

Initial data for charting changes in the unknown functions along the length of the rod for the different diameters of reinforcement (armature): $E_s = 2{,}04 \cdot 10^5$ *MPa*, $A_s = 7.854 \cdot 10^{-5}\ m^2$, $E_c = 2.7 \cdot 10^4$ *MPa*, $A_c = 0.01 m^2$, $f_{ctm} = 1.9$ *MPa* (concrete class – C20/25), $N_s = 0{,}022 MN$, $d_s = 0.01 m$, *0,012m; 0,016m* (armature class A400C).

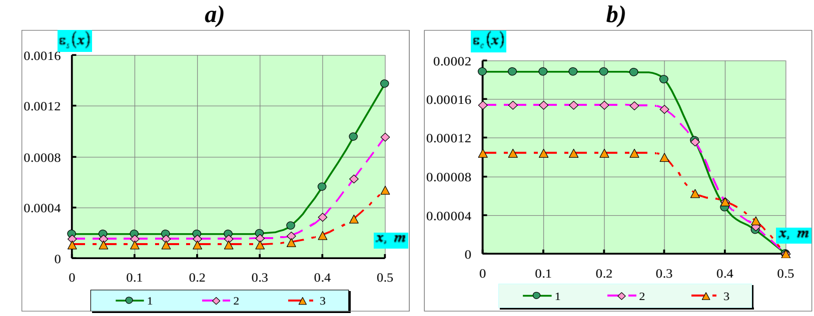

Fig.3. The relative longitudinal strains in reinforcement $\varepsilon_s(x)$ *(a)* in concrete $\varepsilon_c(x)$ *(b)* along the length of the rod, depending on the diameter of armature:
1 – armature Ø 10 mm; *2* – armature Ø 12 mm; *3* – armature Ø 16 mm

On the graph $N_s(x)$, depending by the length of the rod there is a slight increase in the current efforts by increasing the diameter of the armature; graphs $\varepsilon_s(x)$, $N_s(x)$, $N_c(x)$, show an increase in the values of these functions with decreasing diameter rebar (fig. 2), which also corresponds to a physical picture of the phenomenon.

Conclusions.

From these graphs it follows, that the proposed nonlinear analytical model of bond rod is a highly accurate and informative. It allows to perform a fairly complete and comprehensive analysis of the problem.

This model adequately take into account the elastic-plastic work of concrete, as well as the non-linearity of the valve in contact with the concrete, and allows to get the desired force distribution graphs and deformations of concrete and reinforcement (armature) along the length of the rod. The proposed model is relatively simple, although it is not without drawbacks, and therefore requires experimental confirmation. This is important, and the implementation of numerical simulation bond problems and a higher level of granularity.

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UDC 624.074

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Composite steel and concrete large-span constructions for airport structures

The new composite constructions for airport structures are proposed. Feature of the construction is original structural concept. The construction combines the advantages of the best-known spatial structures, enables efficient use of building materials at sufficiently low complexity, and consists of space modules and flexible bottom chord.

Introduction

An infrastructure development of airports except machinery and equipment modernization needs modernization, changes or rebuild existing structures and construction new buildings. Structures that completely satisfy the demanding requirements of buildings of modern airports are composite structures that are a combination of steel space trusses, steel cables or bars and slabs that used for not only cover or protect from aggressive external factors, rain, snow and other atmospheric influences but also used as bearing element. The slab for composite construction can be made from concrete, glass, plastic and other modern materials, choice material depends on building function.

These composite structures have been designed by the authors at the Department of structures from a metal, wood and plastics of the Poltava National Technical Yuri Kondratyuk University (Poltava city, Ukraine) and have been patented. They were called Composite Steel and Concrete Grid-Cable Constructions.

Structural concept

The purpose of the study is to present the new kind of spatial composite structure made from modern and strength materials for civil construction in particular to cover halls, hangars for aircraft and other vehicles, garages for a large machinery, large-span buildings and structures of airports, etc.

Novelty of the composite steel and concrete grid-cable constructions lies in effective application properties of materials [1]. The composite steel and concrete grid-cable construction as noted earlier consists of the three different kinds of structural elements: slabs, steel space trusses and steel cables. The steel space trusses are made from segments of steel tubes or rods. The slabs are used as the top chords, steel space trusses are used as diagonals and steel cables or bars are used as flexible bottom chords. The diagonals and slab create space module (Fig. 1) that is main element of the composite steel and concrete grid-cable construction. The space module can has different size A, h and height H (see Fig. 1) but recommended size slab A=3 m or 1.5 m with a height H=0.7072A.

The composite steel and concrete grid-cable constructions are assembled on construction site from space modules and the flexible chords. The structural members are routinely joined at Node 1 and Node 2 (see Fig. 1) by bolted connections but sometimes in specific case can be joined by welded connections.

Choice of a connection type are routinely depend on buildings function, their span and shape but preference is given to bolted connections because they are relatively easy to assemble, maintain, and they are able to carry the high loads that typically appear in structural members of civil structures.

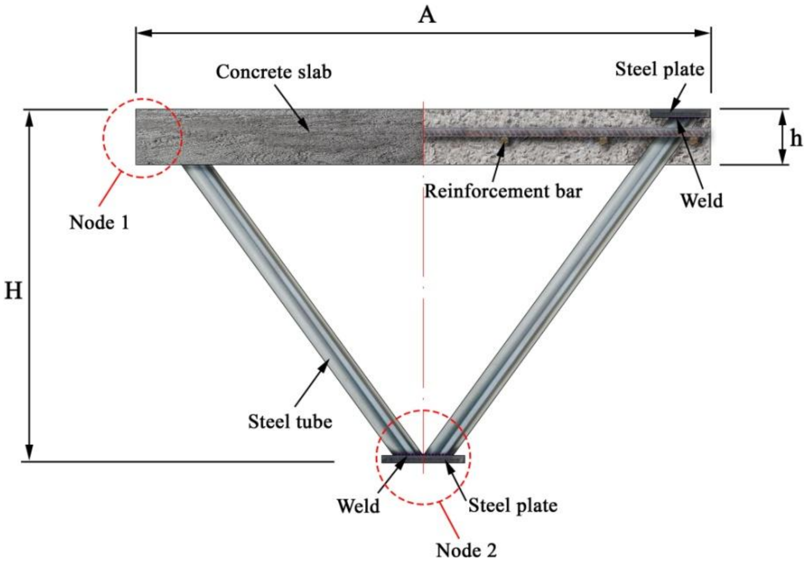
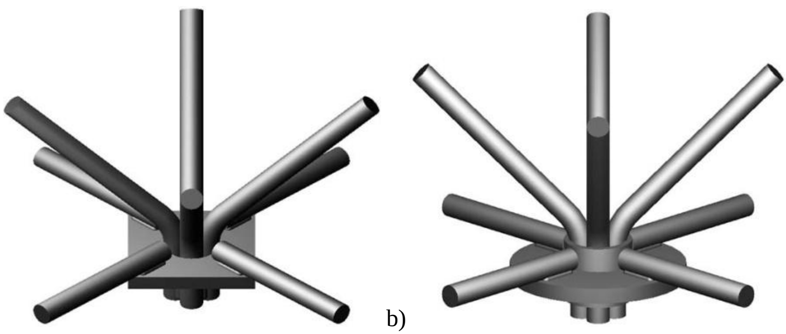


Fig. 1. Space module of the composite steel and concrete grid-cable constructions

Besides, Node 1 and Node 2 can have different designs (Fig. 2) depend on the forces that appeared in the structural members [1, 2].



a) b)

Fig.2. Kinds of node connection (Node 2) of structural members made from rods and steel plate

Shaping structures

The composite steel and concrete grid-cable constructions have various shapes and contours. Curvature of the composite steel and concrete grid-cable constructions is achieved by the segments length L changing of the bottom flexible chord (Fig. 3).

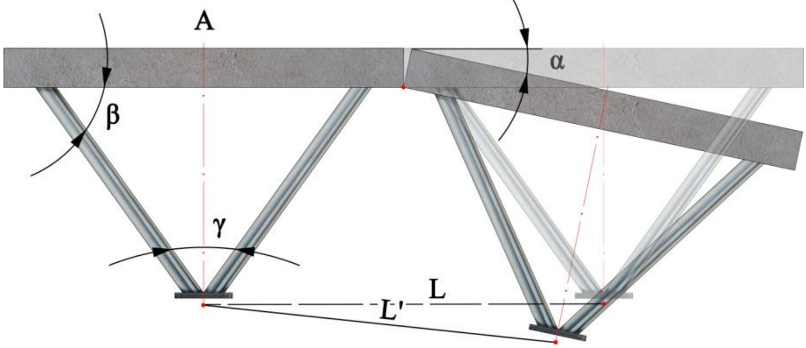


Fig. 3. Scheme to determine the length L of the bottom flexible chord

The length of the segments of the bottom flexible chord L depend on angle α and the size of the slab A (Fig. 4).

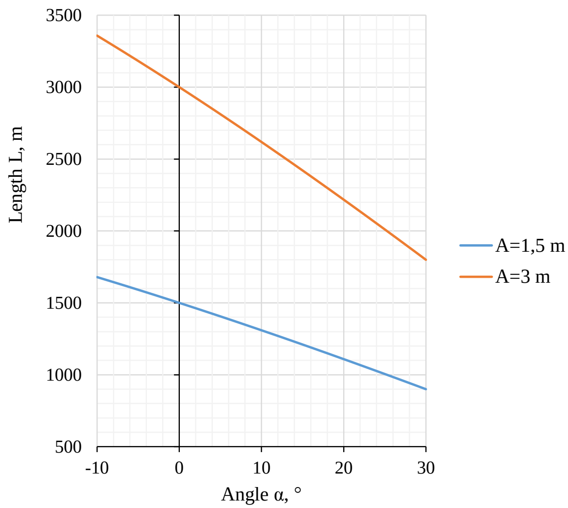


Fig. 4. The length determination L of the bottom flexible chord

The space modules are used for assembly various structures including flat double-layer grids (Fig. 5, a), single-span shells (Fig. 5, b) and other [3]. Distances that are covered with these structures reaches 200 m.

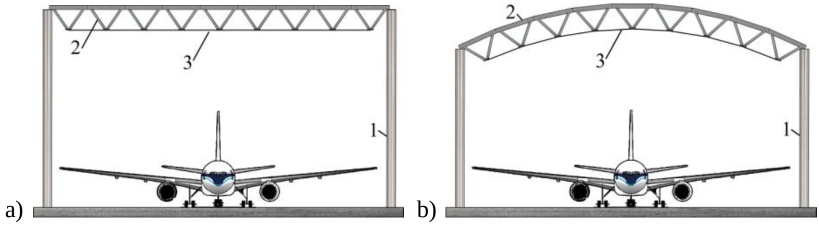


Fig. 5. Large-span structure systems
a) flat double-layer grids; b) single-span shell; 1 – support; 2 – the space module; 3 – bottom flexible chord

The composite steel and concrete grid-cable constructions may also be used to assembly cantilever covers for small-span areas (Fig. 6).

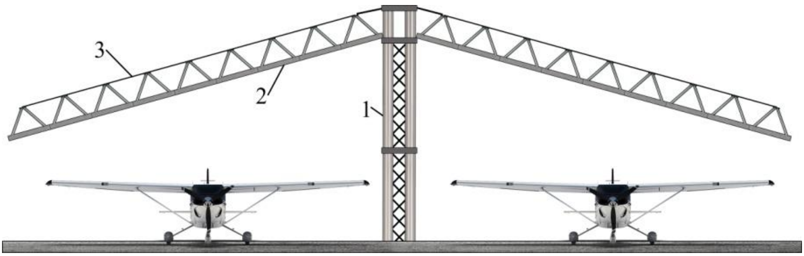


Fig. 6. Cantilever structure systems
1 – support; 2 – space module; 3 – flexible chord

In general, the curvature of the composite steel and concrete grid-cable shell (see. Fig. 5, b) depends on constrains. If the structure is fixed or pinned from both side the angle α is limited [4] but if it has roller connection, at least from one side the angle α can be as shown in Fig. 4.

Manufacturing and construction of the structures

Production of space modules can be performed in the plants that produce steel building structures, and other plants that have the equipment for processing steel and concrete casting of products. Technologies of processing, assembly, welding, loading and unloading of steel structural member of the composite steel and concrete grid-cable constructions are similar to the technology of production of conventional steel structures and concrete structures. Manufacturing technology of the composite steel and concrete grid-cable constructions is divided into two separate processes: fabrication of a steel lattice (frame) and the making of slab.

Construction of the composite steel and concrete grid-cable constructions is perform by the methods described in [5].

Conclusions

The composite steel and concrete grid-cable constructions are the new kind of large-span structures, which have significant advantages; in particular, they are lighter and have lower complexity of manufacturing and assembly than analogues. The composite steel and concrete grid-cable constructions consist of bottom flexible chords and space modules, which combine slabs and rods made from steel tubes. This structural concept makes it possible to save materials due to the rational using of them. The conclusion that this type of constructions is reliable and efficient in exploitation, allows to save materials was made based on experimental, theoretical and analytical studies and the stress-strain state numerically investigation.

In conclusion, it should be noted that the composite steel and concrete grid-cable constructions have different forms and shapes. This allows to use structures successfully in construction of buildings and airports of structures.

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UDC 656.71:72.012:656.7.052(043.2)

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New face of air traffic service's objects

These are the results of the proposals development for the construction, airfield control tower in the territory of one of the local airports. The authentic traditional symbols of Ukraine such as the fertile fields of ears and white bird stork.are the basis of the architectural and artistic image of this special purpose object.

In September 1992, Ukraine became a member of ICAO (International Civil Aviation Organization). This provided Ukraine with the opportunity to open new horizons in civil aviation, successively reform management system and move to a new level of mobility. Nowadays airports require reconstruction and modernization. And since the development of airports in most cases is accompanied with the increasing of the territories in size, the requirements for visual control are changing as well.

Architecture of domestic airports recently received a new high-rise accents, which are airfield traffic control towers (ATC), and the leading specialized organizations of Ukraine were involved in the creation of those [1-3]. According to the modern world practice, this element of the airport integrated development requires an individual approach from architects as well as architectural and artistic silhouette solution and, consequently, the respective financial costs [2].

Towers are blocked with a set of buildings designed to house maintenance services of airport. The buildings within the complex have different storeys and volumes, but they act as "minor" in the composition of the object of special purpose, allowing you to enhance the contrast between high-rise ATC's buildings characteristics and development that surrounds it.

The aim of the diploma project educational qualification of "Bachelor" in the direction of 6.060102 "Architecture" is to create the expressive, architectural and artistic image ATC, space-planning, design and engineering solutions which should ensure the implementation of modern technologies of air traffic.

Design was preceding stage of the regulatory study and operational documentation, research of the world's and domestic experience in the design, construction and operation of premises [2, 3].

On the basis of the analysis of the existing airport master plan and possible prospects of its development it was decided to develop a project proposal for building a new ATC without blocking of existing buildings.

At the same time, it made possible to implement the principle of increasing the volume of the building to accommodate the maximum permissible for the technological standards of services and businesses. Estimated number, which is the maximum number of aircraft that should be served during 1 hour, is defined the category III of ATC and, consequently, the size of the premises to accommodate the specialized units (services) and buildings generally (Figure 1, 2).

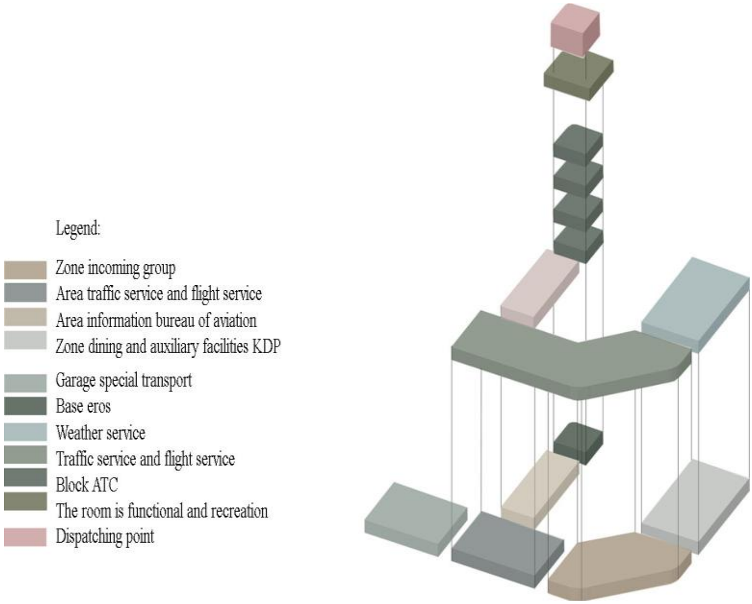

Figure 1. Functional zoning scheme

The building is U- shaped and this helped in creating a composition landscape courtyard. Stylobate - storey part - designed to accommodate pre-flight training unit. The ATC has seven floors. On the sixth and seventh floors the recreation area and dispatch hall are located respectively (Figure 2, 3).

Figure 2. General view of building

Figure 3 . The facade of the building

Figure 4 . General view of the designed object

The basis of the architectural and artistic image of the special purpose object are authentic, traditional symbols of Ukraine: the fertile fields ears and white bird stork.

Using the idea of fertile ears in the facade is looking good in a perspective view (Figure 4). The idea of a bird is transmitted through color and is clearly visible from the species point located opposite the main entrance to the building (Figure 5).

The project design, compared to similar objects, characterized by the following technical and economic indicators (Table 1).

Table 1

Techno-economic performance of modern domestic ADV

№№	Name indices	Airport «Donetsk»	Airport «Kharkiv»	Project decision
1	Total land area, ha	2,12		0,9
2	Building area, sq.m	2951,06	1697,90	1300,00
3	Total area, sq.m, totally:	4422,00	3189,60	2900,00
	including			
	- ATC		3044,90	3487
	- garage building		88,30	114
4	ATC's height	47,50	43,60	26,6

Conclusion

1. Studying of the designing and building experience of special purpose facilities at the airport revealed the current trends and made possible to create one of the main components of the complex airport, the airfield -control tower.

2. The clear from architectural and artistic view control point (CDP), space-planning, design and engineering solutions which ensure the implementation of modern technologies of air traffic over the territory.

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UDC 72.01

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Determination of stress-strain state hard cement constructions airport paving the presence of weak soil layers

Abstract. *The paper analyzed the stress-strain state hard cement constructions airport paving the presence of weak soil layers* (*for example, the airport "Odessa"*).

The task of calculating airport paving - to provide safeguards against the onset of it during operation of a limiting condition. When the limit state considered that the design is not able to resist external influences. For cement coating such as the limit is cracking.

In order to thoroughly study the behavior of cement-concrete construction hard coating under load, an example was taken cover design runway airport "Odessa".

The design of the existing coverage provided rectangular cement slab thickness 24 - 26 cm to enable compact soil basis .

According to the materials of engineering and geological surveys airport paving background soil consists of silty loam type II subsidence. Power active thickness is 7 m. These soils are stable only in the natural state. In violation of their natural state these soils lose their resistance and give uneven subsidence.

The airport able to take aircraft code D 4 and below, including: A320 , Boeing 737 (-300 / -900), B757 (-200 / -300), B767 (-200 / -300), E190, AN- 124, AN- 70, AN-148 , AN- 140, Il- 76, Il- 62, Tu- 154, Tu- 204.

Existing artificial surfaces are in poor condition.

Also there is the problem in checking soil airfield, which according to geological studies are weak in ability to withstand the wheels of modern aircraft.

The design of cement-concrete coatings airport "Odessa" is shown in Fig. 1 and has the following options:

- the top layer - the high-strength concrete class B40 (R_{btb} = 3,73 MPa , R_{bn} = 29,0 MPa , R_{btn} = 2,1 MPa , $E_b = 3,53 \cdot 104$ MPa , $\nu_1 = 0,22$, $\gamma_1 = 2500$ kg/m^3).

- the bottom layer - lean concrete B15 (R_{btb} = 2,26 MPa, R_{bn} = 11,0 MPa, R_{btn} = 1,15 MPa , $E_b = 2,60 \cdot 10^4$ MPa , $\nu_2 = 0,23$, $\gamma_1 = 2400$ kg/m^3).

- rigid foundation - piskotsement B5 (R_{btb} = 1,2 MPa , R_{bn} = 3,5 MPa , $E_b = 1,33 \cdot 10^4$ MPa , $\nu_1 = 0,23$, $\gamma_1 = 1800$ kg/m^3).

The coefficients bed for specified geotechnical following elements :

- for soil layer EGE- 2 K_{se} 2 = 70 MN/m^3;

- for soil type layer 3 EGE- based step-down ratio, K_{se} 3 = 70 (-0.35 %) = 45.5 mN/ m^3;

- for soil layer type EGE- K_{se} 4 4 = 70 (-0.35 %) = 45.5 mN /m^3;

- for soil layer type IGE -41 K_{se} 41 = 45.5 mN / m ^{3}.

It was also equivalent calculated coefficient bed with the appointment of three layers of grouped settlement basis. The value of this ratio is bed : K_{se} = 50,04 MN/m^3.

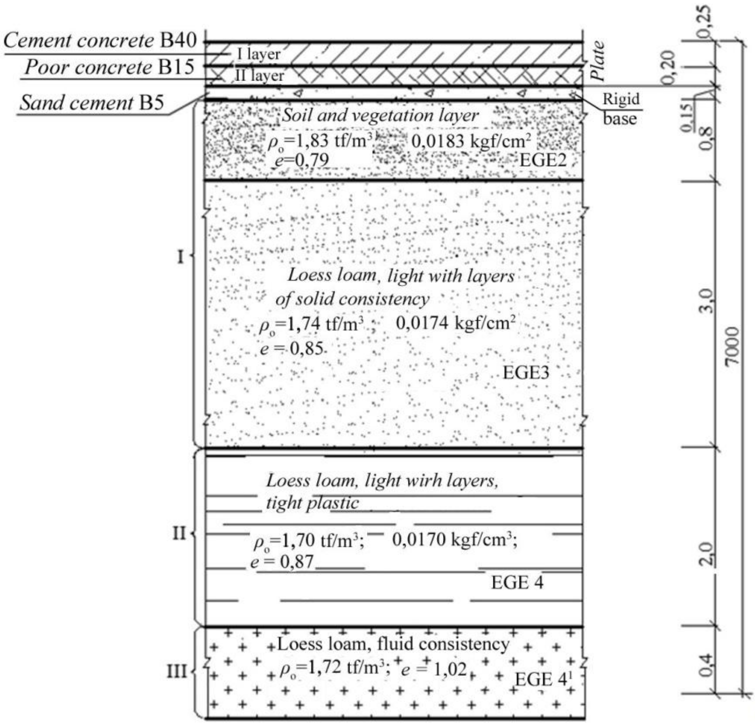

Fig. 1. Basic design of pavement flexible type to study the influence of parameters on VAT

As the estimated ship was passed aircraft Boeing 767-300. Wheel load of this aircraft is : F_d = 226,53 kN.

Estimated linear bending moment in each of the layers airfield coverage shall not exceed the permissible within ± 5%, in accordance with existing regulations [1, 2, 3]:

$$m_d^p \leq m_u \tag{1}$$

m_d^p – calculated bending moment on the top or the bottom layer;

m_u – permissible bending moment considering regulatory material resistance to stretching.

In this case, the difference is about 54%. The bottom layer of coating is clearly with high rigidity. Existing rules [1] is clearly outdated, do not include parameters of modern aircraft of type Boeing 767-300, do not account for the presence of weak soil base layers of soil.

Based on geological engineering survey found, that geological layer EGE- 3 is very heterogeneous and contains layers of organic soil , thus able to uneven subsidence under load and when soaking . Layer IGE -41 has a very large voids , voids ratio is: e = 1.016.

Therefore, given that the initial conditions are difficult, it is necessary to use other than artificial methods of numerical methods. This method is the finite element method (FEM).

To perform the calculation covering runway airport "Odessa" at the wheel load of gear wheels of an aircraft used ITU V767-300 was , and is one of the most versatile circuits ITU - moment scheme of finite element (MSSE) [4, 5, 6].
Calculations are performed using automated software complex calculations walled spatial structures (KARTPK), providing a high degree of reliability of the numerical solutions for a class of problems of calculation of thin plates on elastic foundation coefficient bed which can be represented as two-dimensional spline function in a neutral plane of the flexible membrane.

The equivalent thickness of conventional panels (equivalent linear section) is : $t_{(e)}$ = 46 cm (Fig. 2).

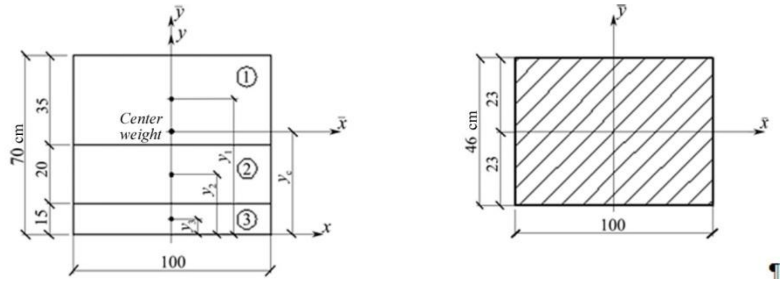

Fig. 2. Construction of the equivalent analog design airfield plates airport "Odessa"

Equivalent Poisson's ratio for the material plate is conditional : $\nu_{(e)}$ = 0,2336.

Equivalent Poisson's ratio for the material plate is conditional : ν _ ((e)) = 0,2336.

The average weight of conventional plates is : γ (e) = 0,00357 kg/ cm^3.Equivalent modulus is : E(e) = 4,176 $\cdot 10^5$ kgf / cm^2. Diagram based coverage so that it included all of the load wheel gear of the aircraft , given that the main pillar of the aircraft was located on the middle plate fragment calculated .

It was constructed discrete model containing nine boards runway to the size of each 10,0h7,5 based on the symmetry of the fuselage of the aircraft.

Finite - element model estimated coverage fragment shown in Fig. 3.

Discrete model is constructed so that the main four- pillar placed in compliance with the parameters of the aircraft landing gear.

Fragments of topological models of wheel prints on cover design scheme has the following grid S1, S2 beginning S_2^N , S_3^N and the end S_2^k , S_3^k piece wheel load:

1) $N_2^1 = 12;\quad N_3^1 = 25;\quad k_2^1 = 14;\quad k_3^1 = 27;$

2) $N_2^2 = 16;\quad N_3^2 = 25;\quad k_2^2 = 18;\quad k_3^2 = 27;$

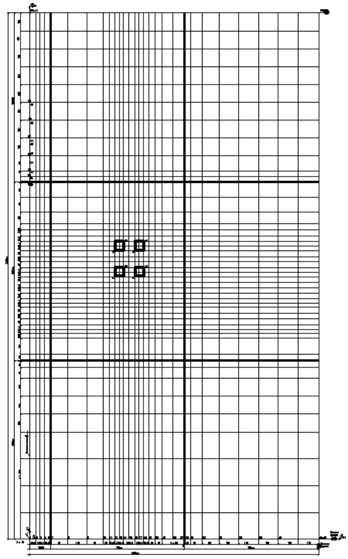

Fig. 3. Finite - element model estimated fragment covering

3) $N_2^3 = 12; \quad N_3^3 = 30; \quad k_2^3 = 14; \quad k_3^3 = 32;$

4) $N_2^4 = 16; \quad N_3^4 = 30; \quad k_2^4 = 18; \quad k_3^4 = 32.$

The maximum displacement of the plate is : u_{1501} = -1.41 mm. Maximum linear bending moment occurs at the wheel main landing aircraft and is: M_{1571} = -7585 = -75,85 kNm/m , exceeding the result of engineering calculation on the value of : $\Delta = \frac{(75{,}85-73{,}11)\cdot 100}{73{,}11} = 3{,}75$ %. This is not much higher than the range of errors caused by errors in the original data.

Plane problem is solved in the development of plastic deformation in the core subgrade hard coating during the regulatory period of its operation under the influence of the aircraft in the 767-300. .

The four-wheel main support of the plane is modelled by a one-wheeled support with a pressure in pneumatics. This load is reduced to the band load acting on the flat half-space in the central load

$F_d^e = 566{,}33$ kN; $R_e^e == 0{,}386$м; $a_e = R_e^e \sqrt{\pi} 0{,}68$ м; $q = 0{,}35$ МПа $= 3{,}5$ kgf / cm^2.

Fig. 4 shows the design scheme of the plane problem of determining the stress-strain state airfield pavement in contact with the active zone of the soil half-depth of 7 m, consisting of four non-homogeneous isotropic soil layers.

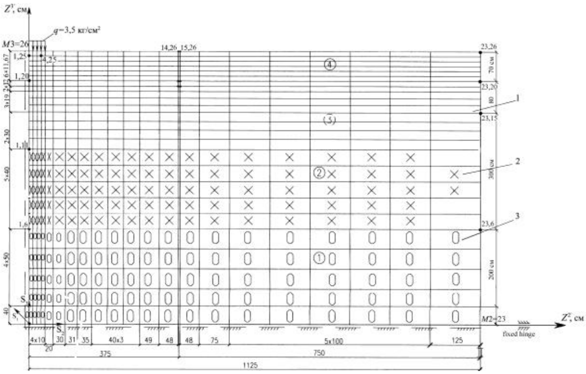

Fig. 4. The development of plastic deformation zones: 1 - elastic region; 2 - plastoelastic deformation of the self-weight of the soil and bandpass load; 3 -. plastoelastic deformation only on its own weight of soil

Conclusions

It was studied and analyzed the mode of deformation structures of cement-hard surfaces in the presence of weak soil layers on the example of the airport "Odessa".

Completed engineering calculations on the strength of the hard concrete pavement runway on an elastic vinklerivskiy basis.

There have been numerical study of stress-strain state of multilayered soil base with the development of plastoelastic deformation in a flat statement of the problem.

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Identification of options construction of roads on the basis comparative economic efficiency

In the construction and in the reconstruction of the highways efficiency of the capital investment is crucial - the choice and the economic justification of the most acceptable version; the establishment of priorities and the construction schedule and reconstruction of the individual sites.

Introduction

The present state of the road industry leads to the formation of the decision of three main problems that generally determine the course of development the road industry in perspective for several decades:

1. Provision of the nominal lifetime of investments in roads, which provide further development and improvement of technical and technological bases of industry.

2. Improving the efficiency of highways, which includes all the engineering and economic issues, feasibility assessments and analyzes the effectiveness of the feasibility studies, reduced cost price of transportations, increase driving speed, optimization of the road network and its condition.

3. Ecology of highways, that encompasses the totality of keeping issues and improve the results of interaction of the road and rolling stock of road transport, pollution and disturbance of the ecological balance.

Formulation of the problem

In justifying the fundamental direction of the route of highway between the given points with a selection of main transit points in the production stage of the project work, the development of general schemes of highways or regional planning schemes, volumes and types of works set the following technical parameters options:

- the length of areas, laid on the terrain with various characteristics of the relief;
- the characteristics of the terrain of each of areas;
- the composition of the traffic;
- the average technical types of automobiles speed in the traffic flow;
- the category of the road;
- the type of road surface.

The following indicators are set with the feasibility study variants of highways reconstruction projects (overhaul), that reflect condition of the existing road:

- intensity and composition of the traffic;
- the vehicle speed in the traffic flow;
- the number of traffic accidents on the stretch of road;
- the total area and quality of lands excluded during the reconstruction;

- the state of road pavements and coatings.

The rates of traffic flow, line graphs accident rates, traffic accidents graphics, and other information necessary for comparing and selecting options highways are got on the basis of procedures set out in the existing regulatory and technical documents and technical guidelines approved by the Ministry of Regional Development of Ukraine.

Solving the Problem

The weighted average for value options of technical vehicle speed j-type, defined by the formula:

$$v_j = \sum_i v_{ij} / \sum_i N_{ij}, \qquad (1)$$

where v_{ij} - the speed of the vehicle j-type on the site i;

N_{ij} - the annual average daily traffic of vehicles j-type on the i-th site with different characteristics of the relief.

At a substantiation of derogation from DBN V.2.3-4-2015 in subsection of width and number of lanes, the bandwidth options prescribed on the basis of the composition of traffic on the road, the estimated vehicle speed and the overall size of the car. In the mixed composition of the traffic flow calculation determine the width of lanes for each type of vehicle. For comparison, take the widths of the carriageway, providing the possibility of movement with the calculated speed for the combinations of the following types of vehicles:

-passenger car with a passenger car;

-j-type car with truck having the largest overall width.

In determining of the transverse profile with edge strips their width should be included in the width of the carriageway for the comparable variants.

Calculations of the comparative economic efficiency of the justification carriageway roads width is recommended to be conducted in the following sequence.

Variant of the width carriageway is designate. For roads with two lanes consider variants, including an increase of the width of the roadway up to 8-9 m. This should simultaneously solve questions about shoulder width and edge strips. When the intensity of promising more than 7 thousand aut./day the width of the carriageway is determined simultaneously with the calculation of the number of lanes and the width of the distribution strip, focusing on the position of DBN V.2.3-4-2015.

For each of the options refine the amount and cost of the work, determine the average speed of traffic flows and calculate the probable number of road accidents.

Calculate the performance of one-time and current costs and perform calculations of comparative efficiency of capital investments.

In determining the current cost of options should be based on the speed of movement of vehicles flows caused by the expression

$$\nu = \tau_1 \cdot \tau_2 \cdot \tau_3 \cdot \nu_{nm}, \qquad (2)$$

where τ_1 - coefficient taking into account the effect of the width of the carriageway: at Bw<7,5 m, τ_1=1,43-0,375Bw+0,416B_w^2; when Bw>7,5 m, τ_1= =0,77+0,0307Bw;

Bw - the width of the carriageway, m;

τ_2 - coefficient taking into account the effect of the width of the roadside: τ_2=0,603+0,175B_r+ 0,019B_r^2;

B_r - the width of roadsides, m;

τ_3 - coefficient taking into account the effect of the number of traffic lanes on the speed of traffic:

Table 1.

number of lanes	1	2	3	4	5	6	7	8
τ_3	0,50	1,00	1,05	1,13	1,16	1,20	1,21	1,22

v_{nm} - the average speed of traffic flow, calculated taking into account the category of road, type of pavement, the nature of the terrain and structure of the traffic flow, km/h.

In determining the number of accidents (hell) to 1 million aut.-km computation making by the formulas:

- for the road with two lanes (accidents million aut.-km)

$$a_д = \left[0,15 \cdot 10^{-3} N_p - 0,63 \cdot 10^{-5} \cdot (\varepsilon \cdot N_p)^2 + 0,14 \cdot 10^{-7} \cdot\cdot (\varepsilon \cdot N_p)^3\right] \cdot M_д (3)$$

- for the road with the number of lanes for more than two ,

$$a_д = \{0,90 + 0,94 \cdot 10^{-5} \cdot N_p\} \cdot M_Д , \qquad (4)$$

where N_p - traffic intensity of the settlement year, cars/day;

ε - factor of transition from the average daily settlement hour intensity (ε = 0,076);

$M_д$ - coefficient taking into account the effect of the elements on the roads accidents:

$$M_Д = k_1 \cdot k_2 \cdot k_3, \qquad (5)$$

where k_1 - coefficient taking into account the effect of the width of the roadway when the number of lanes to four (with the number of lanes 4 and more it is 1,0) k_1=428,015$B^{3,169}$+0,317;

k_2 - coefficient taking into account changes in the width of the roadsides:

k_2=3,831-1,527B_r+0,193B_r^2;

k_3 - coefficient taking into account the number of lanes.

If necessary, define and other private factors: the visibility of the road, the radius of the curves, the intersection at the same level, the distance from settlements, etc.

The optimum design of road pavement of number of variants of the same vehicle operating parameters are selected on a minimum total given travel expenses, which are determined according to the cost of the time.

If the one-time costs are made repeatedly and at the same time and ongoing costs vary with time, an indicator of a better option is the minimum reduced costs (P_g) for comparison of options period:

$$P_g = K_g \cdot E_e \sum_{1}^{t_c} \frac{1}{(1+E_{ind})^t} + \sum_{1}^{t_c} \frac{Z_t}{(1+E_{ind})^t}, \qquad (6)$$

where K_{np} - reduced to one basic point in time non-recurring costs of the embodiment;

E_e - normative coefficient of efficiency of capital investments in the national economy;

E_{ind} - normative coefficient of comparative effectiveness of capital investments of a single industry;

Z_t - running costs of the embodiment in the t-th year (tc - term comparison of variants over the years);

t - the number of years between the base year and the costs of the year.

When a small number of variants (2-3), and provided that each of the compared options time costs over the life do only once - in the beginning, the distribution costs for the construction period are not counted the service life of objects in all variants the same, and running costs do not change from year to year, the index of the best option will be a minimum annual of given expenses:

$$P_g^{\text{year}} = E_e \cdot K + Z, \qquad (7)$$

or the cost calculated according to the simplified formula:

$$P_g^{\text{year}} = K + T_{ad} \cdot Z, \qquad (8)$$

where K - non-recurring costs for option;

Z - annual running costs for option;

$T_{ad} = 1/E_e$ - standard payback period of additional capital investment through savings in operating costs.

It is also possible the consistent comparison of the costs of the following formulas:

$$E = \frac{Z_1 - Z_2}{K_2 - K_1}; \;\; T = \frac{K_2 - K_1}{Z_1 - Z_2}, \qquad (9)$$

where K_1, K_2 - non-recurring costs for the compared variants;

Z_1, Z_2 - operating costs comparable variants.

If $E>E_e$ or $T<T_{ad}$, the additional time costs, and consequently the more efficient variant capital intensive.

When comparing variants with unequal transport and operational performance of the total of given expenses also include transportation costs.

The speed of traffic at the feasibility variants compared pavements is recommended to determine the following calculation:

$$V_p = \nu \left[V_{nm} - f\left(E_y, S, N_{sd}\right)\right], \qquad (10)$$

where ν - indicator takes into account the change in the speed at different operating condition of road surface throughout the year under the influence of climatic factors

$$\nu = 365^{-1} \overset{i}{\Sigma} m_i g_i, \qquad (11)$$

m_i - the number of days of operation with different road surface condition in a calendar year;

g_i - the speed reduction ratio at different road surface conditions;

V_{nm} - average speed of traffic flow;

E_y - modulus of elasticity of the pavement;

S - road conditions;

N_{sd} - the intensity of the traffic safety;

$f(E_y, S, N_{sd})$ - the average speed of vehicles technical paving capital type, taking into account the characteristics of the terrain

$$f\left(E_y, S, N_{sd}\right) = \delta\left[0{,}5 N_1 \psi_{sd} \alpha_S \varphi(t_1) + \beta_S\right], \quad (12)$$

δ - coefficient characterizing the effect of pavement strength at speed;

α_S и β_S - factors which characterize the influence of operational condition of the pavement at speed;

N_1 - the intensity of the movement of the output of the year, aut./day;

Ψ_{sd} - measure of the impact of the movement on the operational status of the pavement and on the speed.

$$\psi_{sd} = 365 \cdot 10^{-4} \sum^{j} \left(G_j + \Gamma_j \nu_j \beta_j\right) J_j, \quad (13)$$

G_j - the mass of the first car in the unloaded condition, t;

Γ_j - rated load (passenger) of each of the first car, t;

ν_j - the rate of change rate of movement of vehicles j-type;

β_j - utilization rate of duty (passenger capacity) and the path of the second vehicle;

J_j - the number of vehicles j-type as part of a transport stream, expressed as a decimal.

The factor covering state is determined by the formula:

$$\varphi(t_1) = (q \ln q) \cdot (q^{t_1} - 1), \quad (14)$$

where t_1 - turnaround time between the average repair year;

q - coefficient of annual growth of traffic volume (with an increase in intensity according to the law of compound interest).

During reconstruction (overhaul) of the road may be different intersection, the unit costs which must be taken into account in determining operating costs.

Compared options intersections are usually characterized by different speeds of movement, loss of time when you're not cars, cars of different length run at common borders for all variants. This makes the need for different rolling stock necessary to carry freight and passengers, and various motor current costs.

Investments in road transport within the intersections required for transportation of goods and passengers in the t-th year are determined according to the formula:

$$K_{t.a.} = \frac{365A}{T_a}\left(\sum^{i} \frac{L_i N_{ti}}{\nu_i} + \sum_{l}^{24} t_s\right), \quad (15)$$

where A - the average cost of running a car of the same car. km;

T_a - an accounting medium during vehicle operation;

N_{ti} – the annual average daily traffic volume in the t-th year at the intersection in the i-direction, the cars. day;

v_i i L_i – respectively, the speed, km/h, and the way cars run at the intersection in the i-direction, km;

t_s – time required while the car stopping at the intersection cars hour.

Dimensions of flow of road costs at the intersections of roads is recommended to determine by the formula

$$C_{taa} = 365\left[\overset{i}{\Sigma} N_{ti} L_i S_i + \overset{24}{\underset{1}{\Sigma}} t_s S_s\right] \tag{16}$$

where S_i - average cost of 1 t.km in the i-direction at the intersection, cop. aut. km;

S_s - expenditure rate while standing vehicle with the engine running, kop. aut. h.

When comparing the options of intersections of roads with railways all indicators lump sum and ongoing costs to determine the area within the zone of influence of the intersection. If the intersection of the options differ in terms of their comparison must be done on the stretch of road, which is all the options considered have a common plan and profile.

Total downtime of vehicles at the intersection with the railway at the same level in cars.-hours throughout the year determined by the formula:

$$t_{nt} = 0{,}005 M_n N_t t_c \left(1 + \frac{0{,}1 N_t}{60m}\right), \tag{17}$$

where M_n - the number of trains per day;

N_t - daily traffic;

t_c - the duration of the closure of crossing when driving a train, min.;

m - directions throughput capacity, the authors. min.

At high intensity traffic on road or rail, when the duration of the interval between the trains pass is insufficient for passing cars, the loss of time is recommended to be determined by the construction of the daily schedule passes of cars in accordance with the schedule of trains, the laws of oscillation intensity of movement during the day, and the mode of movement of cars in moving zone.

Necessary to calculate the annual running costs of time lost in traffic flows cars-hour, caused by reduced speeds within the zone of influence of the intersection can be determined by the formula:

$$t_{rc} = 365 N_t \left(\frac{L_n}{v_{av}} - \frac{L_n}{v_m}\right), \tag{18}$$

where N_t - the average daily traffic on the highway in the t-th year;

L_n - moving zone length effect on traffic flow speed, km;

v_{av} - the average speed of vehicles in the intersection zone of influence is determined

$$v_{av} = 0{,}5(v_m + v_{in}) \tag{19}$$

v_m - the speed of traffic flow of vehicles through the crossing, km/h;

v_{in} - vehicle speed is the intersection zone of influence km/h.

As shown by experimental calculations to determine the economic efficiency of capital investments, given algorithm may be used to determine the stage of comparative economic efficiency or select the optimal variant of construction of roads.

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UDC 796

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Innovation technological support heavy regulation intersections of urban areas

Currently, the traffic conditions in big cities characterized by difficult road conditions, reduced speeds, frequent and traffic disbalance situations, increasing the time spent by passengers of public passenger transport, transport cost, increased accidents, noise pollution. The main reason for the situation is the growing fleet.

Consider the existing methods of traffic management. Therefore, if a network will apply both methods of management, they are divided by time action. The time allocated for local government, chosen in such a way as to limit the impact of traffic on adjacent intersections [3, p. 37]. Separation on adaptive management (on-line) and software (off-line) is often used as a second method of classification.

The first group is certainly the oldest method of control – manual control at an intersection, and already many algorithms for automated control based on receiving information from sensors traffic. Among automated on-line methods should include primarily those associated with the operational parameters change traffic light regulation: the various options and local regulation of flexible admission phases, as well as network management method SCOOT (Split Cycle Offset Optimization Technique - technology optimization phase duration, cycle and shift). These methods are widely used abroad in used computer-aided traffic management (ASTC) [1, p. 39]. Another group of on-line methods include algorithms that are not associated with traffic light control: Managed signs and placards (mainly in case of traffic jams) and reversible lanes.

The group of algorithms related to software management can be divided into methods to modify control parameters in the diurnal cycle and calendar adjustment based on the forecast of the dynamics of traffic flows and methods that provide a single task such parameters for a long period of time. The first group includes all algorithms traffic light control, operating mode automatic calendar. The second group includes almost all the techniques of forced distribution of traffic flows, which are implemented using road signs (unmanaged) and road marking, prohibition of freight transport, one-way traffic, prohibition of traffic on certain areas at intersections, the allocation of lanes for individual directions of movement, etc. This includes traffic lights and signaling with the same parameters regulation.

To exit from this situation is necessary to introduce a set of measures for the organization and traffic management. Automated traffic control systems represent a new approach to traffic management and managed using high-performance computers implement appropriate traffic management technology [6, p. 94]. Automated traffic control system - a set of software and technical means and measures to ensure safety, improve the parameters of the road network, reduce transport delays and improve environmental conditions. The following methods of traffic control traffic, implemented this system.

1.A method of managing change programs coordination over time (day, week, season). Based on measurements of episodic flow characteristics and quality indicators analyzes the effectiveness of existing programs and coordinate their comparison with control values. If efficiency is insufficient, then transferred to "library" that manage and control values since their actions. The introduction of the program is to coordinate certain preset times.

2.Software management of change program coordination on traffic characteristics. This method differs from the consideration that the change program coordination is done automatically based on information received over a given period of time. In making the decision to change the program ignores the coordination of the transition interval, which is characterized by light mode. During the transition interval management efficiency decreases rapidly. Assessment of the length of the interval can be obtained from the condition of minimum error averaging measurement results.

3.Software Management with a total correction program coordination. In this case, for a period control control action is adjusted based on information about the object.

4.Local flexible management. This method combines management techniques to separate the crossroads where late making control actions in relation to the measurement and analysis of performance can be neglected.

5.Combined management. In modern ASUDD usual choice is a combination of program coordination with "library", general and local, flexible correction.

6.Management in real time. This is a management system in which the delay testing control actions calculated in the operation ASUDD does not exceed the time during which stuff negligible traffic.

ASUDD main mode of operation, which reduces the time spent in transit of passengers and goods, reduce the negative impact of vehicles on the environment, improve the overall level of safety, is the mode of coordinated traffic management. Coordinated management called the coordinated work of a number of objects of traffic lights in order to reduce delays vehicles. The principle of coordination is to turn at the next junction towards the previous green signal with some shift, the duration of which depends on the time of movement of vehicles between the intersections. Thus, vehicles are on the line (or any route movement) as if on schedule, arriving the next intersection at a time when it is in this direction traffic signal turns green [5, p. 161]. This would reduce the number of unnecessary stopping and braking in the flow of traffic and delays. Given the current situation on the roads, most promising and best solution for improving traffic management, as the international experience of many developed countries is the development of automated systems for traffic management using adaptive management. There are all prerequisites. First of all, these measures can be implemented as soon as possible with minimal costs compared to road construction. Secondly, the introduction of such systems allow maximum use of the existing road network and most consider the needs of road users [2, p. 16]. Thirdly, the adaptive ASUDD development is one of the operational, available and effective methods to improve traffic management in all more complicated road conditions on highways and urban road network bridge. The process of adaptive traffic management involves optimizing the parameters of CO in real time. This class of problems relates to the problems of extreme control. To construct the objective function of optimization model used must consider the dynamics of traffic. One of the most modern models is the model Osorio:

$$\lambda_i = \gamma_i + \frac{\sum_j p_{ji} \cdot \lambda_j \cdot \left(1 - P\left(N_j = k_j\right)\right)}{\left(1 - P\left(N_i = k_i\right)\right)};$$

$$\frac{1}{\tilde{\mu}_i} = \sum_{j \in DI} \frac{\lambda_j \cdot \left(1 - P\left(N_j = k_j\right)\right)}{\lambda_i \cdot \left(1 - P\left(N_i = k_i\right)\right) \cdot \tilde{\mu}_j}; \tag{1}$$

$$\frac{1}{\hat{\mu}_i} = \frac{1}{\mu_i} + P_i^f \cdot \frac{1}{\hat{\mu}_i}; \; \frac{1}{\hat{\mu}_i} = \sum_j p_{ij} \cdot P\left(N_j = k_j\right); \; p_i = \frac{\lambda_i}{\hat{\mu}_i}.$$

γ_i – estimate of the amount of external TA arriving for the i-th TP; λ_i – estimate of the amount of all who come TA for the i-th TP; μ_i – assessment of the capacity of i-TP; $\tilde{\mu}_i$ – assessment of unlocking congestion of i-TP; $\hat{\mu}_i$ – assessment of the effective capacity of i-TP; P_i^f – the probability of effect and mash-MTP; p_{ij} – transition probability TC IZ i-th control in the i-th TP; k_i – capacity and th AND (maximum TC); N_i – the current total number of TPP and MTP; $P(N_i = k_i)$ – the likelihood of achieving capacity of i-TP (the likelihood of congestion); $j \in DI$ – many TAs, which catches and by-TP.

The model (1) was implemented as a C ++ class in SUMO and integrated package in accordance with the instructions for assembly SUMO. Integration into SUMO allows the calculation of the overall quality of governance indicators, such as: V_a – the average speed of travel in the transport network, km / h; T_w – the average waiting time of vehicles on sections of the network, c; S_v – the total number of vehicle stops in the network; Q_c – total traffic of vehicles on the front parts of the transport network, bus / h; Q_s – total traffic of vehicles in all parts of the transport network, bus / hour.

Thus, the objective function is as follows:

$$I(M_{is}) = W_V \Theta_V + W_T \Theta_T + W_S \Theta_S + W_{Qc} \Theta_{Qc} + W_{Qs} \Theta_{Qs} + W_P \left(\sum W_{py} IP_y\left(M_{is}\right)\right); \tag{2}$$

$$W_V + W_T + W_S + W_{Qc} + W_{Qs} + W_P = 1; \; \sum W_{py} = 1;$$

$$\Theta_V = \frac{V_a}{V_{\max}}; \; \Theta_T = \begin{cases} 1 - \dfrac{T_w}{T_{w\max}}, T_w \le T_{w\max} \\ 0, T_w > T_{w\max} \end{cases};$$

$$\Theta_S = \begin{cases} 1 - \dfrac{S_v}{S_{\max}}, S_v \le S_{\max} \\ 0, S_v > S_{\max} \end{cases}; \; \Theta_{Qs} = \frac{Q_s}{Q_s^{\max}};$$

$$Q_s^{\max} = P_{\max} \cdot \sum_{i=1}^{N_{tf}} V_{\max,i} NL_i \ ; \ \Theta_{Qc} = \frac{Q_c}{Q_c^{\max}} \ ;$$

$$Q_c^{\max} = P_{\max} \cdot \sum_{j=1}^{NJ_{tf}} V_{\max,j} NL_j$$

$$T_{w\max} = \frac{1}{N_{tf}} \cdot \sum_{i=1}^{N_{tf}} T_{w\max,i} \ ; \ T_{w\max,i} = \frac{N_{tf,i}}{Q_i^{tf}} \cdot 3{,}6 \cdot 10^3 \ ;$$

$$S_{\max} = \frac{1}{N_{tf}} \cdot \sum_{i=1}^{N_{tf}} S_{\max,i} \ ; \ S_{\max,i} = \frac{N_{tf,i}^{\max}}{N_{jtf,i}^{\min}} \ .$$

The task of extreme control target function (2) is as follows:

$$I(M_{is}) \xrightarrow{M_{is}} \max \ ; \ T\min_{l,k}^{ph} \le T_{l,k}^{ph} \ ; \ Tc_l^{is} = \sum_k T_{l,k}^{ph} \ ;$$

$$Tc_{\min} \le Tc_l^{is} \le Tc_{\max} ; \qquad (3)$$

$$0 \le Ts_l^{is} \le Tc_l^{is} \ ; \ M_{is}(X), X \in \mathrm{N} \ .$$

M_{is} – Matrix intersections (control action); $M_{is}(X), X \in \mathrm{N}$ – All elements of the matrix M_{is} s matrix elements that make up the matrix M_{is}, belonging to the area of natural numbers; $T_{l,k}^{ph}$ – activity time traffic light phase, c; $T\min_{l,k}^{ph}$ – minimum allowable time traffic light phase, c; Tc_l^{is} – the full cycle of phases of traffic light object (CO) at the intersection with; $Tc_{\min}$ – minimum allowable time Tc_l^{is}, s; $Tc_{\max}$ – the maximum allowable time Tc_l^{is}, s; Ts_l^{is} – time shift cycle phases CO on a common time reference transport system, s; isn – intersections, $l = \overline{1, isn}$; phn_l – number of traffic light phases l-th crossing, $k = \overline{1, phn_l}$.

Thus, the task is a task of global conventional full numbers multidimensional combinatorial optimization.

It is important to list the following properties of the objective function (TF):

– FIT is need and can not be reduced to a set of nested optimization problems;

– FIT is discrete;

– FIT in the construction of the continuous gap is, therefore, as a result, not differentiated;

– FIT is multy module;
– settings FIT is integer.

Conclusions

To solve this problem can be used the following methods: a method of branches and boundaries; simulated annealing method; genetic algorithms; ant algorithm; method swarm of particles. The method of branch and bound poorly applicable for finding the optimal values of the task in view of the specific features of calculation of using simulation. Simulated annealing method (and other methods in the class of Monte Carlo) has weak convergence. Methods of genetic algorithms, ant algorithm and particle swarm belong to a class of evolutionary optimization methods. A feature of these methods is high convergence. This genetic algorithms found the most widespread use in the optimization parameters CO ASUDD. The most important indicators of the quality of management is the average travel time in the transport network, and the average waiting time at the intersection. It must be emphasized that the introduction of ASTC will increase the efficiency of traffic:

¾ reduction of 30-50% in intersections traffic delays due to optimization of traffic light systems;

¾ increase by 10-15% the average speed of vehicles on the intersections between race by reducing the length of the queues waiting to allowing traffic signal;

¾ reduction of 10-20% of the time travel on the road network;

¾ an increase of 15-25% of transport;

¾ 20-25% improvement of sanitary state air quality by reducing city pollution engine exhaust gases (by reducing the vehicle stops, increasing the average speed).

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Features of architectural education contents in Poland and Ukraine

Abstract. *The paper discusses the questions of the content of professional training of architects at present stage in Ukraine and Poland. New computer technologies, their development and improving, contribute to the urgent need in reviewing the content of education and cause rethinking of current approaches to the training of highly qualified future architects.*

The growing importance of higher education as a key component of the educational system that determines national potential of competitiveness and degree of attractiveness for foreign investments in the national economy has to examine the functioning and improvement of higher education. Nowadays there is a shortage of qualified architects who are fluent in computer technology of architectural engineering and in building information modeling technology.

This paper aims to present training content comparison of future architects in Poland and Ukraine.

Nowadays there are about 800 higher professional schools of architecture. Architectural activities are considered to be unique in nature. The architect should be trained in architectural design, in the three-dimensional arrangement, in the sphere of building engineering, in building production technology, in economics and organization of architectural design and construction.

At all times being changed education in Ukraine and Poland retained its culture-defining core. Analysis of the data shows that education systems in countries were formed over several centuries and absorbed national spiritual and cultural traditions.

Researches in the architectural education field show that the basis of professional competence of the architect is considered to be the project activity [1]. Features of professional architectural education are related to the specific architectural profession its diversity and interdisciplinary courses. Apart from the art, design and engineering components it also involves the consideration of economic and social factors and environmental requirements as well.

Architectural education is everlasting. An architect is studying all his life and thus must constantly monitor the latest scientific developments. Therefore, an integral part of architectural education is the prediction of the future, which is impossible without research, predictive approaches, and dynamic changes taken into account.

Analysis of the content of architects’ training in higher education institutions of Ukraine has showed that the content does not always fully reflect the specific architectural education, and the latest trends in theory and practice of teaching are not always taken into account either, consequently curriculum must be constantly refined. Unfortunately, Ukraine has not developed a universal mechanism for designing educational content of future architects yet. This mechanism ought to stay ahead by allowing to bring up a personality who will be in harmony with themselves and the environment and will be capable to resolve professional tasks so that to meet dynamic working conditions and who will be able to prepare a highly qualified staff.

The Architectural Activity Act of Ukraine [2] that is considered to be outdated nowadays, restricts the service sector and architects' professional responsibility, while in the EU architects implement full control and supervision of the production process. Due to this restriction by the law we can observe the poor quality of construction and a visible backlog of construction industry in technology, engineering systems, management techniques, the quality of work. This gap is automatically projected on the educational process and on the peculiarities of educational programs in particular.

International and domestic experience shows that the process of information in the architectural activity is developing in two directions [3]:

1) Technology support design;

2) Forming a virtual design environment, which does not only activate the expert creativity, but also forms a new structure of the modern architect professional culture.

The higher architectural education in Ukraine follows the first direction mainly. It introduces information technologies by examining the application program packages - computer-aided design (AutoCAD Architecture, ArchiCAD, SketchUp, etc.). It meets the market demand for professionals who have the skills that are necessary to design the project documentation in electronic form. Unfortunately, it does not encourage any development of professional skills of future architects and the artistic component of the architectural profession

Significant changes in education system in Poland have been made for the last period of time. The level of computerization in higher education institutions has significantly increased, due to non-state organization of education the number of higher education institutions has rapidly increased as well; and the number of students has increased too; the system of educational levels has been reviewed, and the European system of transfer and accumulation of credits has been introduced; etc. Undoubtedly, the system of higher education in Poland has made a significant progressive changes as compared to the system of education in Ukraine.

Nowadays the diplomas of the Polish institutions are recognized in all European countries and in most countries all over the world, and they don't need the confirmation, unlike the Ukrainian ones which must be confirmed in most countries (except countries of the former CIS). Unlike the education system in Ukraine the education system in Poland functions according to the two European standards: European Credit Transfer System (ECTS) and International Standard Classification of Education (ISCED). But the main difference between the modern educational system in Poland and Ukraine - is the decentralization of education management, and self-government of schools, which opens the potential prospects for their development.

Today, computers are considered to be the only technological basis of all the works on the architectural design.

A defining feature of the implementation of computer technologies in the architectural design is the transition from disparate operations on specific problems' solution to a common design process based on a single digital BIM model (Building

Information Model) and building information modeling technology. Therefore, a modern architect has to use the appropriate tool software for gaining a successful professional activity.

During the research there was found software that is required for using in the architect's practice (AutoCAD Architecture, Revit, Allplan, etc.). The use of building information model facilitates the work with the object and is superior to classical methods of design. BIM allows a virtual mode to develop and agree on the components of the system for future buildings in advance and to check their viability, functionality and performance. The European leader in the field of architecture and construction of VIM Technologies nowadays is Nemetschek concern, the owner of multi-CAD Allplan.

Introduction of licensing CAD Allplan in the educational process National Aviation University, implementation and testing of the informative training of incoming specialists in all phases of the study subjects, self-study work, course and diploma projects is based on a set of theoretical and methodological approaches and provides a competent creative professional new generation prepared for the professional activity.

There is focusing not on the study of software but on the mastering and its practical use during the course and degree design arsenal of advanced computer technology and on the mastering of the technologies that are the ways and methods of working with objects and information. Their aim is creating informative products that have professional use. It will enable the incoming architects to independently acquire new tools and create new informative products in their professional careers. Eventually students will have the need for continuous personal and professional self-development for individual and creative approach to the process of new knowledge acquiring through all their lives as an architect work is predetermined by time requirements and technological progress.

As it is known the final output of the architect is the architectural visualization. Using, creating and editing of three-dimensional graphics and animation (3ds Max, Lumion, Cinema 4D, etc.) will give an architect the opportunity to convey an idea in its best way and to effectively give the projects presentation in the sphere of design and construction.

Cloud technologies are considered to be modern addition and expansion of educational information environment. Students who have mastered the software architectural design, and by the "cloud" technology in particular, will be in great demand in the labor market.

The study has showed that all the courses of the architectural department involve different program means for the purposes of architectural design (AutoCAD, Revit, Allplan, etc.) and visualization (Cinema 4D, 3DMax etc.). Sometimes building information modeling systems are missing.

Currently the issue of BIM is discussed on conferences, courses and meetings by both the academics and professionals in Poland; however, it is still far from the actual implementation of BIM in the construction industries. In comparison to the worldwide state of BIM adoption, which is regularly surveyed, the rates of adoption in Poland is very low [4]. However, in 2017 EU countries are planning to move to VIM and adopt it as a standard for public procurement.

In education institutions the highest standards of training that meet all international standards have been implemented. Institutions are constantly moving forward and developing, which is the main driving force of social and economic development of countries. There is highly qualified scientific and pedagogical staff working there. Only modern ways of teaching are used in educational process and the professional training in different directions is constantly held in every institution.

Such conditions make universities in Poland attractive to students' studying. International mobility of students and teachers and higher restructuring architectural education promote continuing education and lifelong learning. Students have the opportunity to not only get quality training and professional competence but also financial confidence in the education and employment prospects after the graduation.

Conclusion. Training content comparison of future architects in Poland and Ukraine shows that the process of architects' training to the professional activity is a complex dynamic system. The informative training of architects in postsecondary institution should be focused on the future and should have proactive and predictive nature. The study of advanced foreign experience, analysis of the basic parameters of the architectural system of higher education in Poland will provide an opportunity to strengthen the practical training in higher educational institutions of Ukraine.

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Houses similar in scope for psycho different person

Abstract. The paper discusses the questions of the houses similar in scope for psycho different person. The study is based on the use of different figurative aesthetic techniques, planning and performance color and decoration of the design of residential buildings similar in scope answering basic human psycho significantly expands their subsequent distribution

Actuality report. Houses similar in scope despite the obvious economic advantages over "traditional" housing is still not widely available, which we believe is unlawful and to some extent due on the one hand a conservative attitude to the choice of projects, and the second - the imperfection of the design decisions this type of buildings in Ukraine who do not take into account the specific architectural and artistic perception of individuals. To overcome this ignorance and imperfection projects and directed the theme of the report is intended to give reasoned, evidence that houses similar in scope at certain of improving, should receive wider distribution range.

The main results of the study. To obtain reliable results from the comparison similar in scope and "traditional" house, has established a research base:

• fit, four types of design decisions residential buildings similar in scope, which in its architectural and artistic characteristics meet the basic psycho people and address specific Ukrainian mentality.

Structurally, the developed design solutions residential buildings similar in scope chosen different options dome of which is formed of three, five angles and segments, combined with hemisphere, based on the kind of ground are. The diameter of the scopes - 8 m. The design scheme is designed so that the five and hexagonal panels are composed in turn of triangles, which provides strength and stability of structures, its reliability. Each triangular panel portion has a wooden frame which is sheathed with boards (lining), which forms Interior space and roofing material ("soft tile") - outside. The middle is filled with environmentally friendly insulation. If the panel is placed in an area where there is room quarantine, it is clear (filled fiberglass). This method allows to combine constructive placing transparent and opaque parts create various expressive compositional solutions that can decorate the environment [1].

Typical building solutions psycho "creator" is characterized by relative compactness, some asymmetry. Central area covers fireplace (grate), which comes in the form of decorative chimney to the roof. Color decoration is sufficiently bright, medium intensity. Planning decisions and efficiently structured (Fig. 1).

Regarding "Romantic", they are very fond of plastic and decorative and color saturation, December correlations between different plastics, texture and color.

This kind of festive clothes, which helps cheerful mood and positive charges for communication.

Fig.1. Psycho house similar in scope "Creator"

Fig. 2. Psycho house similar in scope "pragmatists"

Much attention is paid to architectural details that are full of plastic, decor, color and decorate around the perimeter of the building, gleaming in the day and at night. In interior and exterior space is widely used swimming pools, fountains, aquariums, sculptures (Figure 4).

Conclusions: The study is based on the use of different figurative aesthetic techniques, planning and performance color and decoration of the design of residential buildings similar in scope answering basic human psycho significantly expands their subsequent distribution. This suggests feasibility of implementing this technique in practice design and construction of individual housing in Ukraine.

Fig. 3. Psycho house similar in scope "intellectuals"

Fig. 4. Psycho house similar in scope "Romantic"

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Features of location under airports technogenic landscapes.

Modern changes in human activity significantly alter the appearance of the urban environment and occur in three areas: diversity and transformation functionality by creating additional conditions for recreation, entertainment, climate change due to changing the system of transport services, the creation of new transport infrastructure (eg airports) the use of new methods of spatial organization of urban areas; desire for brightness architectural forms, unusual appearance of urban design elements, compounds in them diverse functions.

With the growth of the deficit areas in large industrial cities and metropolitan areas there is a need to review the planning structure of the urban environment in search of reserve areas for urban needs, including placement airports. Analysis of current planning structure of cities with the most characteristic features of disturbed urban environment, revealed features of the placement of airports and airport facilities on the basis of urban conditions, which in turn define the principles of placing elements of external transport planning and their functional connectivity of the city structure, system service population, transportation network and environmental issues into account anthropogenic regions.

One of the most important components of the transport system of large urban structures or agglomerations coal-mining regions have airports with sophisticated infrastructure that provides fast, safe and efficient transportation by air of passengers, baggage, cargo, mail and making sending and receiving aircraft using the means necessary for their take-off or planting, and maintenance and repairs. The main criterion guiding the choice of the location of the airport is a rather large piece of land that can be used for construction. At the same time, this place must be sufficiently close to the metropolitan area that serve the airport. These areas of specific regions such as coal are open spaces in urban areas or long-distance areas in agglomerations.

During the construction of the airport put the absence of obstacles, such as buildings, piles and piles whose height in Europe reaches 130-150 meters, antenna elevation or terrain, over a distance of 30-50 km. runway of the airport that may impair the safety in adverse weather conditions. Choosing a place for the construction of the airport often depends on the problems posed by aircraft noise, the nature of the terrain, the type of land use, degree of economic development of the surrounding area and the existing transport systems and capabilities. Architectural planning analysis selection area for the construction of airports shows that in a specific architectural - planning structure of cities coalmining areas, these areas are located in the peripheral areas of the urban area, far from the areas of residential and large heavy industry. These areas may be close to the communal storage, recreational, industrial zones of small businesses. Given the shortage of green spaces and recreational areas, particularly in the city of coal mining areas, open spaces, which are allocated to the construction of airports, selected exclusively from unsuitable land for agricultural lands, territories of the former business and adjacent sanitary protection zones, recorded a distance of residential areas.

The factors affecting the placement of airports and runways:

- Consideration of gas and dust "noise pollution" of the environment;

- The definition of suitable soils without evidence of subsidence, flooding, landslides;

- The approach to man-made obstacles in the form of heaps, dumps and quarries;

- Taking into account wind load forces prevailing wind side and use "screen" as a "ridge" heaps or piles;

- Identification of areas "rotor wind" generated by man-made obstacles.

Thus, the size of the city, the nature of its anthropogenic impact, the structure of transport services, organization of transport connections to the airport and have a great impact on the architectural and planning organization of airports in the structure of the city.

Town Planning involves use of damaged areas to achieve functional compliance needs intensive development of the city, preserving the fundamental basics of urban planning situation modifiable, depending on the areas of territorial-planning development of the city, the development of transport networks and their relationship with the city planning structure, provide visual correlation ' links with natural and man-made landscapes.

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Optimization environment urban development in different conditions of degraded landscapes.

In the modern industrial city most consistent solution that provides a gradual creation of conditions to optimize urban environment, is the implementation of architectural and landscape rehabilitation of urban areas. Implementation of reconstruction works associated with changes in the quality of the urban environment, can be effective only if their social and ecological. In this regard, architectural and spatial formation of the urban environment is considered in conjunction with the functional and ecological optimization and compositional harmonization.

According to the dominant influence of technogenic landscape potential of coal-mining regions proposed recommendations appropriate choice of urban planning techniques to optimize the impact of landscape structure:

- The quality aeration processes to achieve wind-gas dust comfort of the urban environment;
- Functional use of the territory for the purpose of ecological improvement of the urban environment;
- Formation of architectural and spatial composition for the purpose of aesthetic improvement of the urban environment.

Analysis of urban structures with complex shapes degraded landscape points to the need to develop their versatility and multires. Formation of architectural planning, three-dimensional compositions is the result of the semantic content of methods of spatial environments. A group of these methods of disturbed urban environment, which aim to:

1. Increasing utility area (utilitarian, sanitary and aesthetic) incl.:

- Increasing the density and variety development;
- Removal of areas not used;
- Man-made transformation plots in urban centers with features attraction public recreation and leisure residents.

2. Re operation "passive" active areas in the urban environment of the multifunctional structure, namely:

- Diversification of infrastructure in areas rehabilitated impaired environment;
- The formation of a functional city within the frame of degraded landscapes;
- Providing them relief centers communicative functions tensions of the urban environment.

3. Improving the environmental situation in the region by:

- Output of man-made hazardous areas with discharge affecting the environment;

- The inclusion of degraded landscapes in greening the city and create its ecological frame;
- The creation of "green filter" industrial zones of the city due to large-scale planting of disturbed areas and in the sanitary protection zones recreational areas;
- Organization of remediation measures damaged areas to create "barriers" to curb the spread of gas and dust emissions in the urban environment.

Thus, re-cultivated and planted and built or ordered degraded landscapes, both urban accents are concentration means a visual composition, architectural and spatial, functional and relevant skills of basic units, which suggests their significant urban values.

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Ecological planning in a design and quality of life

The question of ecology is considered in an industrial design. Displace attention on innovative technologies and their applications in developments of design. The question of design of landscape, interior, clothing is taken into account. It is separately marked small architectural forms and electronic videos terminals. More thoroughly it is considered question of ecology of fabrics.

An industrial design takes into account requirements in relation to providing of man the articles of way of life and productive equipment. Also in relation to providing of environment and environment objects what touches airports. It is the articles of landscape design, interiors, furnitures, clothing. The articles of landscape design are small architectural forms, including, fountains, cascades. In interiors, including airplanes, furnitures and clothing one of main materials there are fabrics. Among a productive equipment separately it follows to distinguish video terminals of electronic devices. Consider the research and development that produces new technology. At the University of the West of England (UWE) in Bristol developing technology of microbial fuel cells (MFC) smart bricks. The building will function as a large living organisms. MFC will be built into the bricks to give them smart features. They can be used to generate electricity from human urine, dead flies, or simply from dust, garbage, recycle waste water, to generate electricity and to produce oxygen. Also convert carbon dioxide, sunlight, algae, bacteria and nutrients, and produce clean water, oxygen, light, heat, bio-decomposing detergents [1]. Of course, for landscape design such technology is necessary. Very important is also the environmental issue of computer monitors. And especially how visual monitor of the concepts of ecology. What threats, what natural disturbance exist for clear vision when looking at the monitor? To this question a satisfactory explanation is not yet available [2]. Question tissues let's consider the example of clothing. Clothing as a design object is a reflection of the natural development of human culture. Accordingly is an object of the design activity with a specific development project and technological cultures. Axiological meaning of things is always, in addition to the purely material, absorbed sociocultural achievements. So, thanks to the skill of the performers, the thing was a masterpiece, including world culture. Modern human development has brought about changes in design culture, where, in addition to others that relate to the functional, artistic, aesthetic, ergonomic, technological, economic, high quality components, highlighted the concept of sustainability. This concept must comply with the new system of values in design clothing. That is, the qualitative characteristics of the object of design could be characterized by its utilitarian properties, or, to meet the stringent requirements of the consumer, for example, about the prestige of the product, satisfying his emotional requirements.

However, at the present stage of world evolution requirements to the quality of the product as a product in industrial production become more widespread sense. We are talking about the quality of human life, first, her life support in certain shell, which is the clothes, and, secondly, life in a particular environment. Clothing is a versatile design object that in the first place is a protective feature that people should feel comfortable. However, not only comfortable, clothes should not harm the health. Clothing as the protective sheath shall meet the requirements of safety of use, for example, to ensure the normal parameters of homeostasis – not to push, not to cause injury when using etc etc.. But the material warehouse of clothes should not harm the biological level, that is, to have certain hygienic measures, for example, non-allergenic, to provide moisture and vapor-air insight, anti static. In addition, the constructive the device of the garment shall also provide these numbers as not to disturb the steam-air exchange in Odegova space. And, at the same time, the clothes should look aesthetically pleasing. Historically, with the development of science, technology, technology advantage in the production of clothing started to give materials of chemical fibers, i.e. artificial, synthetic and mineral. In addition, when the finishing processes in the manufacture textile materials, which are cleaning textile materials from contamination, coloring (dyeing and printing) and finish (dressing) can and usually are used chemical compounds. Even in the children's clothes are such materials used! It gave economic benefits in the production. But not only that. With the advantage of functional indicators clothing when using such materials, for example, when the protection from the weather, humid repulsion, not wet, certain of formability (low elongation) and hygiene began to take second place. And this is to some extent influenced the decline of human life. It should be noted that in the production of clothing uses materials from natural raw materials – linen, cotton, silk, wool, leather, fur and some other or mixed materials add chemical fibers to natural. Additional materials included hemp, soy, jute, nettle, eucalyptus, frame and bamboo fiber, fiber from seaweed and cellulose (Lyocell),, Tencel, organic fabric from wood, crab tissue ("Crabyon") and others. In modern world the approach to eco-ensuring garments materials determined much strict requirements to the concept of eco-friendly materials. This concerns not only the lack of chemical constituents in the materials and the processes of growing natural raw materials. Therefore, the role of design as art and design practice that provides the needs of mankind in the appropriate things at this stage lies in determining the structure of needs, statement of environmental values through the things and, thus, forming a way of life. Here why in a modern, ecologically oriented, the design stood out project directions, which should ensure, respectively, the greening of production and greening of consumption. To these areas in the design and manufacture of clothing are the following (Fig.1).

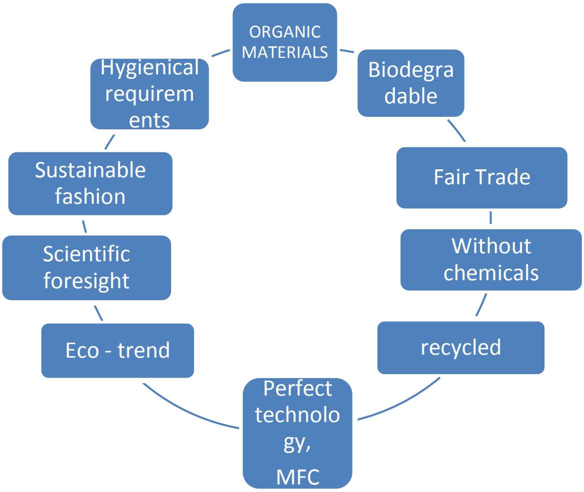

Fig.1 Graphical representation of project areas

It is mandatory the use of organic materials (fabric is any organic structure, consisting of cells with similar structure and General functions, organized or constrained definitely; organic - proper to the vegetable or animal world). Wares are made only from the natural and environmentally clean raw material grown without pesticides and other, insalubrious components. At the production of eco-clothing and shoe does not use natural skin and fabrics of animal origin (all types of skin, ivory, fur, whalebone, horsehair and other). Symbolic illustration is on fig.2 evidently demonstrates dressed acco [1]. On the whole, design-planning of eco-clothing is based on principles of ergo-, eco-, ethno-design, design management and, actually, planning. In a project process a corresponding place is occupied: divergence as expansion of limits of project situation with the aim of providing enough large space for the search of decision (checking for firmness of ideas, approaches, directions in research, search of paradigms and points of counting out);

Fig. 2 Symbolic illustration of dressed acco

transformation as transformation or change is forms that characterized by a certain dynamics; convergence as specification and working out in detail of research decisions. Among composition factors it follows separately to distinguish the concept of tectonics both in relation to the shells of clothing and visible expression of form through a construction (underlying structure) and properties of materials and methods of their treatment (technologies). Obligatory is taking into account of standards, certification and innovative technologies. Substantial are processes of form-creation of both silhouette and details. Also important is a selection of materials with certain properties for the package of sewing good, because on properties of materials efficiency of technological decisions depends in relation to form-creation and general treatment.

Conclusions

Experience directions are certain in relation to innovative technologies in a design. The circle of questions of ecology is outlined in an industrial design. More wide spectrum of questions of ecology can be considered on the example of fabrics of clothing.

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UDC [930.2+069](477)(06)

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Recommendation for individual protection of sacral objects

Today it is not always possible to recognize safe different, sometimes non-standard solutions that were once used in the temples with rich architectural anger. The crime rising that except breakups is often characterizing by actions that cause devastation inside of the temples needs for a solid protective measures that have much more complex structure.

To get the complete picture of the security object-risk criminal attacks it`s necessary to analyze the status of its construction, mechanical and electronic security systems, and physical surveillance. And these factors are crucial, especially for the classification of the object as reliable or secure enough or badly protected, and their detailed evaluation requires the specialist`s control.

Some circumstances worsen the actual degree of safety and adversely affect the existing system of protection (Table 1). They certainly must include the repair of external facades. An additional very serious risk poses the scaffolding, whose presence is certainly related to the implementation of facade work poses (Table 1, a), defects in wood and locksmiths' performance (inexact fit individual items, too large parametrical gaps) (Table 1, d), deformation of individual items, the corroded closures parts, use of low quality or "microscopic" size loops, staples and padlocks, which instead complicate criminal intentions, encouraging them to intruders (Table 1, b-c).

Besides the defect of protection, the above items are also distorting the image of the sacred building. Scaffold destroy street facade and destroys the urban situation; grille and inappropriate carpentry destroy the perception of details.

Table 1.

Condition of building and mechanical protection systems

			
			
a) scaffolding facade	b) grille in front	c) locks	d) damaged woodwork

Among the many factors that distinguish sacred objects from the other, but are essential for the system alarm, it`s necessary to pay a special attention, especially at locations scattered throughout the complex of sacred art works to be protected as well as the complex architecture and rich interior decoration, which allow attackers to discreetly stay in the temple.

In particularly dangerous places inside the church, which must pay particular attention to the design of signaling system should be ranked as follows:

− side chapels;
− altar (altar design, usually criminal assures easy to escape);
− very large confessionals;
− choirs and design of the old organs.

Round the clock security and alarm system equipment secluded side chapels is an effective form of protection (Table 2, a). The combination of mechanical devices with electronic protection, which work constantly, gives the best guarantee of safety, however, in this case, the aesthetic appearance and perception of integrity of an artwork is violating.

One of the most important elements in the overall protection against burglary and assault in sacred objects is a personal protection of extremely valuable art works. Individual protection is particularly important if there is a desire to limit access for tourists (Table 2, b).

Table 2.

Forms of protection

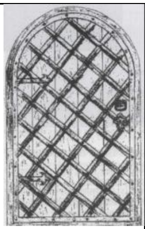
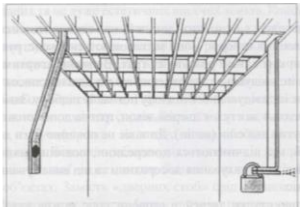
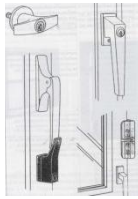
a) separate side chapel guarded

b) individual protection

Maximum protection can be achieved only coordinated all types of security – mechanical, alarm systems and physical protection, while not destroying the holistic perception attractions. Before installing security systems, it`s necessary to develop a conceptual design. It may seem that this is unnecessary expense, but it really is a very wrong idea, because it was in the process of developing this project should pay attention not only to the type of protection but also to a way of placing protective agents (Table 3).

Table 3.

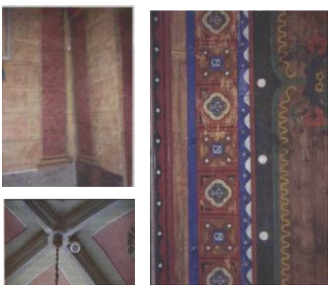
Development Project

		
Faced fortified leaf doors	Protected bars top lantern light and door	Window latches

Of course, the cable guard system between bricks masonry is a hard work but it hides a system of protection (Table 4, a). Placing of fire sensors also requires a certain skill and lightness (Table 4, b). The lighting of sanctuary facade not only enhances its protective ability but also creates additional tourist attraction in the evening. A temple in darkness gives the impression of defenseless and easily accessible to thieve attacks (Table 4, c).

Table 5.

Installation of security tools

		
a) Laying of cable in an old masonry	b) Latent placing sensors	c) Lighting

Conclusions

There is no an ideal recommendation for personal protection of ancient monuments. The selected solution is largely dependent on the imagination of the designer or artist of the system, but even due to the cheapest and easiest way is possible to achieve quite satisfactory results.

Clergy and religious communities engaged in the management of sacred art and culture would remember that they control not their property but the most sacred and national values, integrity and the inviolability of which it`s necessary to protect with the greatest care and responsibility.

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UDC 725.381

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Energy saving due to underground construction parking, classification

Examples of energy-efficient approach to the construction of parking lots, namely the underground construction. The classification of underground parking.

Trends in urban planning, namely in designing underground parking, expressed in the formation of prospective laws, rules and regulations to improve the culture of the population and reduce wasteful spending free time population. Nowadays territorial problem in large cities has become economical use of the territory. In urban planning it turned into a more intensive use of the territory of reconciliation at one site various buildings and the use of underground space as a reserve to increase the area of construction.

In the analysis of international scientific research and practical achievements identified trends in the use of underground space for transport objects, leaving pedestrians ground level. The current experience of major cities Ukraine points to the development of construction of underground parking in historic areas, but recommendations for architectural planning and functional organization of internal space is insufficient and needs further study. The main task - creating artificial climate, that environmental comfort in an underground space that will provide favorable conditions for the stay of people. This made it possible to achieve the broad development of construction of underground car parks, because the historical areas of the largest cities in Ukraine their construction is a necessary measure. Underground car parks - the most current and future direction of this development, as well as providing solutions to many social and economic issues in urban planning.

The possibility of using the car largely depends not only on its maintenance, but also on storage conditions. From the parking characteristics and its capacity is largely dependent on the cost and efficiency of these facilities.

The four main factors that determine what will be the parking, above-ground or underground, one-level or multi-level.

- The cost of creating parking;
- The cost of land;
- Town-planning constraints;
- Technical restrictions.

Benefits underground garages and parking lots clear. First, save underground parking area, as can be accommodated in existing buildings, roads and greenery.

Ecologically parking lots also have advantages over ground: emissions from motor vehicles is carried out only by ventilation, and in the surface layer of the concentration is lower. Because hygiene requirements to accommodate underground parking lot softer. Especially important is the energy aspect: the fact that the temperature underground remains constant throughout the year and can be 8-13 ° C (depending on species), which can significantly reduce energy consumption. Therefore, to realize this advantage requires appropriate insulation of buildings.

The important role played by factors determining the possibility of creating underground parking. On the one hand, underground parking is sometimes the only possible option for building surrounded by historic buildings.

Difficulties underground construction:

- The existence of underground utilities;
- Complicated hydrogeological conditions in urban development;
- The need to strengthen the foundations of the nearest houses;
- High cost of the construction cost, compared to surface parking.

Design of underground parking.

In the design of underground parking should ensure that the number of general requirements:

- Security;
- Adaptability;
- Ease of entry and exit (they are available);
- Good waterproofing;
- The necessary engineering systems that provide climate (ventilation and gas contamination control, heating);
- Fire suppression and smoke;
- Communication;
- Lighting;
- Enough for all car ceiling height and width of entry and exit and parking spaces.

Hydrogeological conditions - one of the most important characteristics of the site chosen for the construction of underground parking. Groundwater and soil composition may limit depth and also complicate the construction process. In addition, any major construction it affects the underground watercourse, and must take into account the impact of parking created on the foundations of nearby houses.

In the design and take into account the urban limits, in particular - security zones of monuments, various communications.

However, should the requirement to provide 10-minute walking distance to owners of vehicles, when it comes to parking, designed for permanent storage of cars.

The most difficult task is the placement of underground parking under roads. Underground parking, organized directly under the roadway - convenient but more costly to strengthen the supporting structures and coatings. These costs will be justified if there are several underground layers. On the other hand, increasing the number of underground layers of sharply increased costs associated with the conditions of the work.

Examples of construction of underground parking.

Construction of car parks in Europe started in the sixties. Among the underground parking of the last century is very difficult technically buildings, which today are of interest to architects. Yes, Geneva was established underground garage built by movable well. This well outside diameter of 57 m under its own weight and special knives lowered 28 meters below ground level. On the inside reinforced concrete walls of the well established guide width of 21.5 m, which provides rigidity wall of the well. This guide is eight revolutions reaches a length of about 1,000 meters, her two band width of 9.5 m allow simultaneous movement of vehicles in both directions. Designated parking are located on both sides of the lane perpendicular to it and divided into 500 boxes.

Classification of underground parking at the location:

- For roads, highways;
- At stadiums, sports fields, playgrounds for entertainment;
- In the area;
- In parks, squares, gardens, boulevards;
- Under water, embankments, canals;
- In areas in the building.

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UDC 515.2

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Geometrical method of automated designing of torsos surfaces

The geometrical method of automated designing of torsos surfaces of the ploughs is developed and realised in the form of the computing program of TORS. The result of automated designing of surfaces is provided.

Torso surface is received at external spinning of two curve of the second order by a tangent plane. The automated designing of a rectilinear forming of torso surface is carried out on such geometrical algorithm (Fig.1):

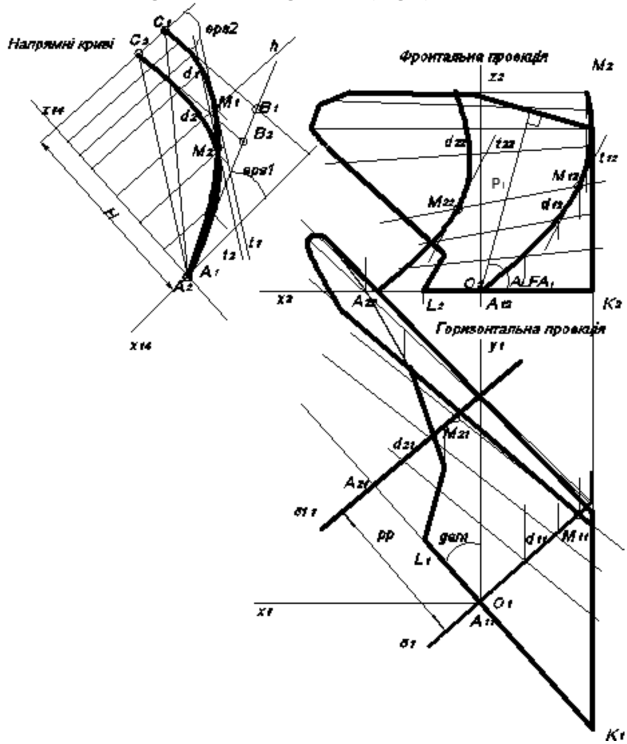

Fig.1. Designing of torsos surfaces of the ploughs

1. Find array of intermediate points T_1 of curve d_1, as points of crossing of horizontal planes h with a directing curve d_1.

2. Define in each point T_1, values angular coefficient of tangens t_1 to a curve d_1.

3. Define coordinates of points T_2, under condition of equality angular coefficient of parallel tangents $t_1 // t_2$.

4. Find array of intermediate element of torso surface, as straight lines passing through respective points T_1,T_2 curves d_1 and d_2.

5. Set a front contour of a plough on a frontal projection (see Fig. 1). Plough surface it turns out as intersection of frontal-projecting planes, which pass through limiting straight lines of a front contour, with linear generatrix of torso.

The geometrical method of automated designing of torsos surfaces of the ploughs is developed and realised in the form of the computing program of TORS.

As a result of realisation of program TORS it is received (Fig. 2): frontal and horizontal projections of ploughs; are set torso surfaces, the form of directing curves and a front contour; 3D images of working torso surfaces. Accordingly, all entrance and output information stands out in a graphic and tabular kind.

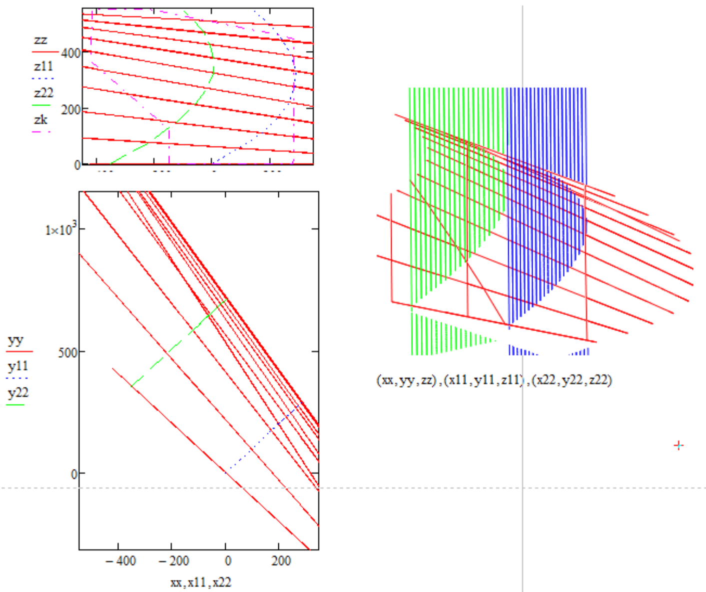

Fig. 5. Projections of a plough

Thus the offered method can form a geometrical basis for working out of algorithms and programs automated design of various compartments of technical surfaces.

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UDC 514.18

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The construction of the geometric models of ecosystems discrete interpolation method

The paper considers discrete-interpolation method for modeling multiparameter ecological systems and environments. Using this method creates discrete interpolation environmental matrix, which is a geometric model of ecosystems, and allows us to solve their problem of modeling.

In today's global crisis, destructive human impact on the environmental studies associated with the development of methods for modeling complex multivariable ecological processes and systems, forecasting and decision of ecological safety problems of particular importance.

Natural ecosystems are closely linked with each other that can be attributed to their modeling, forecasting, monitoring the status of various components to the multivariable and stochastic processes. Obviously, in the modeling of such systems, which are not amenable to analytical description, use the continuum model is not possible. In support of the above it should be noted that the parameters of such systems are essentially heterogeneous. Moreover, they are often affected by external factors which sometimes can not be foreseen. A very important factor is the fact that certain parameters or components of ecological systems are measured at certain times and in certain places. It is clear that this information may change with time, has a pronounced discrete character.

Therefore, in our opinion, one of the options to address these problems is the use of discrete geometric models of ecological processes and systems, presented in the form of some discrete numeric arrays defined structure, ie, it is proposed to use the methods of geometric modeling. It should be noted that the digital way of representing the geometrical information about an object or a process that is modeled, is one of the most rational. The discrete approach can also be considered more versatile because of the continuously-analytical model can always go to the discrete.

The need to build one or n-parameter sets of different objects or processes occurs in many problems of geometric modeling. For example, such an object can be a surface, and more hypersurface, as a model of certain multi-component environment, defined in most cases discrete functionality.

Modelling ecological processes and systems presented as a discrete database components of these systems is well within the interpolation scheme based on Lagrange polynomials which allow to receive one or n-parametric, depending on the dimension of the interpolation process, a plurality of specific objects or processes. In previous papers considered various schemes create a one-parameter sets of discrete numeric arrays using Lagrange polynomials. Lagrange interpolation polynomials allow optional equally spaced interpolation nodes, as well as the possibility of submitting to each variable of his number of such units.

The originality of the proposed approach lies in the fact that under the node of interpolation in the classic view is not understood the point, and more complex mathematical object, such as a discrete numeric array, including certain parameters of some of the ecological system, or even the whole process, presented in the form of a specific functional as aggregate its parameters and properties.

In the future, the location of points of interpolation scheme described above will be understood as an interpolation scheme.

These so-parameter sets are discrete mathematical models of environmental objects and processes. The elements of these sets is a discrete function that can generally be represented as discrete numeric array, the dimension of which can be varied in a certain way. Then, interpolation of functions is reduced to placing at the interpolation nodes, if possible, equations or discrete arrays, and getting some functionality with the parameter vector that includes an interpolation parameter, the coordinate variables, parameters that characterize the shape or position of objects, certain characteristics of the processes.

This approach allows you to include a one-parameter set of objects and parameters that have different structures and properties, and this picture is just inherent in most ecosystems.

Using this approach, the Lagrange interpolation polynomials will be as follows:

$$\Phi(u)_n = \sum_{i=0}^{n-1} F_i(p_1, p_2, \dots, p_m) \prod_{\substack{j=0 \\ j\neq i}}^{n-1} \frac{u-u_j}{u_i-u_j},$$

where **u** – interpolation parameter, **F** (p_1, p_2, ... p_k) - nodal function, p_1, p_2, ... p_k - nodal function parameters, **n** - the number of interpolation nodes.

For more complex ecological systems can be used, for example, two-dimensional interpolation, finding in this kind of power polynomial the $\mathbf{\Phi}_{m,n}(u,v)$ of degree **m** for **u** and **n** on **v**, and determine the F functional value at any point to the parameters (**u, v**). Geometrically, this means that, when a two-dimensional interpolation through the nodal point passes a surface $\mathbf{z}=\mathbf{\Phi}_{m,n}(\mathbf{u}, \mathbf{v})$. If you build a regular grid, and set its node value of the function z, then the whole area then splits into **mn** rectangles, one of which hit and a point (**u, v**).

Thus, we can get a two-dimensional interpolation $\Rightarrow$ $\mathbf{\Phi}_{m,n}(u,v)$ degree **m** in **u** and degree **n** in **v** $\Rightarrow$ **z(u, v)** at an arbitrary point T (x, y). Geometrically through the nodal point will be some surface z = $\mathbf{\Phi}_{m,n}(u,v)$:

$$\mathbf{\Phi}_{m,n}(u,v)=\sum_{i=0}^{m-1}\sum_{j=0}^{n-1} F_{i,j}(p_1,p_2,\cdots,p_t)\prod_{\substack{p=0\\p\neq i}}^{m-1}\prod_{\substack{q=0\\q\neq j}}^{n-1}\frac{(u-u_i)(v-v_j)}{(u_p-u_i)(v_q-v_j)}$$

An important factor in the use of discrete interpolation approach is that the introduction of a specific interpolation criterion, which is linked to the fact that the polynomial interpolation is, in fact, a truncated (analogue) Taylor series. Therefore to ensure the convergence of the corresponding series of analogue necessary decrease of the absolute value of the coefficient of u with increasing degree of **u**.

In the case of n-dimensional interpolation formula that will be a polynomial of **n**-variables, actually expresses some hypersurface passing through the nodal point.

Let **F** (p_1, p_2, p_3, ..., p_k, ..., p_m) - multiparametric implicitly given function. We will form it in the form of a functional **Φ** (pi, j), which is given by the matrix **M** [i, j].

$$F(p_1, p_2, p_3, \dots, p_k, \dots, p_m) = M[i, j] ,$$

where p_1, p_2, p_3, ..., p_k, ..., p_m - environmental different structural and different quality parameters (pollution indicators, the level of concentration of certain substances, taking into account the natural features, etc.), and

$$M[i,j]=\begin{pmatrix} p_{1,1} & p_{1,2} & \cdots & \cdots & p_{1,n} \\ p_{2,1} & p_{2,2} & \cdots & \cdots & p_{2,n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ p_{m,1} & p_{m,2} & \cdots & \cdots & p_{m,n} \end{pmatrix}$$

Thus, **M** [i, j] is the nodal discrete interpolation environmental matrix.

Considering the **M** [i, j] as specified node interpolation using Lagrange polynomial interpolation in the case of one-dimensional interpolation we obtain **Φ** ($p_{i,j}$)

$$\Phi(p_{i,j}) = \sum_{i=0}^{n-1} M_i(i,\ j)\prod_{\substack{j=0\\j\neq i}}^{n-1}\frac{u-u_j}{u_i-u_j} \quad ,$$

where **u** – the parameter interpolation, for example, a specific vector direction; **n** - the number of interpolation points.

The expression $\mathbf{\Phi}(p_{i,j})$, which is a generalized discrete interpolation ecological matrix, and have discrete interpolation geometric model of a certain ecological system and ecological environment.

Thus, the proposed hike may be the most effective in the simulation of environmental processes and systems, which are characterized by a large number of different quality parameters. For example, is considered a qualitative and quantitative assessment of the impact of environmental pollution on the example of the harmful production, airport, etc. It is possible to formulate some current and future challenges that may be addressed on the basis of the proposed discrete interpolation campaign:

1. Determination of the level of harm to ecosystems.
2. Dynamic and long-term forecasting of pollution of the territory.
3. Optimizing the location of the structural components of ecological systems.
4. Determination of some integrated indicators of the ecological situation.

Conclusion

The proposed discrete-interpolation approach for modeling multiparameter environmental systems and environments provides a discrete mathematical model of complex objects, processes and systems, which are characterized by a large number of parameters and properties that have, in turn, diverse structure and a certain anisotropy of some characteristics in time and space.

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UDC 159.9

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Determination of conditions of the visual load video terminals operators

The conditions of visual work of computer operators with video terminals and ergonomic features, characteristics of physical environmental factors were considered. Experimental research using "Devices for determination of near point of clear vision when working with monitors electronic devices" were held.

To increase human operability, first of all, it is necessary to provide a comfortable environment for the eyes, as the main stream of information about the external world flows through vision (~ 90%).

Working conditions at the monitor opposite to those accustomed to our eyes. In ordinary life we perceive mostly reflected light (unless you are looking at the sun, the stars, or artificial light sources), and the objects of observation are continuously in our field of vision for at least a few seconds.

Perception of information to the PC user's from a display screen different from the usual reading of the paper for the following reasons:

- When working with display user depends largely on the position of the display in space, while reading printed text it is easy to find the position of the sheet for the most comfortable perception of information;

- The screen is made of glass has a mirror or mixed reflection, is a source of light and considered the active contrast device; when reading from a sheet of paper, we are dealing with a diffuse reflection text, ie passive contrast, which marginally dependents on the intensity and angle of illumination light flux falling on the paper;

- The text on the paper is the same, but the text on the screen is periodically updated during the scan of the electron beam on the surface of the screen. Low enough refresh rate ($f < 60$ Hz) causes the images flicker. If the refresh rate higher than 80 Hz operators do not notice the flicker, however, the human visual system feels an increased load.

Most favorable conditions for visual operator when working with textual information are the following:

1) The font style.

In normal cases, it is recommended, as a rule, straight font. Italics can be used to highlight selected places in text. Inscriptions, specifications, instructions, etc. can be performed with gothic, spartan, calligraphic fonts (narrow, medium and bold options).

2) The font size.

10 points Font Size (text height) is preferable, but the pins are allowed from 9 to 12 points (1 point = 0.376 mm).

3) The distance between the lines must be not less than the height of the font.

4) For multicolor representing it is not recommended to use more than 6 colors at the same time. The color of characters and background color should not be complementary colors (a pair of complementary colors: red - green, blue - orange, yellow - purple).

Production research were conducted in the department of Automatic Control Systems of state-owned enterprise "Antonov". The objects of study were computer operators with video terminals.

Terms of visual work, ergonomic peculiarities, characteristics of physical environment factors were identified on 11 permanent and 4 unpermanent working places.

During the measuring the device to determine the near point of clear vision at work with monitors electronic devices was used. The device allows an additional measuring and adjusting the parameters of the environment that influence the definition of near point of clear vision. In particular, fixing the value of general lighting with illuminometer; regulate it; moving the light sources up and down; using scales measured the distance to the source of light and the amount of light directly at the monitor at it's any point.

Level of illumination was studied in horizontal and vertical planes in the areas of visual control using illuminometers DT-1308.

When study in industrial conditions follow that light tests are not different from the illumination of the workplace, the level of which must comply with sanitary norms, and need prior to the survey operators located within 40 minutes of lighting conditions, which meet the requirements of the experiment.

Determination of the speed processing of the information done by the method of calculation, taking into account the proof-test execution time and number of errors. Focus switching functions was studied using the Schulte tables. The essence of working with Schulte tables is quick succession finding of all the numbers, or other objects located in the table. Moreover, emphasis is placed on the finding speed, which enable to enhance with special methods of working with these tables. Typically Shultz tables are using for perception of tempo information as well as a test for the studying of the current state of the tempo. Permanent work with tables Schulte helps to extend peripheral vision. In addition, Schulte table is often used for the production of so-called high productivity state, which is carried out by switching the critical consciousness of the perception of a certain apathy and to effectively perform logical and sequential operations.

All computers working on the Microsoft Windows operating system (operators computers system - Windows 7, experimenter computer system - Windows XP). TimeLeft stopwatch program used to fix the tasks performing. Stopwatch were running on the operators computer remotely from the experimenter computer, to control it remotely were used TeamViewer.

Research of short-term visual memory were conducted by presentation 10 words to the operators. In was dedicated 12 sec. for remembering and one minute for recreation. The amount of RAM memory was calculated in percentage.

The number of signs that were entered by operators per hour of the continuous work interactively reaches 7780 ± 1160, which is 2-3 symbols in 1 s. This accompanies by locally-dynamic muscle work and moving loading of eye when using keyboard. During working process operators perceive different by it’s the nature visual objects. Images on the video terminal screen are specific unlike the paper-blank transmitters of information and keyboard.

At quality image on the screen evaluation (green characters on a dark field) and the conditions of its perception - 40% of respondents expressed dissatisfaction by some characteristics. All operators who suffer the violations of refraction, gave a negative assessment to image sharpness, it’s brightness, contrast, size of text elements.

Working with video terminals specificity is related to the need for frequent and rapid transfer and fixation of view on the screen, keyboard, and other objects of visual control. Frequency and duration of view fixation depends on the submitted text characteristics.

Frequent switches of view, continuous, for an hour, when information input by the operator, determine the importance of the function of switching attention. The efficiency of the functions associated with readaptation to the different characteristics of the images and the level of brightness, which caused by variability of reflection coefficients of objects in the areas of visual control. Photoelectric glossmeter FB-2 with a measuring device were used to investigate the reflectance of colorful materials as registrar characteristics reflected light beam. It uses microammeters that is placed at the bottom of the screen. Creating eclipse regulate the position of the registrar flux.

According to the indexes of the microammeter we can determine the value of coefficient ρ_m reflection and degree of reflection K (%) as follows:

$K = (\rho_m/\rho_{st})x100$,

where ρ_{st} - reflectance standard (as standard glass were used UV glass with $\rho_{et} = 0.65$). This allows to define shine indicators of colored materials to select the material with the lowest rate.

The absence of dissatisfaction of operators with work places lighting conditions associated with high enough (400-1000 lux) values overall lighting level with natural illumination, a uniform distribution of fluorescent lamps at artificial illumination, and using a finishing material of white color with high reflection coefficient. The presence of subjective symptoms of visual fatigue on this background testifies to the lack of an enabling environment visual work. What is important is the location of visual control zones in 2 differently highlighted planes and the number of view changes.

Conclusions

Using the device for determination of the near point of clear vision working with electronic devices monitors allowed to take into account the physiological, hygienic, ergonomic requirements, and safety and health requirements, and to identify the appropriate relationship for eye comfort between light and indicators, monitor screen brightness; fencing wall background characteristics, allowing to determine if they meet the parameters of the computer screen indicators illumination on comfort perception of the value of illumination and information on the monitor with the operator screen visual device, the general increase comfort working with the computer, including taking into account background color enclosing walls, consideration sanitary requirements, reduce fatigue and the risk of eye disease and therefore, operator nervous system.

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Modern tendencies in the design of small architectural forms

In the article on the basis of factors that was folded in modern society, and personal touches of change of original appearance of cities, tendencies are outlined in the design of small architectural forms. The positive and negative sides of process of changing of role of small architectural forms and their place in architecture and design of environment were discovered in results.

In connection with appearance of new megalopolises and increase of area of already existent building there is a requirement in quality and expediency in the designed environment of small architectural forms. Today not a single city environment does without them. Exactly their prerogative is remained by providing of important for perception city space that changes constantly, to the transition from a human size to the sizes of building, streets and areas. Presently about small architectural forms it is possible to talk as about the fully independent objects of subject design, that set in the determined location, in a concrete environment.

Modern world tendencies, that consist in general multivectorial economic integration, wide European globalization, swift scientific and technical and technological development, dictate a dynamic lifestyle and walking away from traditional looks to the thing, sometimes even their "reformatting" under the modern standards of vital functions of people. Therefore fully naturally, that urbanization of society, swift development of technologies, reckless rhythm of life of people became appropriate factors in the vector of development of town-planning and architectonically-building spheres as to the world on the whole, so Ukraine in particular. And as a result, exterior appearance changes, and in some cases structure of settlements. It is possible to distinguish the features of this change, namely: increase of town settlements (so-called "coming" of settlements to the limits of megalopolises), complication of infrastructure of cities, appearance of new types of buildings, in particular large city complexes. As a result of such city-planning situation, described processes in architectural industry the role of small architectural forms and their place in architecture and design of environment was changed. Thus, the marked factors in the vector of development of town-planning and architectonically-building spheres create an actual situation that directly already becomes a factor, and more precisely the factors for forming of direction of development in the design of small architectural forms, and they, in turn, set general tendencies.

So, with appearance of multifunction complex establishments, and accordingly high opening buildings, transit apartments, different scenarios' open areas there is a tendency in modern architecture, for example, to the transition of small architectural forms from an exterior environment in interiors (Table 1). Today examples of such building it is possible to lead quite a bit: office and trade centers (for example, supermarkets), dwelling-relaxation (as star hotels) and sporting-entertaining (fitness-centers, spa-salons, trainer halls) complexes, in particular nearby water (for example, resorts, hydro-parks, aqua-parks), other public resting-places, where in finishing and filling of environment widely apply small architectural forms: in the winter gardens of office centers and supermarkets, vestibules of establishments of public food consumption, halls of administrative establishments, waiting of train station rooms, different places and establishments of relaxation, and sometimes the special apartments are taken for this purpose. In such buildings in atriums or other, mainly, transit apartments (as vestibules, halls, lobbies) or vice versa, in comfortable corners, that are winter gardens being widespread phenomenon in modern sky-scrapers, office centers, - such small architectural forms are set, as sculptures, other by volume compositions, fountains, cascades, reservoirs, rows-sofas, lanterns, balustrades, decorative vases, informative boards, pavilions and others like that. Such practice is already a long ago widespread in Western Europe, American continent and South Asia region. In Ukraine it purchased distribution relatively recently - in the last time, however while concentrated only in large settlements: Kyiv, Kharkiv, Lviv, Odesa, Dnipropetrovsk and others.

In addition, next to the transition of small architectural forms from an exterior environment in interiors in their decorating there is a change of sizes and/or function of domestic objects, communications with the aim of extending of their exploitation. So, gigantic "tableware", decorative "stoves" that dismember space, appears in interiors; furnitures from a mobile equipment grow into the stationary tiers of flowered amphitheatre; the pipes of ventilation and heating create plastic compositions being something middle between an abstract sculpture and arbour, so-called by a "interior in an interior". Exactly this is explain large distribution in modern ensembles and interiors of independent spatial compositions from small architectural forms (so-called subject interior) as though unconnected with architectural basis, but such, that form necessary to the man "mini-spaces", isolated rooms, finishing of that has the own face that answers their setting and forms this complex of small architectural forms. All of these form the tendency of transformation of elements of domestic and technical design in small architectural forms, what sometimes create so-called a "interior in an interior". So, today small architectural forms due to unconventional technologies and fantasy of designers come forward as fully independent objects in a environment design.

Today there is already their generous amount in the typology row of small architectural forms. And to invent something a new it is difficult, and sometimes it is impossible. Therefore designers are succeeded to such reception, how to present an object (his form, type) through unusual for him form or method / material of creation. Such examples in the landscape design of city spaces it is possible to lead already quite a bit. It is therefore possible to talk about the tendency of transference of signs from one object, technology or material on other, not peculiar to this new object. In the developed countries this reception is collecting all greater demand and variety of his application.

Will of form-creation, supported by unconventional modern materials and constructions (tubular frameworks, textile, the plastics, inflatable and awning structures), unusual color and the plastic arts, does today small architectural forms by the extraordinarily powerful means of creation of any vivid maintenance in environment objects and systems of different character, driving back on a background in many cases such basic function of small architectural forms in historical ensembles, how to develop in close to the man scales stylish descriptions of "large" architecture, architectural environment [1, p. 112-113]. By the way, in the conditions of fixing of the higher marked tendencies such phenomenon as disparity of space appears by a time in a certain environment. There is a danger of taking root of this phenomenon that is ignoring of existent style and can become negative for the general view of cities, harmonious development of an architectonically-plan structure of the inhabited places and creation of town ensembles. Unique exit is at any terms to hold an already existent stylish line in the outlined cell at introduction of new small architectural forms to certain space (Table 2).

Between that, except introduction in the structure of small architectural forms of different sort of technical devices or introduction of elements of monumental decorative art, it should be noted also their close connection with the landscape (natural) forms of environment [2, 3]. By the way, the existent since olden times close copulas of small architectural forms and landscape architecture sharply grew with appearance of new technical feasibilities of landscape design.

Conclusions

Having regard to that on this period of becoming Ukraine goes out on an international scene, original appearance of the cities especially densely populated has a decision value. One of key elements at forming of the impression from cities there are small architectural forms that accompany habitants and his guests everywhere.

Creation of new small architectural forms for equipping with modern amenities of the Ukrainian cities, especially their introduction to the historical environment, having regard to account the modern necessities of society and feature of today's architecture, is multivectorial artistically-structural activity. She needs individual and complex approaches planning fundamentally of new objects. It is therefore necessary to consider by general tendencies in their design, between that, taking into account all sides of this artistically-structural activity.

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Table 1.

Tendencies in the design of small architectural forms and factors of their forming

Factors of forming straight of development of design of small architectural forms	Tendencies in the design of small architectural forms	Examples of small architectural forms
Appearance of multifunction complex establishments, and accordingly high opening buildings, transit apartments, different scenarios' open areas	Transition of small architectural forms from an exterior environment in interiors	 Atrium of housing complex, the USA
Change of sizes and/or function of domestic objects, communications with the aim of extending of their exploitation	Transformation of elements of domestic and technical design in small architectural forms, what sometimes create so-called a "interior in an interior"	 Interior of Google's office, Zurich
Presentation an object (his form, type) through unusual for him form or method / material of creation	Transference of signs from one object, technology or material on other, not peculiar to this new object	 Beach library, Bulgaria

Table 2.

Quality sides of changing of role of small architectural forms and their place are in architecture and design of environment

Positive sides	Negative sides
Will of form-creation and color	Disparity of space appears by a time in a certain environment
Unconventional modern materials and constructions	An isolation is from "large" architecture
New technical feasibilities of landscape design	Ignoring of stylish line of the outlined space

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Concept interior design in modern scenography

Analyzing the major trends Ukrainian scenography end of XX - XXI century. With examples of specific performances, the author notes the strong influence of other arts involved theater process. Against the background of global cultural processes, Ukrainian design experience had a powerful influence on modern scenography beginning of.

In contemporary visual culture, synthesis of the arts takes on new forms, embodied in the boldest design concepts. In particular, the new Ukrainian scenography, referring to the illustrative naturalistic trend, based on the principles of interior design. Most clearly, this trend was in the design of the performance of small scenes. After all, the chamber stage artist creates an environment that would meet the most dramatic problems and disclose director accented characters characters. Scenographic decision should base on practical impossibility "over-" limited space, thus causing an imbalance and disharmony proportions incompatible solutions [1].

The play "Sirena and Victoria" on the product Galina A. (2013) Kiev Academic Theater of young audience Linden on the small stage, fully sustained in the tradition of modern design kitsch. Director-producer - V. Gyrych, stage designer - K. Kravets. Lately design course design stage event is particularly popular. It differs from traditional associative naturalistic design as focused solely on visual perception, devoid of any philosophical and semantic load. Set design stylized luxury apartment. Stage space has a triangular shape, placed on the walls of a huge canvas with reproductions of the painting "Danae" middle stage - piano, revised on the bar rack, which is a lot of bottles and glasses and dishes of snacks. Lighting greenish-orange, like a bottle of alcohol. The compositional center around which the action is deployed, two, piano and a chair with a table that is somewhat remote. Pipal, immutable attribute wealthy middle-class apartment, antique furniture, carpet on the floor of a magnificent cascade fall rich drapes... Luxury borders on kitsch. All design gives the impression of wealth, which is presented so defiantly that immediately arise the question "who is the owner of the apartment?" "Social environment from which he came?", "How gained this wealth?". During the action appears another feature decoration: the fragments of paintings hidden cabinets with props and hidden corridor, which the actors move in different episodes. From there, there are the characters of the second plan - the next bride, Victoria shove sirens and siren friends and colleagues. Regulated by the emergence of new characters and their moods swings duplicated due to changes in lighting: bright red, yellow and blue flares complement the appearance of each. In addition, every siren image transformed: she changes wigs and clothes, turning it on business businesswoman, then the seductive "grandmother-berry" is a hospitable hostess. The end of the play is based on emphasizing the loneliness of the individual in society - all the characters wander the stage, talking on a cell phone against the backdrop of the sky, they are countless stars and planets travel the universe, clearly following their orbits.

Sometimes their orbits intersect, sometimes-individual stars and galaxies goals collide, exploding or absorbing one another, but often for their existence and are secluded. The feature of this show is the real involvement of elements of the interior - input and internal doors. This not only guided the audience on a visual flow of gaming space, but also on their sense of external and internal space.

Well-known Kyiv artist and stage designer Vakarchuk working on the design of chamber performances involving design correctly interpreting gaming space. Consider setting "Shynday" (2013) author and director Ivan Afanasyev on the stage of the Kyiv Youth Theater. The play combines naturalistic principles and metaphorical design, basic conceptual solution based on the principles of interior design. According to the director plan, all components subject to the principle of imitation of Japanese art. The scenery contains elements of shadow projection design: a large white backdrop was carried over streetlights and landscape lights. Space planning audience interpreted the principle contemplation of two angles, similar to the already mentioned play "Sirena and Victoria". Japanese ornaments become like improvised screens to windows. Planning decorations made in a way that uses real inputs and outputs to a small room scene. Plane steps outlined square of carpet on the floor, within which the actors move. Lighting not only change the visual perception of the performance, but also philosophical subtext - of the sublime, euphoric mood for drug hysteria. Making performance demonstrates the ability to work with Vakarchuk Chamber stage without creating dissonance scale. It uses symbolic detail, gives much attention to design elements of design. Overall, for Vakarchuk typical household illustrative, complemented iconic elements, certain eclecticism environment, make images of characters at the same time close to the action, and abstracted reality beyond time and space. Performances on the historical and contemporary themes are equally close to the modern perception of the audience, the use of new materials and technologies form a complex, indivisible space for action. The artist often refers to the principles of design, including introducing artificial decoration items, consumer goods.

In the context of a combination of decorative elements in a single synthetic track, stage space should consider the next play, namely performance "Edith Piaf. Confession "(2012) Kyiv theater-school" Image" Directed by A. Myhnevych, artist and stage designer - S. Trykolenko. Decided to play solo performances in the format. In the play based on "indifferent handsome" Jean Cocteau (written specifically for Edith Piaf) which was first staged in the theater "Buff-Paryzen" in 1940. Then the role of Edith Piaf performed very same singer. In the interpretation of the director on stage is close interweaving of videos and photos from the life of Edith Piaf and directly acting. Although the show decided to mono version, it seems the audience present at the scene, and other characters. Some personal compositional center decoration enable actor implement dialogues with imaginary interlocutors. This effect is achieved through directing the applied successfully receiving verbal scenery - interaction with the audience and the use of sound on stage. Edith talking on the phone and her dialogue with interlocutors conventional sounds so vividly and emotionally, as if they are spacious auditorium. When the plot should appear Emile, the scene heard a loud noise and ringing key steps. Lively conversation with him without any response, fueling feelings and provoke a real scandal. In addition, this silence is a catalyst for future "flash nerves" and "confession." The basic idea of staging - a time that, on the one hand, driving the singer snare waiting and suffering, and on the other she was his unshakable character. All the objects that surround the singer are certain characters heyday of her work - the mid-twentieth century. In general, the present modest performance typical of rationalism interior pre-war period, even the red carpet - the brightest spot on the stage, evenly covered with a black veil chair, player , projector, small table. This right is associated with the "era Piaf" - the time when the humble appearance of great talent hidden and inflexible will to work. Staging performances was dictated by the need to create a scene interior of the hotel, which would at the same time, gave the impression of Intimacy Street. In developing this project, S. Trykolenko guided primarily emotional state and Edith major problems inherent in the play [2].

The atmosphere of expectation has been achieved with a large number of clocks showing different time. These clocks varying shapes and sizes, have their own importance in the play. The dominant place is disproportionately large, wall clock covered with posters of the Edith Piaf. On its front wall fixed mirror, in which the singer looks and through which talks to his inner world. Custom posters display its achievements - it is not just a woman who is waiting for her lover, she celebrity, which, in fact, this time holding; and it has the right to demand answers. The main subject of the conflict - the newspaper at which hid from Emil frank conversation. Guided by the fact that this newspaper is clearly not the first in their life together, artist decided to pile on the stage packs of newspapers and lay the tablecloth with newspaper print. This well placed print and shade floor lamp when it is lit, newspaper pictures clearly discarded. Edith hate that Emile distract from her, his mistresses, his newspaper and even his dreams. Clock - a subject of constant contemplation and, at the same time, it’s suffering. She cannot throw these items out of your life, because they associate it with Emily. Instead, objects that are of the world, limited player of plates, windows curtained with white curtains, and a bottle of alcohol. White curtains at a back stage function screen, which video series. Screen edged punching above and below as recognizable symbol photography and film. The performance is accompanied by the songs of Edith Piaf records that sound a phonogram and which actor sing along. Her emotions eagerly displayed on Emil and the telephone interlocutors, one-way or another knowledgeable of their problems. It is in telephone conversations revealed the scale of emotional dependence on Emile. She is ready to endure any humiliation just to keep him near himself. This application narrative scenery on the overall naturalistic decision completes the visual perception of psychological action audience.

Conclusions

Considered performances demonstrate the features of the application of the principles of design on the theatrical stage: the artist not only develops the concept of image-conventional elements, and creates interior design, employing relevant to the chosen decision directing style.

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History of design of planes

Development of design of planes from the first flights in the 21st century is investigated. The main features of objects of interior design and a shaping external and an interior of planes throughout history are revealed. Are defined style which are used in an interior of planes.

Statement of a problem. Air transportation is one of the fastest methods to travel from nowadays existing. In conditions when the prices and availability of tickets from various air carriers is identical, the passenger chooses those airlines offering flights with comfort. Since the beginning the design of internal space of the plane has been urged to simplify and reduce the price of the cost of flights as the plane became more and more to resemble a public transport. However in present conditions when cost on transportation grows, one of factors that forces people to use and further air flights is not only the speed, but also huge comfort in flight, features of design of planes. Analysis of the last researches. V. Kuzmin has analysed 12 works on history of design of planes [8]. In Khayrullin M. A. monograph. and Kondratyeva V. I. development of aircraft construction during the XVIII-XX Art. has been considered and the main lines of design of salon [6] are marked out. General ideas of change of design of concepts of planes throughout history are provided in S. Babkin's work [7]. Modern airlines pay a lot of attention to design of own planes. In conditions when they offer almost identical services in comparison with the competitors, the only way to be allocated and attract passengers is the design of the plane, first of all registrations by furniture of salon. More volume analysis of design of planes and their salons are submitted in Keith Lavgrouva's work [2]. But in general the question of history of design of planes demands further studying.

The formulation is more whole than article. To investigate history of design of planes and to characterize their features from the first flights to the present.

Main part. Investigating history of design of planes considerably that the aerodynamic style (AS) is compound aerodynamics in aircraft construction [1]. The EXPERT not only carries out the working function, but also provides esthetic expressiveness of design of air transport. His emergence is result of achievements in a historical design of aircraft.

The first aircraft on a structure were similar to structures of a body of a bird, had the corresponding name - ornithopters (fig. 1). As envisioned, in air the device has to rise for the account "wave" of artificial big wings [4]. But in practice the ornithopter couldn't come off a surface at least.

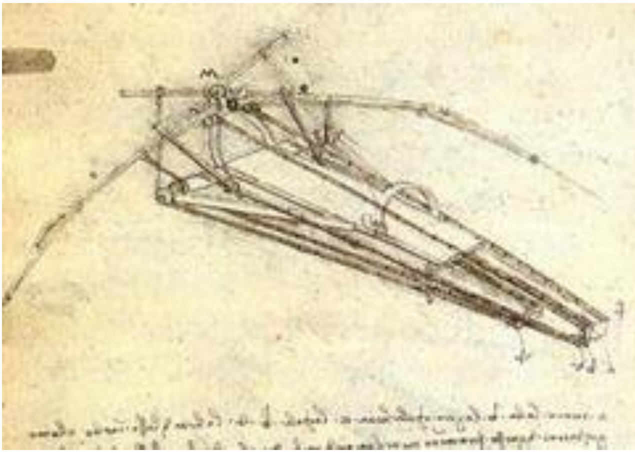

Fig. 1. Ornithopter of a design of Leonardo da Vinci of 1490.

Since 1783 several aeronauts carried out uncontrollable flights in balloons (fig. 2). It is difficult to call this transport practical as it depended on the direction of wind. However these attempts have poured out in separate branch of aeronautics - airships, the form of the case like cylinder of which gives the chance to maintain loadings (fig. 3). The peak of airship building falls on the 30th years of XX in. But the balloon in the perfective aspect and is used today for movement in air.

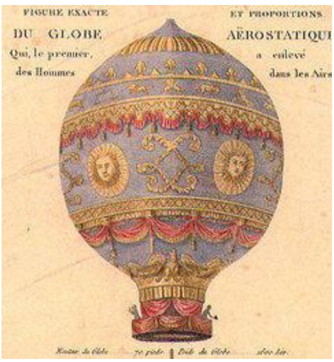

Fig. 2. Balloon of brothers Mongolfye, 1783

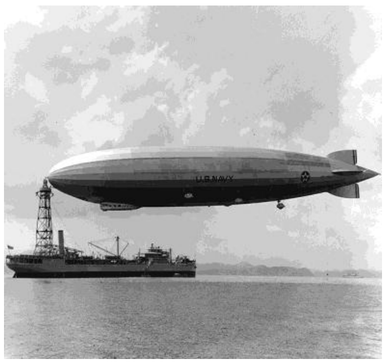

Fig. 3. Airship of the Navies USA «Los Angeles", 1931

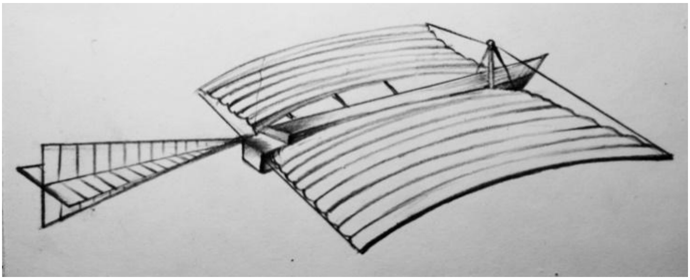

Fig. 4. Model of a glider of George of Cayley, 1799

Creation of model of a glider with the fixed wing (fig. 4) by the English baron G. Cayley became a significant event. He has created the first concept of the plane on the basis of which aircraft industry developed for years. The main difference of a design - wings and a mobile tail for management are recorded.

In 1799 Cayley determines forces of rise and draft and represents the first scientific design for the air vehicle. Relying on its innovative work in aeronautics, scientists and engineers have begun to develop and test planes.

1903 Wilbur and Orvill Wright have made the flight first in the history on a motor glider "Flyer-1" (fig. 5, [3]). After this success brothers Wright have understood that it is time for development and creation of airplanes in goods quality for the market, as for personal, and group transportations.

Fig. 5. "Flyer-1" and the first is weeded by Wright

The first planes were modelled in various variations. It were biplanes as with tail plumage behind, and ahead [4]. More rare monoplanes. All design keeps on extensions, struts. As elements of a wheel served cables. Material of which made the first planes, - light wood and fabric. All this has been urged to lose the weight of the plane. The continuous fuselage was rather heavy and besides created the additional resistance to an air flow. General impression from a shaping remains for the next decades: accent on a framework between the planes of wings.

However in 1913 the plane has been constructed I had a continuous wooden fuselage which comprised a cabin in the streamline case - "Ilya Muromets"

I.I. Sikorsky (fig. 6). This plane had four engines and could serve weighing more than 3 ton for transportation of passengers, freights and so forth. Considerable load-carrying capacity of the plane I have allowed to increase comfort of flight: by this plane there was a balcony, in salon the sofa, a mirror, a table have been placed [7].

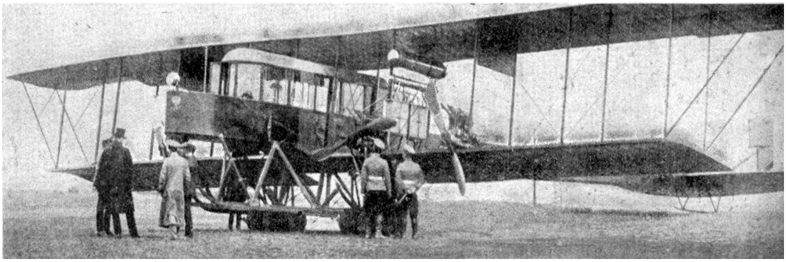

Fig. 6. "Ilya Muromets" of I.I. Sikorsky, 1913

1910 were characterized by low interest to air flights. They became much more popular already in the twenties, first of all because of growth of safety of flight.

Shortly after there were first civil air flights, again airlines have begun to put the planes, having added names, logos on an aircraft fuselage [2]. Nevertheless, the plane remained generally silver color.

Travel by plane cost the considerable sums and were quite boring. Therefore air carriers tried to compensate it by considerable comfort. The inside of the plane was close. Seats settled down on one from each party of pass, however were very convenient and are quite often made of leather. Windows closed usual curtains. The baggage was in regiments over the heads (fig. 7).

Fig. 7. Typical insides of planes of the 20th years of the XX century

Monoplanes have begun to develop in the 1930th actively. Refusal of a tree and transition to aluminum and alloys was important change. It was qualitatively reflected in aerodynamics, and also expanded borders of use of airplanes. Due to growth of durability of a design the salon began to be expanded. It has in turn allowed to give to furniture.

The question of comfort remained unresolved: in salon it was noisy, stuffy. Long flights happened to several landings. From innovations in salons there were little tables, rooms for a dream which were similar to a compartment of the car of the train. Such liners could transport up to 20 passengers (fig. 8).

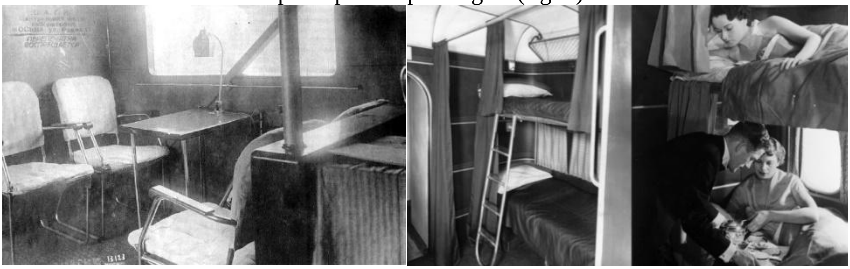

Fig. 8. Inside of passenger planes of 1930-1940

With increase in a fuselage, and with it and salon, there was a need for service personnel - stewards and stewardesses. After World War II the fuselage began to be painted more and more in white color. Only a few carriers remained with silver fuselages till today [3].

At the beginning of an era of jet aircrafts color schemes were simple, expressed in smooth lines. In the 1960th years the tendency to further simplification remained: white upper part, end-to-end sideline and "natural" silver bottom of a fuselage.

The USA designates 1950-1960 "gold years" of passenger aircraft. The cost of tickets still was quite high, but the interior and finishing of internal space of the plane already reminded modern. With noticeable to changes it is a form of windows (it became roundish). Almost all chairs stood in one direction now. Seats could decay, it was possible to receive a pillow and a blanket (fig. 9).

Fig. 9. Comfort of 1950-1960

The 1970th years became peak of comfortableness of planes. The first big planes of the Boeing company had so-called "economy class". Seats were already placed in three ranks on 3-4 sitting, but were not such narrow. Regiments for hand luggage were salon on each side, but is rather high that it was possible to raise quietly a hand (fig. 10) up.

Fig. 10. "Economy class" of 1970.

Bright colors using at registration are a characteristic sign of insides of planes of "70th". The salon was spacious that allowed to move quietly it. On some planes there were musical instruments (fig. 11).

Fig. 11. Interior of a business class of "70th"

The beginning of the 1980th was marked by reduction of prices of air tickets worldwide. Aircraft manufacturers together with designers tried to accomodate as much as possible passengers aboard. From the most noticeable changes there was the fact that there was less place for legs: ranks condensed and consequently there were side places which had no windows (fig. 12).

Fig. 12. Placement of passenger seats on the modern plane

The relation to safety of flights plays today a huge role in design of the plane from the middle too: it is forbidden to smoke, it is recommended not to leave the places.

Speed and comfort - the main requirements of passengers of homebuilt aircrafts (fig. 13). The qualified personnel provides favourite dishes and drinks, movies, books, magazines and music. Modern homebuilt aircrafts guarantee freedom against external circumstances. External have flowing round a form which provides esthetic expressiveness of modern design of air transport (fig. 14). Onboard there is also a kitchen, a bedroom and a shower cabin, is completed with convection furnaces, the coffee maker and the dishwasher. On average the plane can accept at the same time 19 passengers.

Fig. 13. Interior of the private plane

Fig. 14. Appearance of the private plane

In the 21st century process of globalization causes fixed movement of people on the world. And in such conditions if the carrier for the purpose of economy of internal space of the plane cannot provide that maximum level of convenience, work is entered by ergonomics. She can create individual comfort in identical conditions for each passenger. Other important point - accounting of composite properties of a shaping and coloring of objects in interior design of salon. An example is registration of an interior of the plane by Norman Foster conceived of details to the button on a chair.

Conclusions

In the course of research the following features of design of planes have been revealed: integrity, unity, ease, esthetics and compliance to the time. More often in an interior of the plane constructivism and minimalism is now used. From the 2nd half of the 20th. The plane is characterized by smoothness of lines, a roundness of corners, concavity of forms.

Prospect of further researches - research of features of design and ergonomics of internal components of inside of the plane, search and establishment balance a ratio between the price and comfortableness of flights.

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UDC 725.381

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Interior features of design areas: **reception, storage and maintenance of cars in the multi-storey parking garages**

This paper should be referenced for additional guidance for interior design of the multi-storey parking garages. The disclosed methods of forming the multi-storey parking garages interiors that provide safety in use, clear visibility, parking-space marking to enable drivers to remember the location of their vehicles, integration into the context of town planning, clear views to the outside, good natural lighting, ventilation in them.

Architects and building design professionals can usually address the multi-storey parking garages planning aspects of projects that must accommodate small or moderate numbers of cars. However, architects and their clients may seek special parking garage planning expertise and design assistance for projects that involve large quantities of parking garage or that have complexities regarding such issues as vehicular access and egress, security concerns, among others [1].

The objectives of the functional design of a parking garage are to create a facility with a simple continuous traffic flow, parking spaces that are easy to park in, and an atmosphere that gives the user the feeling of safety and comfort.

Functional interior design of the multi-storey parking garages include:

- circulation systems (for pedestrians, vehicles);
- clear visibility;
- parking-space marking to enable drivers to remember the location of their cars;
- integration into the context of town planning;
- clear views to the outside;
- good lighting and ventilation;
- graphics and signage [2].

The multi-storey parking garages design interior should provide:

- painted interior walls and ceilings a light color to improve illumination;
- a minimum floor to ceiling height of 2000 mm exclusive of structural elements and appurtenances [2, 14 p.] ;
- all mechanical equipment must be painted to match the interior of the structure;
- elevators shall be located where the door and open cab are visible to the public using the facility. The shaft and elevator cab should have glass facing the public view. Any glass tinting should be minimal to ensure daytime and nighttime visibility;
- where possible, elevators and stairs should be located on the perimeter of the structure to provide natural surveillance from exterior public areas;
- stairways must be integrated into the design and footprint of the parking garage and shall be more than just open air railings attached to the exterior of the structure;

- for maximum visibility, stairways must be open to the interior and at least partially open at the exterior of the structure;
- stairways should exit out to the street;
- activities such as shops, offices, or other commercial space should be incorporated along the ground level of the parking structure, where appropriate [3].

The architectural design of entrances in reception, the storage and the maintenance of cars areas impacts a successful parking operation. The entrances should be designed to be obvious and to look different from exits. Special architectural features such as arches, canopies, marquees, and other elements attract attention to the entrance and are encouraged.

Generally, entrances are placed on the high-volume streets providing direct access from the parker's origin to the parking garage destination. Parking garage facilities generally will have more than one entrance. This provides convenient entering for parkers from various adjacent streets and offers an additional entrance in case operating equipment malfunctions. Entrances should also be located away from street intersections.

Exits in reception, the storage and the maintenance of cars areas should be placed on low-volume streets, if possible, to reduce exiting delays caused by street congestion. It is preferable to have all exiting cashier booths grouped together so the parking structure can operate with one cashier during low-volume periods, minimizing operating costs [4].

An important role in the interiors of multi-storey parking garages playing graphics and direction signage. Graphics and signage play a significant role in how both vehicles and pedestrians circulate through a parking garage structure. Entrances and exits should be well designated, not only architecturally but also withsignage such as «Enter», «Entry», or «Entrance».

Large graphics in the stair and elevator lobbies denoting the floor and an indication for the parker to remember his floor level should be provided. Memory joggers to help the parkers remember their parking location are often used. Themes such as colors, athletic teams, or animals designating each floor.

Direction signages. The direction signage can be developed using reflective material, neon, backlit, or Light Emitting Diode (L.E.D.). The signage must be «user friendly» and make the entrances and exits to the facility as identifiable as possible [5, 121 – 124 pp.].

In turn, vehicular signage should direct the driver into the facility to a parking space and provide adequate signage to direct the user to the exit. This signage should be centered on the path of travel and placed as low as possible for visibility, but not lower than the maximum allowable vehicle height.

Secondary or pedestrian signage should direct the users from their parking space to the appropriate stair and elevator. This signage should be over the drive-aisle end of the parking space and placed in the direction of the pedestrian flow. In addition to stair or elevator directional signs, pedestrian signs should be provided to direct the parker to emergency assistance call boxes, sound monitors, etc., as well as to specific destinations.

Signage including braille markings must be mounted in appropriate locations. Signage should be provided at each parking module to further assist the user in larger multi-module garages. Some parking facility operators number each space to aid in vehicle control [5].

Signs should be mounted securely to the supporting structure. Lighting should be coordinated with signage so special sign lighting is not generally required. However, lighting should be located so the light's brightness doesn't create glare and interfere with reading a sign.

Both vehicular and pedestrian signage should minimize or eliminate conflicts between vehicles and pedestrians and reinforce the individual's natural directional inclination.

Typical signage in the multi-storey parking garages can be developed using reflective materials enhanced by adjacent light fixtures. Illuminated signage such as L.E.D. or neon signs can be developed at critical decision points in the structure and must be analyzed on each project for their cost/benefit, including the additional maintenance cost involved. Variable message signs or space available count signs may be helpful in large parking garages.

Direction signage is an integral part of a multistory parking garage environment. Signs are used to communicate directions, warnings, and other information to drivers and pedestrians, and their graphics can add architectural life to a parking facility. Other types of graphic features can also be used to create a more pleasant atmosphere for users.

In turn:

- signs and graphics for multistorey parking garage structures should be consistent, harmonious and visually related through the incorporation of common design elements;
- exterior signs shall be consistent and match to main building's signage;
- directional arrows and signage indicating exits, elevators, and emergency buzzers/telephones should be visibly displayed on walls;
- directional signage should be provide at the egress to parking structures indicating directions to primary transportation routes;
- directional signage in stairwells should be provided to orient the pedestrian to adjacent activities and facilities.

Direction signage and wayfinding:

- color-coding, numbering, visual cues, music, and even machines for marking your ticket with your exact location to locate your car for easy retrieval;
- locate signs in areas where driver can read in a timely fashion;
- clear, simple, and direct messages;
- floor zoning can be useful;
- direction signage should locate all major internal pedestrian access points as well as external major roads and buildings.

To accommodate these needs of today's mobile society, planners, designers, and architects will be called upon to provide convenient and safe multi-superficial parking garage. Whether individual passenger vehicles of tomorrow will be powered by petroleum or other fuels, the need for parking planning will be with us for the foreseeable future.

When considering the benefits of the multi-storey parking garages, it is apparent that this form of technological advancement is fundamental from a sustainability standpoint in creating parking accessible to people, our living places and the environment in the search for best architectural solutions for the location, site and program and in developing long term sustainable choices for our environment [6].

The need to create a multi-storey parking garage that precisely fits the needs of the users cannot be stressed enough. Unless the facility is user-friendly, projecting a safe, secure, and easy to use environment, parkers will find other options. These needs have become too vital to their peace of mind to be left unmet by the owner and designer.

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Transportation security administration bases

The problems of transportation security in Ukraine are given little attention to nowadays. In particular, the main normative documents in this field are still not still adopted: strategy and the concept of transportation security, transportation security legislation. And the measures taken to provide transportation security are of low efficiency.

However the provision of the proper level of transportation security is one of the main tasks of the modern state. Nowadays this is confirmed by the attention paid to the security matters in the developed countries, including transportation, and is the subject to the significant importance of transportation development for any modern country. Notwithstanding the necessity of integration into European and world community, Ukraine is doomed to pay much attention to transportation security.

As being correctly specified in the literal sources the selection of the correct sphere to specify the security type significantly depends on the practical tasks to be solved herewith and is quiet conditional.

The condition of the transportation security in Ukraine is insufficient in comparison to the other developed countries worldwide. Primarily it is subject to the automobile and railway transportation being the main source of the threats in the transportation security sphere. Taking into account the requirements of the European Union regarding the Association Agreement in the field of security it is necessary to prioritize the innovations in the field [2]. Thus nowadays namely the provision of all types of security is the propriety task among all its other types worldwide. Accordingly it is the level of the transportation security to be the one of the main indexes of the transportation security level in the country.

The doctrine of the transportation security lays in the formation of the unified normative, technical, methodological and system approaches to the provision of the security while using all transportation types.

The development and implementation of this doctrine is possible while constantly improving the normative base, forming the technical requirements to the transportation vehicles. Herewith the doctrine of transportation security covers the ecological, air, space, economic and administrative legal categories.

Among the main *reasons* of the low level of the transportation security in Ukraine are:

• No unified policy to provide the transportation security in the country;

• Imperfection of the national legislation in the field of the transportation security and no main normative documents to regulate the public relations in the field: law, concept, strategy and program;

• Inconformity and non-systemic character of measures and efforts of the state authorities to uplevel the transportation security;

• Low level of legal consciousness and discipline of the employees and users of the transportation sphere;

• Insufficient technical state of the transportation vehicles, communications and objects, the huge number of the old transportation vehicles and constructions used in Ukraine;

• Divergent growth of the cars in the country against the lag of road infrastructure;

• Insufficient financing of measures directed on uplevel of the transportation security;

• Low level of the efficiency of the persons influencing the transportation security, including the official of this field, the drivers of the cars and the other employees of the transportation sphere etc.

The necessary background for the reliable and effective operating of the mechanism to secure the transportation security and to implement the corresponding measures is the acknowledgement by the state authorities and society of the importance of the transportation security for both national and public security of Ukraine and for the interests of the society and each citizen.

Notwithstanding the great number of deaths due to the car accidents and huge economic losses unfortunately nowadays neither state authority nor the society acknowledge that.

This is confirmed also by the fact that there are almost none normative documents to solve the problem of the transportation security. There is no law on transportation security, no corresponding concept and strategy of the transportation security. The normative documents to regulate some issues of the transportation security are imperfect and very often contain the conflicting provisions. And the comprehensive work is not made in this direction.

The formation of the unified complex of the normative documents in the field of the transportation security in Ukraine is the main task for today. These normative documents must be clearly structured. This requires the development of the main conceptual provisions being the basis for the further system construction. The urgency of this problem is specified by the significant everyday losses of our country due to the low transportation security. This relates to the highway transportation.

Except the normative documents such as law, concept, strategy and program it is necessary to develop the sectoral laws to secure specific transportation types. The highway transportation requires such a program in particular. The program to develop public transport and aviation security is very importance.

The necessity for the national legislation to follow the requirements of the international standards is specified by the importance of active development of the international transit in Ukraine. The deficient legal and regulatory framework and low level of the transportation security in Ukraine can be the main barriers to obtain significant incomes from the international transit as the safety sector is the key determinant for the European partners.

First of all Ukraine requires the Law “On transportation security” to be adopted in order to unify the norms which regulate the matter of transportation security for different modes of transport and to make the Ukrainian legislation in the field of transportation security to follow the international obligations of Ukraine.

Nowadays no scientific studies are made in the field of the transportation security and there are almost no publications in mass media. The financial support in the field of transportation security being the key problem of the development of the effective system of the transportation security and is the single reliable factor of the real state's concern is at the extremely low level.

The recent strengthening of administrative responsibility for the traffic violation is absolutely positive measure. But in spite of the fact that it is almost the only serious step to uplevel the transportation security in Ukraine, it may happen that the main motives to increase the fines were mostly economic and the decrease number of the car accidents has only temporary effect.

Thus it is very important to search the alternative financial sources first of all among the business structures, foreign partners and using the public organizations. The promotion of participation of non-government companies in provision of transportation security of Ukraine can be implemented by decreasing the tax load, providing the additional benefits etc. This activity also requires the attraction of the foreign business structures namely the transportation having the economic relations with Ukraine.

The transportation security procedures including the specific measure rely on the sanction of public opinion in general. Therefore it is necessary to discuss and clarify the significant problems of the transportation security attracting the scientists, officials and society. To highlight them it is necessary to attract the mass media including the Internet resources.

The society in Ukraine almost does not participate in transportation security and expresses no concern on this issue. Thus the experience of the developed countries confirms that the society itself must play significant role in solving this matters.

The unified state policy in the field of transportation security is necessary to be implemented in the economic, political and organizational measures. The specified measures must correspond to the threats in the transportation sector.

The current mechanisms of the transportation security in Ukraine (organizational, political, regulatory and economic) do not completely correspond to the current and potential threats in the field. The state surveillance and control over the statutory compliance, coordination of the activities of the central and local executive authorities in the field of the transportation security are deficient. This deals greatly with the actions for road safety.

The background for the effective system of transportation security to be created is the fundamental scientific studies of its different aspects: political, administrative (organizational), economic, legal, technical etc. In particular, it is necessary to analyze the status of the transportation security in Ukraine, the efficiency of the corresponding measures, the foreign management experience in the field of the transportation security etc.

The following main task of transportation security are specified: legal and regulatory framework in the field of the transportation security; specification of threats to the national security in the transportation sector; development and implementation of the measures to provide transportation security; estimation of vulnerability of the traffic infrastructure objects and transportation means and their classification; establishment of the stable financial support of the transportation security; construction of the system of the objects responsible for the transportation security of Ukraine; networking between them, training of the specialists in the field and their advanced training; control and surveillance in the field of transportation security; informational, material and technical and scientific support of the transportation security [2; 4].

The aim of the transportation security is permanent and safe operating of national transportation complex, safety and defense of the interests and values of a person, society, state and group of the states in the transportation sector.

Conclusions.

The main *directions* of the upleveling the transportation security in Ukraine are:

• development and normative consolidation of the cornerstone of state policy in the sector of transportation security;

• fundamental of scientific researches in the field;

• development and improvement of the national legislation on the field of transportation security including the law, concept, strategy and program of transportation security;

• improvement of transportation security subjects, networking between them, upleveling of operational discipline, improvement of training and advanced training of the persons influencing the transportation security (officials, drivers etc.);

• removal of bureaucracy, simplification of operating and liquidation of the excessive regulation of the transportation security;

• provision of legal and social defense of the persons whose duties include the provision of transportation security;

• provision of the traffic counter-terrorist security;

• improvement of the forms and methods to provide transportation security, employment in the field;

• efficiency improvement of preventive maintenance directed on prevention of injuries and stiffening of legal consciousness in the transport sector including the object-oriented, effective promotion of safe behavior in the traffic among the society;

• renovation of the vehicle fleet and major repair of the vehicles in a critical condition and improvement of their performance criteria;

• improvement of control and surveillance over the operation of transportation security system;

• improvement of financial support of transportation security, search of non-budgetary sources of funds;

• improvement of the transport infrastructure and traffic flow management system, the highway in particular;

• development of the possibilities of the intelligence and counterespionage for timely discover and neutralization of the external threats in the field of the transportation security and analysis of their sources etc.

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The legal regime of the national airspace during military activities

The article considers the issues of the national airspace legal regime and measures taken to provide national and social safety during military activities, which are potentially dangerous for civil air operations.

The issues of the national airspace legal regime and the use of the airspace for a variety of purposes are moved today to the forefront of the global politics, economics and international law due to the variety of traditional and present-day reasons and challenges including instability of military and political situation in the world.

National airspace thus is increasingly used not only for purposes of civil air transportation of passengers, luggage, cargos and mail, aerial works, but also for accomplishment of military tasks.

The aggravation of the international situation in different parts of the world especially draws attention to the problematics of the present article as in the present-day conditions of the high intensity of air-flights the simultaneous use of the airspace for both civil and military purposes decreases the level of aircraft safety. Therefore, every state shall undertake the task of organizing its sovereign airspace to secure interests of both civil and military air operators. While planning and carrying out military activities, which are potentially dangerous for civil aviation flights, the aspects of the national airspace legal regime are gaining increasing importance [1].

In the doctrine of the international law the two types of airspace are differentiated by the legal status: sovereign airspace being a part of the territory of the state, and international airspace (over the high seas and Antarctica) [2]. Military activities affect primarily the airspace over the land and waters of the state territory, which is under its sovereignty. In this regard, the issues of the legal status of the international airspace is not discussed in this article.

In the face of aggravation of the international situation in various parts of the world, restrictive measures, such as cancellation of military aircraft flights (establishment of **no-fly zones**), as well as introduction of **curfew**, become an influential tool for peacemaking between the warring parties.

Introduction of the **"no-fly zone"** regime is one of the measures that may be imposed by the UN Security Council (hereinafter – the UN SC) only in order to maintain or restore international peace and security (art. 41–42 of the UN Charter). Existence of a hazard, which level is determined by the UN SC of the UNO, may be the reason for introduction of the no-fly zone.

Thus in 1991 by resolution 670 (1990) dated 25 September 1990 the **no-fly zone** was established in the airspace of Iraq. By that resolution the UN SC obliged all states to permit no aircraft to take off from their territory if the aircraft is carrying any cargo to or from Iraq or Kuwait, except for food for humanitarian purposes (clause 4).

Another no-fly zone over Iraq was introduced in August 1992 for protection of the Iraqi population. The allies referred to the Resolution 688 (1991) of the UN SC of 5 April 1991, as the legal basis for their decision, although the wording of the resolution did not authorize the establishment of such zones.

Also, the no-fly zones were necessary to the UNO to maintain economic sanctions regime, established by the UN SC towards Iraq on 6 August 1990 in accordance with resolution 661 (1990). The embargo was enforced by military means on the ground, in the air and with the naval blockade. The blockade lasted until the end of the war of 2003, along with the restrictions introduced on the flights at the north and south of the country, there was imposed a naval ban on the vessel movement. On 22 May 2003 the UN SC adopted resolution 1483 (2003), which lifted off the 12-year embargo in relation to Iraq (clause 10).

Resolution 748 (1992) of 31 March 1992 imposed air embargo on Libya (para. 4). It has been later enhanced by introduction of the **no-fly zone** in the airspace of Libya (resolution 1973 (2011) of 17 March 2011). The UN SC resolved to impose a ban on all flights in the airspace of the Libyan Arab Jamahiriya in order to protect civilians from the armed forces (para. 6). In accordance with para. 7 of resolution 1973 (2011), the ban did not extend on flights performed exclusively for humanitarian purposes, such as delivery or assisting in delivery of aids, including medical supplies, food, humanitarian workers and related assistance, or evacuation of foreign citizens from the Libyan Arab Jamahiriya.

Also, paras. 17 and 18 of resolution 1973 (2011) of 17 March 2011 introduced **the ban on flights** of aircraft registered in the Libyan Arab Jamahiriya. The UN SC resolved that all states should withhold permission to any aircraft registered in the Libyan Arab Jamahiriya or owned or operated by Libyan nationals or companies to take off from their territory, to land or overfly their territory, except for the cases when the flight had been sanctioned earlier or in case of emergency landing.

It shall be mentioned that **bans on flights** have been a rather traditional means of sanctions used by the UN SC. In particular resolution 781 (1992) of 9 October 1992 imposed the ban on military flights in the airspace of Bosnia and Herzegovina (para. 1). Herewith the UNO Forces flights on protection and flights to support operations of the UNO, including humanitarian ones, were excluded from its scope (para. 2). Resolution 816 (1993) of 31 March 1993 expanded the ban on flights, extending it to all aircraft and helicopters in the airspace of the Republic of Bosnia and Herzegovina in order to protect the civilian population and the peacekeeping troops brought, as well as civil aircraft (para. 1).

Introduction of the "no-fly zone" regime is one of the measures that the UN SC can take to maintain or restore international peace and security, but there is no clear definition of this concept. The precedents show that the no-fly zones were more often introduced to prohibit flights the military aircrafts, carrying out air strikes on the enemy forces (Iraq, Syria, Bosnia and Herzegovina, Libya). Establishing a no-fly zone purposes the forced separation of the warring parties and enables peacekeeping forces, journalists and humanitarian workers to carry out their activities.

Establishing a no-fly zone in the airspace is a preventive measure to stop an attack from the air, but is not a priority means of protecting civilian aircraft from military activities potentially hazardous to civil aviation operation. In addition, the establishment of a no-fly zone by the UN SC restricts sovereign rights of a state for the airspace above its territory. Any state has full and exclusive sovereignty over the airspace over its territory. This provision set forth in the Air Code of many states (the Russian Federation, the Republic of Belarus, the Republic of Tajikistan and others) and is confirmed in the art.1 of the Convention on International Civil Aviation [3].

Today there are prerequisites for establishing no-fly zones as well. No-fly zones could be established over the territory of Syria, as well as over the territory of Luhansk region of Ukraine. As a reminder: **a no-fly zone** provides that no military-oriented flying vehicle shall go aloft, but it does not provide for the full flight restrictions to civil aircraft, if it is not envisaged by resolution of the SC of the UNO.

Along with that in the international air law there is the process of organizing protection of civil airspace users. This process provides for introduction of **a ban or restrictions on the use of the airspace** in the conflict zone or in the zone of a peacekeeping operation with the use of weapons through introduction by the government of a **forbidden, dangerous or restricted flights areas**. The ban on the airspace use shall be administered by the state – provider of the air navigation services. The responsibility for these areas shall be vested solely on the state over whose territory they are located.

Acknowledging the importance of the flights safety provision in dangerous areas and in order to assist states to ensure safe and well-ordered flow of international air traffic in case of planning and carrying out military operations, which makes a potential danger to civil aircraft, the International Civil Aviation Organization (hereinafter – ICAO) developed the Manual Concerning Safety Measures Relating to Military Activities Potentially Hazardous to Civil Aircraft Operations (hereinafter – the Manual) [4].

The Manual is designed to assist states in determining the action to be taken in situations that create a potential danger to civil aircraft and is made as guidance material, which is advisory in nature.

According to the Manual, prior to development of activities which are potentially hazardous to civil aircraft, the government needs to implement a series of preventive measures to protect civilian aircraft from such a hazard. The Manual clearly regulates the procedure of flights restriction for civil aircraft.

It should be noted that introduction of a ban on the use of airspace – is a statutory basis of national security provision of every state. In international relations due to the principle of sovereignty any state shall determine the regime and procedure of the national airspace use irrespective of the other states in order to carry out domestic and international air navigation. The sovereignty shall appear in the form of supremacy which enables the state to exercise full and exclusive authority over the airspace above its territory.

In a view of the abovementioned it is possible to come to the following conclusions.

The airspace over the territory of the state affected by the armed conflict represents particular danger to international air navigation. Practical implementation of flights in such an airspace is inconceivable without establishing an exact legal order in respect of terms and conditions of their performance over the state territory.

In case of outbreak of hostilities potentially dangerous to civil aircraft flights, there are two mechanisms of civil aviation protection in the world practice:

– **establishment by the state**, affected by an armed conflict, of a ban or restrictions on the airspace use in the conflict zone or in the zone of a peacekeeping operation with the use of weapons, through introduction of prohibited and dangerous areas or restricted flights areas;

– **compulsory establishment** by the SC of the UNO of a no-fly zone or introduction of a ban on flights in the airspace of the state which is carrying out military activities potentially hazardous for civil aircraft flights.

There is still a need to resolve a number of issues in the international air law, in particular, the issue of statutory recognition to be given to the concept of "no-fly zone" remains pending.

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Administrative - legal means of ensuring safe civilian aircraft

The theoretical content of the question of administrative remedies used in civilian aviation activities to prevent, suppress violations and bringing perpetrators to administrative responsibility.

The purpose of the system of civilian aircraft Ukraine is determined by the need to ensure observance of the rights and freedoms of workers in the exercise of aviation by law and safety. The peculiarity of this activity in civil aviation due to the dominant mission of civilian aircraft - care of safety. An important role in gaining qualitative properties personnel necessary for the tasks and responsibilities plays professional use administrative remedies. Given the appropriate closer look content above concepts, namely: - first, referring to the administrative - legal means, in - the second, which is a staff of civil aviation and on - Third, it is necessary to understand by definition safe activity.

In the scientific achievements of the famous administrative scientist V.Kolpakov meet the definitions administrative law - a branch of law, which means (norms, attitudes, laws, methods, forms of status, ways to implement the rules, regulations and individual acts) are formed, guarded and protected public relationship, and provides matches the functioning of public administration (public administration) [1, s.171].

Extrapolating this definition in our study can determine that the administrative - legal means to ensure the safety of civil aviation personnel include: standards; matters arising in the implementation of civil aviation personnel of their functions; determine the status of each of the elements of the system of civil aviation personnel; methods and forms used for regulation of their activities; legislation, regulation means implementing regulations; regulatory and individual acts regulating activity staff safe civil aviation.

Staff civil aviation can be defined as the set of employees who make up the organization of the system [2], which acts as an integrated feature of the unity of purpose in their work, which is to ensure the safety of civil aviation. The staff consists of civil aviation: a) aviation personnel (Art. 49 PC Ukraine) [3]; b) other personnel involved in the civil aviation. These include: 1) employees of the State Aviation Service of Ukraine (The State); 2) employees of airlines (operators); 3) employees of airports; 4) employees of airports; 5) employees of companies with maintenance and repair; 6) state inspectors on aviation oversight; 7) employees of educational institutions; 8) employees of producers of aviation technology in Ukraine; 9) employees of the National Bureau of investigation of aviation accidents and incidents of civil aircraft; 10) employees of Ukrainian state production engineering and Research Institute of Civil Aviation "Ukraeroproekt"; 11) employees of the State Enterprise Air Traffic Service of Ukraine (Ukaeroruh); 12) Public Council at the State [3].

In view of the foregoing is a multifunctional organization, each of the functions of occupational groups of employees in civil aviation shows their orientation (directly or indirectly) to ensure the safety and the implementation of aviation. In aviation activities mean activities of individuals and entities that directly aims to achieve the objectives of civil aviation to all types of organizations and flight support, regulation and air traffic services, development, production, modernization, technical support operation and maintenance of aircraft, regulatory implementation regulation, management and monitoring of and ensuring aviation safety and aviation security as a whole [5].

Common features of include: the availability of resources (human, material, technological, financial, information); Depending on the environment (economic conditions, legislation, competition, etc.); availability of labor division (horizontal and vertical); the presence of certain structural construction and the need for management; certain types of activities in accordance with the outlined objectives. The external environment consists of laws, suppliers, customers, competitors, the system of economic relations in the country, international events, scientific and technological progress.

Internal organizational structure represented by the presence of bonds, which are divided into three main categories: organizational and substantive occurring among workers about their use of various means; organizational and functional, that is, the relationship between workers according to their participation in joint professional work; organizational - administrative, resulting subordination of workers that ties management and employees.

All employees of civil aviation are now in the employment relationship, regulated by the Labor Code (Labor Code), or the Law of Ukraine "On civil service", or the provisions of moonlighting, activities based on the term and indefinite employment contract (contract) that causes major jobs or functional responsibilities, working conditions and wages.

Staff as the human factor is of particular importance in the field of civil aviation. This is due to the fact that civil aviation is the mode of transport increased danger because professional skills, responsibility, self-control, self-discipline, mutual assistance, other individual, social and psychological qualities affect both the safety and the production and economic performance of the entire field of civil aviation. The high part of the human (personal) factor in ensuring aviation safety statistics analysis indicates aviation accidents. According to recent decades in the global civil aviation more than 70% of all aviation accidents is due to the human factor.

Analysis of safety and potential factors of accidents with civil aircraft prepared by the Sector Analysis and prevention of aviation accidents National Bureau of investigation of aviation accidents and incidents of civil aircraft (NBRTSA) for 2015 in the operation of civil aircraft (PS) Ukraine to implement passenger and freight, in carrying out aerial work, training flights and during the operation of the aircraft occurred 3 disaster; 3 accident, five serious incidents; 31 incident.

In 2015, the main factors that led to the emergence of aviation accidents and incidents are: technical factor - 24% (it also includes production and design flaws), environmental factors - 24% (including ornithology). 20% is the human factor (16% - crew, 2% - maintenance staff, 2% - Staff airports) organizational factor occupies 5%. Also, 27% of the events are not the factors that investigation is still pending, or the company considers it unnecessary to inform the National Bureau of the results of its investigations.

Given that the civil aviation, as well as the entire society is constantly progressing in its development, there is a need for adoption and effective implementation of a large system of legal and technical measures that regulate its activity. The aim of these measures is to ensure reliable and efficient and safe operation of air transport. Significantly affect the order of scientific and technological progress, the overall level of aviation regulatory framework and political, economic, and other factors. International aviation agreements, regulations and standards of ICAO (International Civil Aviation Organization) aim to achieve a safe and regular air traffic, uniform application and unconditional implementation of aviation regulations.

Until the administrative and legal means to ensure aviation safety assign, primarily, compulsory rules concerning security of the fact that all other means to ensure their implementation, prevention and suppression of violations, bringing the perpetrators to administrative responsibility. Furthermore, as a separate link of this system means allocated promotional and other measures of persuasion.

Types of mandatory rules relating to aviation security can be classified according to the following criteria: subject of regulation; bodies that set the rules (legal force); content and legal nature of the prescription; scope in time, in space and the range of people.

Compulsory rules and regulations on the basis of which to establish their validity determines. Thus, the leading role played by the rules of the Constitution of Ukraine and occupy the central place the legislative acts which include their own laws, codes, fundamentals of law and other acts passed by the Verkhovna Rada of Ukraine. The focus of the regulatory impact of legislation in force in this area, makes them the division into two types: regulating organization of airspace and regulating the activities of civil aviation personnel to ensure the safety of aviation.

Staff civil aviation exercise their powers in the majority on the basis of the rules of administrative law, as determined by the relationship between power-submission, in which there is legal inequality of the participants.

In - Third, it is appropriate to note that each of the elements of a system Civil Aviation staff has a legal (regulatory fixed) status, which allows to implement state functions in civil aviation. Potential subjective rights and obligations, marketed as an administrative relationships and outside them is a necessary feature of acquiring entity administrative - legal status. The presence of these elements determines the content of the administrative and legal status of civilian aircraft, position (location) of subjects in the field of air transport management system; competence (authority) or authority (manager, aviation personnel); a set of legally prescribed rights and obligations, the implementation of which provides the performance of their main functions; duty to required to bear the legal responsibility for the results of their duties (delikt).

In - fourth, staff of civil aviation to ensure flight safety, according R.Kalyuzhny [7, c.38], using a "set" methods, usually two, persuasion and coercion. Each method allows forming a proper idea of the need of the system to ensure safety as determining the impact of a specific subject to the appropriate object in order to support sustainable air transport safe condition.

A special place is the method of persuasion, which is very closely linked to the prevention and administrative enforcement (such measures can not break and consider each other because between them there is a dialectical unity. They have an objective, and their use due level of public relations). Persuasion is a system of measures of educational, explanatory, promotional measures aimed at forming legal entities consisting of aviation, a clear understanding of the need to meet the requirements of laws and regulations.

However, practice shows that the most effective way to influence the behavior and activities of individuals who impede the implementation of the functions assigned to the system security of aviation, is a method of administrative coercion. This method, according to most scientists, lawyers, consisting of measures of administrative warning, suspension of administrative and administrative responsibility. Similar measures apply administrative enforcement and in ensuring safety of aviation [7, c.39].

State administration in the area of civil aviation security is manifested in particular by the legislation of legal forms, publications competent public authorities and other actors who delegated this right in accordance with the law, regulations, and enforcement of individual (executive and administrative) and acts occurred in certain legislation and other actions that have legal significance.

Using the traditional approach of scientists in administrative law administration forms are divided according to their effects on generated: right and wrong. There are different classifications of legal forms, in particular, scholars have identified: a) content: right stating and enforcement; b) purposefulness: internal and external; c) the method of expression: verbal and conclusive. The most thoroughly regulated forms relating to the implementation of law enforcement, right stating and enforcement functions of public administration. Because they cause the most significant legal consequences and their regulation is important from the standpoint of ensuring legality [8 st.181].

Enforcement form of aviation security - is actually a specific activity of providing security called for the implementation of legal regulations concerning specific life cases. It is carried out by issuing individual (executive and administrative) acts of management, administrative law concluding agreements (in particular the protection of civil aviation) and occurred in certain legislation and other actions that have legal significance. The said activity is carried out by:

-Registration of civil aircraft; civil airfields; airways and local air lines;

- Admission: the operation of aircraft, including light; to the operation of airports, landing areas, airports; aviation personnel to aviation; aircraft for flight;

- Permitting, for the operating civil aircraft; on departure from and arrival airports Ukraine airports; to carry firearms, ammunition, explosives and poisonous substances, nuclear fuel, radioactive materials and other goods belonging to particularly dangerous; pursuant air operations by foreign operators; pursuant irregular international flights testimonies flight crew;

- Licensing - mostly bears to auxiliary and applies only to business entities in the field of aviation;
- Certification (Article 13 PC).

Equally important is the implementation of control and supervision activities, which enables timely detection of causes of violations and their perpetrators, but as the ultimate goal of control and surveillance is still correct and eliminate violations. Control and supervisory activities in the field of aviation - a special kind of administration authorized control (supervision) and hierarchically structured of civilian aircraft, which are aimed at ensuring the proper state controlled (supervised) objects to achieve the objectives and implementation their duties.

Fifth, the formation of innovative mechanisms to use administrative remedies to the staff of civil aviation is largely dependent on the quality of air and administrative law. Thus, the Air Code [3] establishes the legal framework in the field of aviation and determines that state regulation of activities in the field of aviation security aimed at aircraft, providing air transport and air operations. However, the state must not only declare and create an appropriate legal mechanism realization and protection of human rights in the safe transport and aviation activities.

A special place in this mechanism of realization of state policy and strategy of aircraft owned by Ukraine State Aviation Administration of Ukraine, which directly carries out the state regulation of activities in the field of civil aviation and provides a range of measures [Article 10 PC] aimed at preventing aviation accidents by 1) establishing criteria for aviation safety; 2) establishing the necessary level of aviation safety; 3) to analyze and determine the existing level of aviation safety; 4) scheduled and unscheduled inspections, inspection of facilities and aviation; 5) the timing and exercise control over the CAR aviation entities; 6) prohibition, cancellation, suspension or modification to perform any kind of flight and aviation in case of security threats or non aviation standards established and air rules Ukraine; 7) cancellation, suspension of certificates, certificates, licenses, permits, limiting the rights granted to these documents, cancellation of approval of candidates; 8) imposition of fines and take other measures to ensure aviation safety.

In determining the meaning of "safe work" turn to the concept of "security". Security can be viewed as a condition that provides activities: "Safety - conditions that provide flights of aircraft (aircraft) without the threat of danger to the crew and passengers of the aircraft, as well as for households and ground facilities" [9, p. 47] and "security" - the state of protection of vital interests of the individual, society and state from internal and external threats. "

In the aviation industry aviation security is seen as a comprehensive description of air transport and aerial work that determines the ability to fly without danger to life and health. Art. 1 p. 20 PC [3] the legislator has determined that the safety of aviation - the state of civil aviation in which a risk of damage to people or property reduced to an acceptable level as a result of a continuous process of determining the level of danger and manage and is kept at a level or declining further aviation safety, aviation security, environmental protection, economic security and information security.

Conclusion.

Summarizing the above, we conclude that ensure safe aviation personnel of civil aviation conditioned complex mandatory use of specific administrative - legal measures of the modern administrative law, where they are timely, appropriate and lawful use of a subjective orientation and aims to prevent administrative violations in the field civil aviation and compliance with acceptable level of danger to society and the state.

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UDC 347.8

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The US Aviation and Transportation Security Act of 2001

Federal legislation designed to improve the security of transportation systems throughout the United States, with particular emphasis on airport security

The US Aviation and Transportation Security Act of 2001 is also known as Public Law 107-71. It was signed into law on November 19th, 2001 [1].

The Aviation and Transportation Security Act was enacted following the terrorist attacks of September 11th, 2001. In addition to instituting new security procedures, the act established the Transportation Security Administration to assess and amend security policies for all types of public transportation. The act made airport security and other modes of transportation the responsibility of the federal government and changed the way that Americans view travel.

Preceding the September 11th attacks, airport security was shared between airport authorities and commercial airlines. Security screening focused on searching for handguns and bombs (following the suitcase bombing of Pan Am Flight 103 over Lockerbie, Scotland, in 1988). The Aviation Security Improvement Act of 1990 [2] and the recommendations of the White House Commission on Aviation Safety and Security (1996) were either ineffective or not implemented. Aviation security was secondary to concerns about economic efficiency, and there was a strong resistance to spending money to improve security. The Federal Aviation Administration (FAA) was focused on congestion and delays in civil aviation, and Congress was attempting to reduce flight delays by requiring the airlines to provide passengers with better information and to improve baggage handling. Although Great Britain and Israel had created strong passenger and luggage-screening regulations, there were no such protocols in the United States.

On September 11th, 2001 America's vulnerability to terrorist attacks was exposed when four commercial airplanes were hijacked and directed toward specific targets. Two of the airplanes were flown into the World Trade Centre, destroying the twin towers. The third plane hit the Pentagon, while the fourth crashed into a field near Shanksville, Pennsylvania, after passengers attempted to retake control of the plane. Nearly three thousand people were killed in the attacks. Although nine of the nineteen hijackers were given special security checks at the airports, they were not questioned or personally searched. Only their checked luggage was given an extra look.

On September 21st South Carolina senator Ernest F. Hollings sponsored an aviation security bill that was quickly discussed in both the House and the Senate. President George W. Bush, speaking in the lobby of Terminal A at Ronald Reagan Washington National Airport, signed the Aviation and Transportation Security Act (ATSA) into law on November 19th, 2001.

The purpose of the ASTA was to set up layers of security that would prevent future terrorist attacks. Once the ATSA became law, security in all types of transportation, including aviation, rail, other surface transportation, and maritime transportation and port security, became the direct responsibility of the federal government. The act established the Transportation Security Administration (TSA) within the Department of Transportation, headed by an undersecretary of transportation. In 2003 the TSA became a part of the federal Department of Homeland Security (DHS). Important sections of the ATSA outline procedures for hiring and training screening personnel, who must be American citizens. Rather than being hired by private companies, those screening passengers and luggage at the 429 commercial airports are federal employees. All employees and law-enforcement officers who enter a secure area of an airport must have their identities verified. The ATSA mandates that cockpit doors be reinforced and remain locked during flight, and flight crews are trained to handle suspicious travellers. Following the September 11th attacks, the number of air marshals increased from thirty-three to more than a thousand.

Even general aviation was mandated to make security changes, and those running flight schools were required to enhance background checks for foreign nationals who wished to learn to fly. Communication between various agencies was improved, and a "no-fly" list – a secret watch list maintained by federal authorities to prevent those suspected of terrorist ties from boarding commercial aircraft – was expanded. Deadlines for implementing certain requirements were also set. By November, 2002 a federal workforce was to be in place to screen all airport passengers and property, and by the end of 2002 all checked luggage was to be screened for explosives.

Although the ASTA covers all modes of transportation, the resources and focus have been on aviation. Subsequent acts have developed more regulations and assigned responsibilities to other agencies to provide additional security for maritime, rail, land, and other types of transportation.

New security procedures took effect immediately after the act became law. Parking to drop off passengers was not allowed, and restrictions for carry-on luggage were implemented. Access to departure and arrival gates as well as airport concourses was restricted to ticketed passengers. Checked luggage was extensively screened, and all passengers – not just those with checked baggage – were pre-screened. The Computer Assisted Passenger Pre-screening System database (in place since 1997), along with the Advance Passenger Information System, provides information on potential security risks used to create a no-fly list. This list has caused problems and complaints about political and ethnic profiling. Screening of passengers at security checkpoints has also raised a number of issues, from privacy concerns regarding screening devices to complaints of racial profiling.

Despite complaints about invasion of privacy and delays with long security check-ins, most Americans accepted the provisions of the Aviation and Transportation Security Act. Travellers realized that the freedom to travel without layers of federal oversight and restrictions was lost on September 11th, 2001 [3].

Conclusions

Despite general acceptance of most airline and airport security reforms, some programs remain controversial. Some have criticized the incorporation of law enforcement profiling techniques into routine passenger screening practices, claiming that persons of Middle Eastern ethnicity are more often under suspicion, searched, and detained by security personnel.

The controversy surrounding profiling escalated when officials in the Department of Homeland Security and the Department of Defence proposed the introduction of the Total Information Awareness (TIA) system, a searchable database that stores personal information including financial and medical records. Though the TIA was intended to be used by federal law enforcement officials to collate data and find terrorist networks, Congress severely circumscribed the controversial program in 2003, prohibiting its use for domestic security operations. TIA was later renamed the Terrorist Information Awareness system.

With the creation of the DHS many agencies responsible for airline safety and airport security, including the TSA, were assumed into the new government department. The DHS has combined national anti-terrorist efforts with earlier regulations specifically regarding airports and airlines. The incorporation of the Early Alert System, a colour-coded warning system meant to indicate the variable likelihood of terrorist attacks, marked the most notable change in security procedures. As threat levels are elevated, security procedures are heightened. At the Orange and Red levels, airports employ a wider secured perimeter, different flight paths around urban areas, and increased security personnel.

Although TSA is now a part of the DHS, the Department of Transportation and the FAA continue to aid the progress of reforming United States airline security policy through safety recommendations and review of airline practices [4].

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Criminal liability for the commission of the professional activities of the members of the crew in a state of intoxication (art. 276-1 of the Criminal Code of Ukraine)

The article provides an analysis of criminal responsibility for the crime, which is a member of the professional activities of the crew of air transport in a state of intoxication. Discusses issues of conformity of the criminal and air terminology in Ukraine.

Air Code of Ukraine in 2011 sets, as stated in its preamble, the legal bases of activity in the field of aviation. State regulation of the activities and use of airspace aimed at ensuring aviation security, ensuring national interests, national security and the needs of society and the economy during air transportation and during aerial work.

At the same time, significant changes have been made to the numbers of laws, including the Code of Administrative Offences and the Criminal Code of Ukraine. With regard to changes of administrative law, they mainly deal with sanctions Art. 111 "Violation of safety rules," Art. 112 "Violation of the rules of conduct on the aircraft," Art. 113 "Violation of the rules of international flights" and aimed at strengthening the punishment for the offenses.

Thus, administrative law has not undergone major changes, which can not be said about the criminal.

The Preamble to the Air Code of Ukraine does not provide (and can not provide), the problem of changing the rules of other branches of law. But despite this, the Air Code of Ukraine does not simply points to the need to improve other areas of legislation, one way or another related to aviation, it expressly set forth in the section "Final and Transitional Provisions" of the offense and the sanction set - Art. 276-1 of the Criminal Code of Ukraine "Making a professional activity or a crew member of the air traffic service an air traffic control manager (Manager Traffic Services) intoxicated or under the influence of narcotic or psychotropic substances." The appearance of this new norm among transport crime raises a number of questions and comments.

A common way to amend the criminal law is the adoption of laws that are made just for that purpose. Even the new Criminal Procedural Code of Ukraine, adopted on 13 April 2012 and which, of course, has caused significant changes in many areas of legislation, just does not contain articles that should be made to the criminal law. A separate Act of Ukraine of 13 April 2012 "On Amendments to Certain Legislative Acts of Ukraine in connection with the adoption of the Criminal Procedure Code of Ukraine" was adopted. Section XIX of the Air Code of Ukraine "Final and Transitional Provisions", in fact, performs the function of a separate regulation, which introduced changes in a large number of regulations. Final and transitional provisions are now part of many regulations, especially the codes, but there they do not comply with such a non-core part.

In our opinion, Art. 276-1 of Criminal Code of Ukraine is an example of (a few) over-criminalization, and the content is far from perfect. The text of the article is exclusively blanket in nature and, moreover, it repeats the title of the article. But even if we refer to the Air Code of Ukraine, the interpretation of certain terms will be difficult. So, in this article criminalizes activity of specific subjects - the crew member or dispatcher serve motion. Even using the text of Art. 1 of the Air Code of Ukraine "Definition of Terms" is not possible to understand who is the member of the crew. For example, some authors writ that the crew should be considered not only the pilots, navigators, flight engineers, stewards, waiters and other professionals who provide fulfillment processes and the implementation of certain types of aerial work. Of course, a flight attendant on board while intoxicated, less socially dangerous than a drunk pilot. But the technician who prepares the plane for the flight in a state of intoxication, as dangerous as a drunk crew. And about him in the article are not talking. Obviously, in accordance with the doctrinal interpretation of the term "crew member", it should be considered a person appointed by the operator length perform certain duties on board an aircraft during their flight time.

One of the conditions of criminalization is the possibility of proving the crime. If the flight is not an emergency situation has occurred or if the crew coped with it, not allowing to grow into the emergency or catastrophic, in what way we can prove the link between the state, for example, a flight engineer, and such a situation? By analogy with the driver motor it means, if there is evidence, it should be brought to administrative responsibility. We do not deny the fact that the performance of their duties by members of the crew or manager in a state of intoxication greatly increases the danger of flight, but at the same time did not believe in the need for the criminalization of the act. In fact, we did not establish criminal responsibility for the act itself, but for the condition of the person.

Conclusions

As a conclusion, we note that the trivial and widely understood is the basic idea of the legislator with respect to criminal law prohibition flight control of the aircraft while intoxicated. Manage any mode of transport as a source of increased danger and intoxicated, under the influence of narcotic and psychotropic substances is socially dangerous. We believe that in this case it is necessary to apply Article aggravating circumstances.

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Aviation of special purpose and regulation of civil aviation and air transport within the European Union

In this paper, the author examines special purpose air vehicles and sources of air law and international air law development in the light of the integration processes in the world and Ukraine's participation in them.

One of the most notable trends in national economic activity is the creation of numerous aircraft based special purpose vehicles and passenger aircraft. Order and functioning of which is a prerequisite for further development and improvement of civil aviation, the last operation is necessary to increase production in agriculture, the forestry service, monitoring the airspace, as well as solving social problems and tasks to any natural or other character.

Unfortunately, today the state special purpose air vehicles can not be called satisfactory. First increase the area of application of air operations resulting in increased pressure on the park aircraft for special purposes, which are now obsolete.

Thus, according to the draft state program of Special purpose aviation for the period until 2019 (hereinafter - the Program), approved by the Cabinet of Ministers of Ukraine from 2009 which state customer is the Ministry of Transport stated that in 1999 the total area of the use of air operations was 228 0 thousand hectares. in 2000 - 298 thousand. ha in 2001 - 771 thousand. ha in 2002 - 910 thousand. ha in 2003 - 620 thousand. ha in 2004 - 974 thousand. ha, in 2005 - 745 thousand. ha in 2006 - 945 thousand. ha in 2007 - 1.1 mln. ha, 2008 - 1.3 mln. ha, 2009 - 0.7 million. ha., in 2010 - 0.78 [1].

Secondly aircraft used for aerial work for agricultural purposes outdated and in need of updating. Thus, according to the Program farming equipment and special equipment AN-2, Mi-2 and Ka-26 for the past 30 years have not been updated and are not modified.

Thirdly regulatory framework governing the use of aircraft for special purposes is outdated.

To solve these problems need to take these measures. First, you should consider implementing investments for modernization of airports and adjacent areas and provide access private sector to take active part in the design and development of innovative technologies in the aviation and aerospace sectors. Such actions on the part of the state will be doomed to success only because such financial support to help state enterprises to accelerate the development of new technologies and implement them in life and will allow the creation and improvement of good governance in the past.

Next to solve these problems is to update the fleet of special purpose, increase financial stability by airlines as investment inflows from outside the state, on the part of foreign capital. Restoring power in this way is only possible with the introduction of changes in national legislation in the context of granting permission for privatization respective companies or change their legal form, but leave the state's control pact shares by the company or control activities that threaten national security.

The influence of the integration process on the development of international air law is that the first documents resulting in civil aviation are regional character (for example Havana (Pan-American) Convention on Commercial Aviation in 1928). Further international conventions that regulate private and public relations in civil aviation have universal character, which facilitates penetration of norms in domestic law of most countries.

Special attention we should be paid to the concepts of regulation of civil aviation and air transport in the European Union.

EU creates air legislation that is common to the States-Member and associated countries, by introducing common standards, minimum or universal, and through universal adherence to international treaties. An important example of this process is the creation of the Single European Sky and the EU Common Aviation Area (these two categories are different). That is allowed to unify and simplify air services between States Member. The concept of Single European Sky based on the principle of liberalization and deregulation of air services in line with the competition and the free market economy.

It was necessary to create a system of technical regulations and standards which had universal character (standards of ICAO, the International Civil Aviation Organization), or regional character (standard European Civil Aviation Conference, the European Agency for Safety of Civil Aviation) for the operation of civil aircraft. Important role in international air law is played by standards, recommended practices, procedures, adopted by the Council of ICAO, which are known as "international aviation regulations" [3, p. 503]. Technical standards should be reflected in the air law of participants and thus directly affect on development of the national air law. It is also important to note that the sources of international air law customary rules formed in several ways. One way of creating international customs are acts of international organizations. Acts of international organizations don’t have obligatory power but imposes certain obligations on the state. So as the result such acts have created practice in regulation of the relationship. The legal acts of international organizations In the process of using them are creating international customs. The brilliant example of the formation of international custom on legal acts of international organization is an international space law - UN General Assembly resolution used by the world as a recognized international customary law to regulate space activities.

We could also consider several groups in the system of sources of national air law. Firstly, international agreements. These include universal, regional and bilateral agreements. According to an air law of Ukraine we should noted that the development of integration processes within the CIS within the European integration influenced the expansion of the base.

In particular, some bilateral agreements have replaced regional documents: Agreement between Ukraine and the EU on certain aspects of air services from 1 December 2005, Decision on the Concept of harmonization of national air traffic management systems of the Commonwealth of Independent States, on September 19, 2003, etc. The second groups of national sources of air law are technical standards that are already mentioned. They need to be separated because they represent the part of the national air law, which ensures the safety of civil aviation in all its aspects and allows the aircraft to make international flights Ukraine. The third part of the air law system up Ukraine national acts. They can also be classified by the legal force in accordance with national legislation. It is important that the development of modern aviation law in Ukraine is carried out according to the requirements of business aviation in the world and according to current economic trends.

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Legal regulation of luggage air carriage in conditions of transformation in Ukrainian society

The article deals with carriage of luggage by air in conditions of transformation in Ukrainian society. Requirments to luggage, its packing, limits and free luggage allowance, carriage of group luggage, questions of unaccompanied and hand luggage, carriage of animals have been investigated according to the national legislation.

Air transport occupies an important place in the transport system of the world. Aviation plays a very important role in air carriage of passengers, luggage and cargo. In Ukraine in conditions of globalization and transformation of social relations quantity of air transportations increases every day. Nowadays the question of protection of passengers' rights during their carriage by air is very relevant. According to statistics, an average of less than 1.5 % of luggage gets lost during air travel around the world, nevertheless, this number may seem very insignificant only if that is not your own but someone else's lost luggage [1, p. 50]. The mentioned above determines the necessity to investigate legal regulation of luggage transportation by air in modern conditions.

According to the part 11 of Article 100 of the Air Code of Ukraine an air carrier is responsible for loss and damage of luggage during air carriage according to requirements and rules under international agreements of Ukraine, legislation of Ukraine, including Aviation Rules of Ukraine [2].

The article 1 of the Air Code of Ukraine contains notions of: luggage (item 18), luggage identification tag (item 19), registered luggage (item 43), unaccompanied luggage (part 68), hand luggage (item 90) [2]. Section XIII of the Rules of Air Carriage of Passengers and Luggage, approved by the Decree of the Ministry of Infrastructure of Ukraine № 735 dated 30.11.2012 (the Rules) regulates: requirements to luggage (Chapter 1) and its packing (Chapter 4), limits for acceptance of items for carriage (Chapter 5) and the right to refuse to accept luggage for carriage (Chapter 6), its excess (Chapter 8), free luggage allowance (Chapter 2), payment for carriage of luggage in excess of the free allowance (Chapter 9), carriage of group luggage (Chapter 3), a right of its inspection (Chapter 7), the question of unaccompanied luggage (Chapter 10), hand luggage (Chapter 11), luggage handling, delivery and collection (Chapter 12). Also, the section XIV of the Rules deals with carriage of animals, birds and luggage in the aircraft cabin [3].

According to the Rules the luggage of a passenger is accepted for carriage during their check-in in the airport of departure, or in another check-in location. Passenger's belongings, depending on their size, weight and peculiarities can be transported as checked luggage or unchecked luggage (hand luggage). The passenger is entitled to carry up to 6 pieces of checked-in luggage if the weight if each piece does not exceed 23 kg.

The passenger is entitled to carry free of charge on top of the free luggage allowance the items that they keep for themselves and did not put into luggage (unchecked luggage or hand luggage), in particular: a bag with maximum dimensions 55x40x20 centimetres, a paper folder, a coat, a jacket, an umbrella or a walking stick, printed reading material for the flight, food for a child required during the flight, a portable crib for children (if there is a child aged under 1 year), foldable baby carriage, a folded wheelchair and/or crutches. The total weight of items, except for the wheelchair, must not exceed 10 kg.

The passenger may declare the special value of the luggage before it is accepted for carriage. In such case, the carrier will be liable for such luggage up to the limits of such declared value.

Passengers travelling in a group, upon their wish, have a right, whereas the carrier is bound to apply to these passengers the sum of free luggage allowances. The free luggage allowance for groups is also applied to passengers who are members of one family. Aggregation relates only to free luggage allowances. Luggage has to be handled separately for each passenger. Group luggage can be formalised in the name of one person who was empowered by all passengers and is included into the group of these passengers.

Every piece of luggage must have good packing that would ensure its safety during carriage and processing and would make it impossible to damage passengers, crew members, third persons, aircraft, luggage of other passengers or other property, and would also eliminate the possibility of free and accidental access to the luggage contents of unauthorised persons. Luggage that does not require the mentioned rule is not accepted for carriage. Good and proper condition of package is decided by the carrier.

The Rules include norms about items that should not be included into luggage. It means that these items must not be included into checked luggage or hand luggage. They are: goods, items, liquids and other substances that can pose a substantial risk to passengers' health, flight safety or property of the carrier or other passengers during carriage, in particular explosive and compressed gases, materials causing corrosion, oxidisers, radioactive materials, magnets, highly inflammable materials, poisonous, harmful or irritating substances, as well as any items and substances specified in ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air, Doc 9284-AN/905, and Regulations for the Safe Transport of Dangerous Goods issued by International Air Transport Association (IATA) as those prohibited for transportation by passenger aircraft; goods and items, carriage of which is prohibited by current laws of any country, from, into or through the territory of which the flight will be performed; goods not suitable for carriage by their nature, weight, size, shape or smell; live animals and birds, firearms, ammunition and explosives including weapons for hunting or sports purposes as defined by the Applicable Law of any country of departure or destination; item or substance that looks like firearms, ammunition or explosives, cutting or piercing items condensed gas (except for carbon dioxide used for moving artificial limbs, containers with gas used for selfinflating lifejackets; oxygen and air bottles in quantities set forth by International Air Transport Association IATA); briefcases and attached cases with built-in alarm devices, lithium batteries or pyrotechnical materials; items not suitable for carriage because of their weight, size or other characteristics; human remains. Checked luggage must not contain: frail and fragile items, items that are breakable or perishable, money, keys, valuables, electronic equipment, photographic and video equipment, items from precious metals and silver, technical documentation, travel documents, business documents, securities, valuables, medications, medical documentation, works of art and fine arts, passports and other identification documents and samples, perishables, works of art and fine arts.

The carrier is entitled not to accept luggage as checked one if it is not properly packed into suitcases with locks or other appropriate containers that ensure safe transportation of luggage and its handling using conventional means for luggage handling. The carrier is under no obligation to take under their control and incur a liability for goods or items which they refused to accept for carriage as luggage.

In order to ensure flight safety the carrier is entitled to request that the passenger undergoes personal security inspection undertaken by services of the carrier, airport, and to give luggage for examination, and is also entitled to inspect or arrange inspection of luggage in the passenger's absence. If the passenger does not want to comply with this request, the carrier may refuse carriage of such luggage. The carrier is not responsible for damage caused to the passenger or his luggage during X-ray or other scanning of items forbidden for carriage, except for cases of Carrier's negligence.

Excess luggage, oversized luggage and luggage weighing more than 23 kg (per piece) is accepted for carriage only upon the carrier's consent and if the aircraft has vacant capacity for carriage, and also on condition that the passenger pays for carriage of such luggage, except for cases when carriage of such luggage has been agreed with the carrier in advance and paid for.

Carriage of luggage in the quantity that exceeds the free allowance should be paid for by the passenger according to the tariff for payment for excess luggage. The carrier does not carry unaccompanied baggage by its flights.

Hand luggage must be placed safely in the aircraft cabin in overhead lockers or under the seat. It if prohibited to place hand luggage and items allowed for carriage in all aisles of the aircraft cabin. Items that do not comply with the requirements established by the carrier to size and weight of hand luggage or those prohibited for carriage in the passenger cabin of the aircraft are deemed and will be handled as checked luggage. Hand luggage must not contain cutting and piercing objects: knives, scissors, needles, knitting needles and other sharp and cutting objects. It is also prohibited to bring to the aircraft in hand luggage any liquids, suspensions, creams, pastes with the volume in excess of 100 ml (grams) in one container (tube). The total volume of mentioned substances in hand luggage, packed in containers up to 100 ml (grams), should not exceed 1 litre (kg) per passenger. Hand luggage throughout the carriage is in the custody and under the responsibility of the passenger.

The responsibility for collection of their luggage at the place of destination is placed on the passenger. Luggage that is not collected by the passenger is transferred for storage to appropriate airport services. The storage period of such baggage is 60 days, whereas the carrier is entitled to charge the passenger a fee for luggage storage. Upon expiry of this period luggage is sold according to the established procedure or destroyed. The holder of the luggage claim tag (luggage identification tag) is entitled to collect luggage. The carrier is under no obligation to establish and check the right of the holder of luggage claim tag and luggage identification tag for luggage collection.

According to Section XIV of the Rules dogs, cats, poultry and other pets are not transported by carrier's flights, with the exception of transportation of guide dogs accompanying blind or deaf passengers and service animals that assist the state authority officers in performing their functions. Such dogs must be properly placed at the feet of the passenger and have valid vaccination and health certificates, an entry permit for the country of destination or transit. The animals must be clean, tidy and have no unpleasant smell. The carrier is entitled to decide on the type of transportation. Guide dogs assisting blind or deaf passengers and accompanying such passengers are carried free of charge. In this case the guide dog must have a dog collar and a muzzle and be tied to the seat at its owner's feet. If an animal is carried the passenger is absolutely liable for this animal and liable for provision of required certificates, permits etc. envisaged by current laws and regulations. The carrier will not be liable for injury, loss, delay, illness or death of such animals if they are refused entrance into the country of destination or transit, if such damage was not caused as a result of carrier's negligence.

Upon consent of the carrier, luggage (items) of the passenger that require special preventive steps during transportation or special handling conditions may be carried in the aircraft cabin (in particular, frail and fragile items and items that are breakable or perishable, photo- and movie cameras, TV, radio and video equipment, device samples, musical instruments, electronic and optical devices, materials of unpleasant nature, specialized wheelchairs operating on sealed batteries, skis, snowboards, equipment for tennis, diving or surfing, fishing equipment and/or clothes, hunting and sporting trophies, bicycles, poles; other specific items).

Also, to the mentioned question attention has been paid in Passenger and Baggage Carriage Rules issued by airline companies, for example: Private Joint-Stock Company "Ukraine International Airlines" (Articles XIII, XIV) [4], "Wind Rose" Aviation Company (Articles 12, 13) [5], Danish Air Transport (Article 9) [6].

Nowadays it is important to know how to protect passenger's luggage from being lost during the air transportation. Before a passenger hands over the luggage, he should check that all tags from previous trips have been removed. This is needed to avoid confusion during the sorting process on the conveyor belt and prevent accidental sending of the passenger's luggage to a wrong location. At the check-in, the passenger should be sure that a luggage tag has been firmly attached by the airline check-in agent and that it has been attached to just one handle (if the passenger hands over a bag) instead of two. The tag still can be ripped off during the luggage transportation, and this will make the process of its identification much harder. To avoid such kind of situations, it is better to attach the tag with a passenger's name, the country of passenger's residence, home address and telephone number to passenger's suitcase or put it into a transparent pocket (if any). If the passenger has already attached such a tag traveling before, then he should check whether all the information is correct. It is better to put the passenger's name tag, as well as the copy of his ticket with itinerary, into each compartment of a passenger's bag. This will help the airline's representatives decide whether it's better to send the found luggage to a passenger's home address or to the destination airport. The luggage tag has a three-letter destination airport code printed on. It is important to be sure that the tag identifies passenger's final destination correctly. In case of a transit flight, it is better to ask a check-in agent which destination is stated on the luggage tag. It is needed to be sure that the check-in agent has given the luggage claim receipts, as it is easy to forget about them in the pre-flight rush. It is obligatory to retain them until the end of the trip: in case the bags are lost, only the bearer of the luggage receipts can fill out the PIR form (Property Irregularity Report), in order to initiate the further search of the luggage. Upon arrival at passenger's destination, he should compare the number on the luggage receipt given to him before with the number on the tag attached to the handle of his bag, in order to prevent accidental exchange. If passenger's luggage has not arrived at his destination with him, the passenger should not leave the airport before he submits the PIR. A luggage recovery agent may participate to fill out its sections correctly. It is better to give a very detailed description of luggage in the documents and ask for the phone number to get further information on the results of the luggage search [1, p. 51].

On the level of national legislation carriage of luggage is regulated by the Air Code of Ukraine and the Rules of Air Carriage of Passengers and Luggage issued by Ukraine, Rules of Air Carriage of Passengers and Luggage issued by airline companies. To save passengers' right in relation to carriage of their luggage by air and prevent their luggage and valuables from being lost during the flight it is very important to follow the mentioned legal rules.

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Criminological characteristics crimes against flight safety and operation of air transport

Abstracts devoted study of crimes against the safety and operation of air transport in Ukraine. Also defined public danger, regulations aimed at regulating this issue and proposed amendments to the Criminal Code of Ukraine.

Criminal liability for the violation of flight and operation of air transport takes place in a crime stipulated in dispositions of articles 276, 276-1, 277, 278, 279, 280, 281, 282 of the Criminal Code of Ukraine. Actions envisaged in the above articles encroach on public safety, the life and health of people. Especially it concerns acts under article 278 of the Criminal Code of Ukraine (hijacking or seizure of aircraft).

However, the sanction of these articles, not only does not correspond to the severity of the acts envisaged dispositions of articles, but do not have positive preventive results. It should be noted, that the humanity of the Criminal Code of Ukraine does not know the limits and comparisons, and it certainly contributes to the growth of crime in the state. For example, in Kiev, as stated by the head of the National Police of Ukraine Khatia Dekanoidze, in the first quarter of 2016 year compared to the same period last year, the crime rate increased by 45% [1]. No doubt, this trend there, and in all regions of the country.

Currently, it is difficult to gather complete statistics are not only a violation of the safety and operation of air transport, but also about crime in Ukraine. The official website of the Ministry of Internal Affairs of Ukraine, at the time of this writing, was reporting «Status and structure of crime in Ukraine» on p. 7 which sets out the details of the crimes against traffic safety and operation of all transport (rail, air, sea and river) only on November 20, 2012 year. According to these data, 12287 crimes against safety and operation of transport was committed in 2011 and 2012 as of November 20, the crime was committed 13894 [2]. There are no data on the crime under articles 276, 276-1, 277, 278, 279, 280, 281, 282 of the Criminal Code is not in this report. This report is the latest official promulgation of the state of crime in Ukraine.

On the need to strengthen the criminal responsibility for violation of traffic safety and operation of air transport oriented and international organizations. Thus, ICAO (International Civil Aviation Organization), in connection with a major public hazard violations of traffic safety and operation of air transport, as well as the wave of violence in the air force to urgently had to develop and enact the Hague (1970 year) Convention for the Suppression of unlawful seizure of aircraft. The Convention was more advanced in comparison with earlier adoption of the conventions and it introduced some important new provisions:

a) the unlawful seizure of an aircraft is an international crime and obliges states to set for this crime severe punishment;

b) the provisions of the Convention shall apply regardless of whether they are engaged in an international flight or a flight on domestic routes;

c) considered a crime the act which is as follows: unlawfully, by force or threat to use violence, or by other form of intimidation, seizure of aircraft or exercise control over them [3].

As can be seen from the first position of this Convention, all states were to establish penalties for the hijacking or seizure of an aircraft that has not been done Lawmaker of Ukraine.

Conclusions

Therefore, article 278 of the Criminal Code of Ukraine (hijacking or seizure of aircraft of railway rolling stock, aircraft, ship or boat) should be as follows:

Hijacking or seizure of railway rolling stock, aircraft, ship or boat –

shall be punished by imprisonment for a term of six to ten years.

2. The same acts committed on preliminary arrangement by group of persons, or connected with violence not dangerous to life or health of the victim, -

shall be punished by imprisonment for a term of ten to twelve years.

3. Actions envisaged in the first or second paragraph of this article, committed by an organized group or associated with violence dangerous for life or health of the victim, or where they caused death of people or any other grave consequences, -

shall be punished by imprisonment for a term of twelve to fifteen years or life imprisonment.

A similar kind of strengthening of criminal responsibility should be under articles 276, 276-1, 277, 279, 280, 281, 282 of Criminal Code of Ukraine.

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Legislative regulation of administrative responsibility of legal entities in civil aviation

In these theses the author explore the problems of absence and legislative fixing of administrative responsibility of legal entities in the civil aviation.

Socio-economic changes that took place in Ukraine substantially influenced on becoming and development of right, caused the necessity of not only "repairing" of "soviet" laws but also acceptance of fundamental codified and ordinary laws the norms of that regulate a variety of social relationship in the country. The reason of activation of normative activity were problems that related to proclamation of euro integration course and legal adjusting of different spheres and industries of social life. In the same time, creation of new legal base induces certain directions of researches, in particular in aviation industry.

First of all it should be noted that legislative establishment of administrative responsibility for offence on an air transport is one of basic types of organizational and legal measures to ensure the normal functioning in the civil aviation. Herewith consideration of question in relation to administrative responsibility for offence on an air transport complicated by the fact that in our time is not enough of comprehensive scientific research in relation to administrative responsibility of legal entities in the field of a civil aviation and legal researches that related with the different aspects of activity of civil aviation in Ukraine on the whole. Another problem is the continuing scientific debate and controversy that related with the institution of administrative responsibility. On that score Kolpakov V.K. notes that the concept of administrative liability, her contents and volume of to today's time, remain to one of the most contradictory and debatable questions of Ukrainian administrative and legal science, that predefined as possibility of application of term "administrative responsibility" in the realm of legal-scientific and general education and at social level, and as ambivalent position of legislator, that uses this term in numerous normative acts, but does not give his explanation [1, p. 288]. In fact, even the acting Code of Ukraine about administrative offenses, that contains a chapter 2 which name is "The administrative crime and administrative responsibility", does not disclose the concept of administrative responsibility. However, without regard to the marked legislative vagueness and doctrine contradiction in the decision of concept of administrative responsibility, taking into account the last scientific researches of Y. P. Bytyaka, I. P. Holosnichenka, L. V. Kovalya, V. K. Kolpakova, Y. M. Kozlova, D. M. Luk'yantsya, L. L. Popova and other scientists, is considered that administrative responsibility for offence in the area of civil aviation can be define as a diversity of legal responsibility, that is totality of administrative legal relationships, that allow for application of the state of statutory administrative penalties the authorized organs (by public servants) to the individual who have committed these delinquency.

The modern conditions of development of our country, that is predefined by serious changes in political and socio-economic life of Ukraine, need the special attention in relation to reformation of legislation in the field of administrative responsibility of legal entities. Activity of legal entities in industry of civil aviation in relation to carrying passengers, luggage and load continues to play an important role in the Ukraine economy. Adjusting of such activity takes place by norms of the national law and by the international law. Speaking about the legislation of international level, it is needed to mention: Convention for the unitization of some rules that touch international air shipments from 12.10.1929 [2], Convention about the unitization of some rules of international air shipments from 28.05.1999 [3] and other. At the level of national normative-legal acts the specified range of problems is regulated: by the Air code of Ukraine from 19.05.2011 № 3393 - VI [4], By order of Ministry of infrastructure of Ukraine "About claim of Rules of air shipments of passengers and luggage" 38 from 30.11.2012 № 735 [5], By order of Government service of Ukraine from a supervision after providing of safety of aviation "About claim of Rules of air shipments of loads" from 14.03.2006 № 186 [6] and other. Legal entities can be subject only civil liability according to positions theories of right, that was inherited by Ukrainian legal science from times of stay of Ukraine in composition of the USSR. The point of view, after that the subjects of administrative responsibility can be only physical persons, continues in scientific circles to remain. The said statement follows from the analysis of norms of main codificative rules of the normative-legal act of this field of law. In Code of Ukraine about administrative crimes (further according the text - Code of Ukraine of about administrative offenses) from 07.12.1984 [7], a term "person" is used, but this law does not give exact specification in relation to that, what kind of person (physical or juridical) are the subjects of administrative responsibility. If to analyse the articles of the indicated normatively-legal act in relation to age responsibility can come after the achievement of that, in relation to circumstances that eliminate administrative responsibility, to diminished responsibility of persons, it is possible to come to the conclusion, that Code of of of Ukraine of about administrative offenses sets administrative responsibility only physical persons. A question about establishment of responsibility of legal entities for today is debatable. In opinion of I. Holosnichenko., today law-enforcement practice needs expansion of types of subjects of administrative misconducts, to that it is needed to include legal entities [8, p. 22]. To our opinion, it costs to agree with the indicated point of view, so as she answers realities of present time fully. For example, Law of Ukraine "On responsibility for offence in the field of town-planning activity" from 14.10.1994 № to 208/94-BP [9] responsibility of legal entities and physical persons-businessmen sets for offence in the field of town-planning activity. The procedure for imposing penalties for committing these offenses as stipulated by the legislator in the Resolution of the Cabinet of Ministers of Ukraine "On approval of the imposition of penalties for violations in the field of urban planning" from 06.04.1995 № 244 [10]. In the field of civil aviation CAO establishes liability for the following offenses: violation of flight safety (Art. 111), violation of rules of conduct on the aircraft (Art. 112), violation of international flights (Art. 113), violation of fire safety in air transport (p. 3, Art. 120), violation of rules of transportation of dangerous substances and objects in air transport (part. 3, Art. 133), violation of rules designed to ensure the safety of cargo on air transport (Art. 137). On the basis of the above facts can be drawn conclusions about the need to introduce and fix the administrative liability of legal persons in civil aviation in acting Code of Ukraine about administrative offenses, laws and other regulations of our country.

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Directions to improve protection of copyright objects in context of development of education and science

In this article the author examines special aspects of legal protection of copyright objects in accordance with current legislation. At the same time, in the process of research the author places greater focus on shortcomings in current legislation and proposes the main directions of improvement of current legislation in accordance with international law in the context of protection of copyright objects. Special attention is paid to analysis of the major threats to infringements of copyright and possible solutions of these problems.
In the context of bringing national laws in line with EU legislation, the author considers it appropriate to finalize the draft Law of Ukraine "On Amendments to the Law of Ukraine" On Copyright and Related Rights "(relating to activities of collective management organizations)" in order to protect the proprietary rights of copyright and related rights proprietors.

Effective protection of intellectual property objects, in particular copyright objects, associated to some extent with digital technologies is one of the major problems in Ukraine today. Literary, audiovisual, musical, photographic works, computer programs and other copyright objects reproduced in digital form are increasingly becoming offence objects. The problem is aggravated by the fact that every year Ukraine holds a leading place among all countries in the world in terms of software piracy, circumvention of technological protection. Each year, the US Trade Representative prepares a "Special 301" Report which determines the countries creating obstacles to the development of American business. Ukraine has been included into this list since 1997. In 2001, Ukraine was given the status of priority country (priority foreign country). As a result, some products imported from Ukraine were put under economic sanctions, and preferential customs import conditions in the US were repealed. In those turbulent years the main claim involved the fact that Ukraine was the largest producer and exporter of counterfeit CD products in Eastern Europe [1]. However, in 2006, the status of Priority foreign country in the "Special 301" Report was removed from Ukraine that made it possible to intensify the innovation process, attract foreign capital and innovation projects. However, in 2013, the Office of the United States Trade Representative (USTR) criticized protection of intellectual property rights on the Internet in Ukraine, situation with collection and distribution of royalties and the number of unlicensed software on the officials' computers, including Ukraine into Priority foreign country "Special 301". The reference to Ukraine in this list has a negative impact on the investment attractiveness of the country. These are huge reputational risks for the state, as for investors the status as a Priority Foreign Country in the "Special 301" is a wake-up call. Economic losses are borne by business entities whose business is related to the export of certain goods to the US, they lose access to the US generalized system of preferences [2].

Taking into account the challenges and criticism of copyright safeguard and protection, Ukrainian authorities adopted a number of changes of economic and legal nature, which led to the fact that in 2015 the status of Ukraine in the "Special 301" Report was changed to Priority watch list, which is a certain status weakening and evidence of some progress in the legal protection. Thus, according to A. Zharikova, "positive changes include implementation of EU directives, which provide for transparency, control, public access to all information of collective management organizations. The directives have been implemented in the corresponding draft law, as was stated above. But since conciliation process dragged on, we decided to test implementation of directives using the example of the collective management organization, which is controlled by the State Intellectual Property Service of Ukraine - Ukrainian Agency for Copyright and Related Rights (UACRR). The Web site of the Services started to publish information on the organization activities: the amount of funds collected, distributed and spent on their own needs, information on contractual partners, etc. European mechanisms are being tested in practice" [2].

All the above mentioned shows the relevance of research related to major prospects of improvement of copyright safeguard and protection in Ukraine in the context of European integration. Thus, the subject of our research is an analysis of ways to improve legal protection of copyright and related rights in accordance with current legislation, major threats and areas for improvement in the context of European integration.

In general, creative people create a variety of intellectual property objects with the purpose to provide a decent life for themselves and their relatives. Thus, a writer creates his work in order to sell it and get an adequate remuneration, a composer creates a piece of music with a similar aim, but there are cases when scientific works are created not for commercial purposes, that is evidence that creativity is not always commercially-based. At the same time, creativity is a type of socially useful activity resulting in emergence of valuable works that bring great benefits to society over the years. According to S. Bondarenko, intellectual activity constitutes a significant part of creative activity in total, the level of which depends on the welfare of society as a whole. The experience of countries with developed market economies indicates that those areas of creative activity that are covered by the term "intellectual activity" are becoming highly influential, priority-oriented and valuable [3, c. 16].

Copyright objects hold a special place among all intellectual property objects. Legal regulation of this group of objects is carried out on the basis of the Constitution of Ukraine, but the basis of legal regulation is the Civil Code of Ukraine [4], international legal acts, the Law of Ukraine "On Copyright and Related Rights" [5], and other legal acts of Ukraine.

It should be noted that despite extensive legal framework of Ukraine, international legal acts on copyright, there is no clear definition of a copyright object. Although legal acts contain the list of copyright objects and requirements to their protection, the definition in unmistakable terms is absent.

Thus, according to V.L. Musiyaka, "an object of copyright is a product of an author's creative activity embodied into known definite form ". He further notes: "The very form is always meaningful: it is a content as a set of all elements of the phenomenon that expresses specific demonstration of its essence" [6, p. 15].

Similar definition of a copyright object is given by O.P. Orlyuk and O.D. Svyatotsky, namely: an object of copyright is a material embodiment, some material form of intellectual, creative activity, i.e. objectification of the work [7].

In accordance with the Berne Convention for the protection of literary and artistic works, the term "literary and artistic works" includes all works in the field of literature, science and art, expressed in whatever way and form. These are books, brochures and other writings; lectures, appeals, sermons and other similar works; dramatic and musical-dramatic works; pantomimes and choreographic works; musical works with or without text; cinematographic works and works in the nature of cinematography; pictures, drawings, paintings, the works of architecture, sculpture, graphic arts and lithography; photographic works and works in the nature of photography; works of applied art; illustrations, maps, plans, sketches and plastic works relating to geography, topography, architecture or science (p. 2, Art. 2 of the Berne Convention) [6, p. 130]. Written literary works include such traditional works as novels, fairy tales, poems, articles, research papers, etc., as well as non-traditional works, works for more practical purpose: advertising texts, operating instructions, technical specifications, provisions on labor remuneration, user guides and other works recorded on tangible media using symbols and marks.

Oral works include lectures, speeches, sermons and other oral works. Peculiarity of an oral literary work is the fact that it has no such material object like a copy of the work.

In addition, according to the types of creative activity literary works are divided into the following types: scientific literature, fiction and art works. Artistic works include mainly works of fine art, such as pictures, drawings, paintings and other works.

Works of fiction include books, magazines, brochures of various genres [9, p. 14]. In order to be legally protected, the work must meet certain criteria specified in legislation, and only in the presence and compliance thereof it may become a proper object of copyright. All works, whether published or not, expressed in any objective form, regardless of the purpose and scope of the work, are considered to be objects of copyright. In general, we can distinguish four criteria of legal protection for works being objects of copyright:

- a criterion of creative nature of the work means that the work may be an object of legal protection if it is the result of intellectual and creative activity of its author;
- a criterion of physical form of expression means that the work may be an object of legal protection if it is expressed in a physical form;
- a criterion of the content of the work means that the work of any content may be an object of legal protection with some restrictions defined by law;
- a criterion of publication of the work means that the work may be an object of legal protection, regardless of whether it is removed from the private sphere or not [10, c. 102].

Analysis of judicial practice shows that in order to establish presence or absence of creative character of a derivative work an examination is inevitable, which, of course, complicates legal proceedings, significantly increases legal costs of the parties and results in long-running litigation. As rightly been said by V.G. Rotan, "an extensive and restrictive interpretation of civil laws in the national legal system is unacceptable, as it is not provided by the Constitution and laws of Ukraine. The Court should literally interpret and apply acts of civil legislation [11, c. 13]. Therefore, all rules of law, including definitive ones that specify the author's powers shall be applied only to the extent clearly defined by law.

In the field of copyright and related rights national legislation of Ukraine also applies a criterion of the work completion. The work is an object of legal protection, regardless of whether it is completed or not. A completed work is subject to legal protection to the same extent as uncompleted one. According to O.A. Pidoprygora, a derivative work is inextricably associated with the presence of two criteria - creative nature of the work and physical form of expression [9, p. 154].

Despite simplicity and obviousness of described legal protection criteria for scientific, literary and artistic works, we consider appropriate to conduct their brief analysis. First, legal protection extends to works created due to intellectual creative activity of one or more authors. The concept of creativity is not defined by legislation, as creativity is a universal category. Creative nature of the work is characterized by its originality or novelty, and novelty and originality may find expression both in the content of the work and in its form [6, p. 171].

O.O. Pidoprygora, for example, considers "creativity" as a purposeful human activity resulting in something totally new that is distinct in uniqueness, originality and historical uniqueness [9, p. 230].

Second, in order to gain legal protection, an author's creative result must be expressed in a physical form. This requirement is enshrined in Article 2 of the Law of Ukraine "On Copyright and Related Rights" [5]. Therefore, legal protection may be ensured if the work is expressed in any material form, allowing its use. For example, a literary work is usually recorded on paper using handwritten, typewritten or computer-aided means. A musical work may be recorded on paper using musical notation, and performance of this work - on magnetic or optical media using analog or digital recording. A sculptural work is created from material medium.

Fourth, publication of the work is any action by which the work is made publicly available. The main forms of making the work available to the public are publication, public performance, public display, announcement for information purposes using radio and television, the Internet or other means. However, none of these actions are necessary to ensure that legal protection is applicable to the work [6, p. 230].

It is interesting that literary and artistic copyright does not always coincide with the right of ownership to physical medium in which the work is embodied, for example, a literary work the content of which is embodied in a book. Thus, a separate right of ownership, right of use (lease), etc. to a physical medium in which the work is embodied may apply, but not copyright. However, sales of books, paintings and sculptures do not deprive the authors of their copyright [9, p. 233]. It should be emphasized that acquisition of copyright and its implementation are not associated with any formality.

Another conflict of law is a need to improve legal regime of computer programs. A computer program, which a few decades ago was merely recognized as a new copyright object in many countries, now can give place to the most recent object of copyright: a Web site. Academic circles are more and more confident that a Web site should be recognized as an object of copyright, along with literary, musical and other works, and a person who created it should be recognized as an author.

In most cases a Web site is created on a by-order basis by persons who have certain skills in web design and computer programming. Thus, a Web site is destined to become an object of copyright, which usually will be recognized a company's work (if the person created the site under an employment agreement) or an object of copyright created on a by-order basis (if the site was created under works (services) agreements.

As for the most outrageous infringements of rights to software, not all facts of infringements were confirmed, according to A. Zharikova. Thus, at the recent Parliament hearings organized by the Committee of the Verkhovna Rada of Ukraine for information and communication the figure of 80% of illegal software in government agencies was mentioned. We have other data: in the agencies where audits were conducted the figure amounted to 38-40%. The audit process is ongoing. Let me give you some data on the results of audits: illegal software in the State Statistics Service - 0%, in the State Agency of Fishery - 98.6%, in the State Inspectorate of educational institutions - 94.1%, in the Antimonopoly Committee of Ukraine - 16.4%, in the Ministry of Defense of Ukraine - 42.4%, in the State Migration Service - 64%.

The audit started with the State Intellectual Property Service of Ukraine to work out the plan of action. It was found 10% of illegal software. Now we (and the agencies controlled by the State Intellectual Property Service of Ukraine) are purchasing licensed software and constantly updating our "stock." In 2015, the State Intellectual Property Service of Ukraine purchased software for a total amount of 99,000 UAH.

Another aspect of the problem is a procedure and compensation for infringement of copyright and related rights. Thus, according to E. Kompanets's opinion expressed in his report at IV International Legal Judicial Forum, there is a problem regarding an ambiguous approach to calculation of property damage caused by infringement of intellectual property rights, which is one of the key aspects that gives rise to contradictory court judgments and decisions for this category of cases. The following documents were adopted under civil procedure: Resolution No. 5 of the Plenum of the Supreme Court dated 04 June 2010 "On application by courts of legislation in cases involving protection of copyright and related rights", but it applies only to the scope of copyright / related rights; Resolution No. 12 of the Plenum of the Higher Commercial Court of Ukraine dated 17 October 2012 "On certain issues of dispute settlement related to protection of intellectual property rights", which, in particular, established that when calculating property damage the courts should assume that at the time of offence one counterfeit product / copy of the work drives out of the market an original product / licensed copy of the work.

This problem is known in the field of science and jurisprudence, but unambiguous solution has not found yet. I.B. Lavrovska notes that issues resolved differently by pre-trial investigation agencies and courts include an assessment of material damage caused by illegal use of intellectual property rights. In particular, the courts assess and calculate such damage in different ways. Analysis of judicial practice related to intellectual property offences shows: different approaches and methods of calculating material damage caused by illegal use of intellectual property rights apply to similar wrongful acts under similar circumstances, which leads to unequal classification of wrongful acts, imposition of different penalties, wrong adjudication of a civil claim in the criminal case with regard to the amount of compensable material damage. She proposes to distinguish between: the amount of damages caused by illegal use of intellectual property objects; the amount of proprietary rights of intellectual property; total amount of proprietary and non-proprietary intellectual property rights [12, p. 36].

G. Androshchuk proposes to apply the principle of doubling the size of royalty to the copyright and related rights. He proposes to use double size of royalty as an appropriate measure of compensation. According to the author, this provision, as well as the principle of proportionality should be reflected in the Law of Ukraine "On Copyright and Related Rights" in the form of de lega ferenda in the case of compensation for damages caused due to infringement of intellectual property rights on the Internet. This is especially relevant in view of constant growth of the number of such infringements on the Internet [13].

From another point of view, there is a problem of terminological gaps in the current copyright legislation. Such a gap was highlighted by the Supreme Court of Ukraine in the general conclusions concerning "Application by the courts of legislation on administrative offences in the field of intellectual property (Article 51-2, 164-9 of the Code of Administrative Offences)" when interpreting the term “computer game”, which leads to misidentification of the offence object and lies in the fact that Article 1 of the Law of Ukraine "On Copyright and Related Rights" defines a computer program, not a computer game, which is not the same thing.

Computer game is created for the purpose to entertain, spend free time. A computer game may involve simultaneous or sequential operation of two or more computer programs which artificially create gaming multivariate opportunities to move to a higher level, to achieve victory in the game (or suffer defeat).

Conclusion

Thus, in the context of bringing national laws in line with EU legislation, we consider it appropriate to finalize the draft Law of Ukraine "On Amendments to the Law of Ukraine" On Copyright and Related Rights "(relating to activities of collective management organizations)" in order to protect the proprietary rights of copyright and related rights proprietors. A computer game should be given a definition and included in Article 2 of the Law of Ukraine "On Copyright and Related Rights". In addition, it is necessary to amend other acts governing liability for infringements of rights to this object. Until the definition of a computer game as an object of intellectual property rights is given and the above laws and the Code of

Administrative Offences are amended, there is no legal basis to bring any persons to administrative responsibility.

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Normative - legal regulation of inspections operators and maintenance organizations

A comprehensive analysis of normative - legal acts determining the status of state inspectors airworthiness their training and establish procedures for organizing inspections operators and maintenance organizations.

State regulation of activities in the field of aviation and airspace use Ukraine aimed at aviation security, the interests of the state, national security and the needs of society and economy in air transportation and aviation [1].

According to Article 5 of the Air Code of State Aviation Administration of Ukraine State policy and development strategy aircraft Ukraine, performs state regulation of activities in the field of civil aviation. One of the priorities of this regulation is to create conditions for the development of aviation, air transport and service, the performance of aerial work and general aviation flights. The implementation is done by:

1) the development, adoption and implementation of aviation regulations of Ukraine;

2) certification of aviation facilities and activities;

3) licensing business of providing services for passengers and / or cargo by air and providing rights for operation of the air carriers and appointments;

4) continuous supervision and inspection of compliance with the legislation, including Ukraine aviation regulations and requirements.

The feature air transport caused by social and economic feasibility of air transport, defense and security, aviation and environmental safety. Because staffing system today requires new HR technologies, especially in the selection, placement, assessment and promotion of staff at national, sectoral and production levels.

To ensure safe and reliable air transportation, aircraft airworthiness State Aviation carried on state control organizations in the form of certification and issue of the certificate, without the presence of which the activities of the maintenance of aviation equipment is illegal. The State shall exercise control and supervision of the certified inspection organization by Organizations. The organization may carry out only those activities and only on the type of aircraft, which are specified in the Certificate of organization and only at the production facilities that are certified [2].

Carrying out inspections of operators and maintenance organizations must have a legal basis, which is a set of regulations governing activities, the establishment and organization, define the structure, powers or competence.

Legal act - a written document from the competent authority which assigned mandatory rule of conduct of a general nature. He is at present the preferred source of law is divided into laws and regulations. Form of lawmaking is to develop appropriate subjects of legal norms, rules of conduct that govern various aspects of social relations developing on the inspection of operators and maintenance organizations.

Basic regulations can be divided into two levels: national and international. The national law include: ASE laws, regulations and regulatory - legal acts (CMU, presidential decrees, orders, orders, instructions, regulations, programs, etc.). In the legal field of international human rights on the organization and activities of operators and maintenance organizations there are different forms of legal documents, including: declarations, international conventions, covenants, aviation regulations, agreements, protocols, reports and statements of the Assembly and Conferences ICAO and others. These acts governing the organization of inspections.

To carry out inspections appointed Inspector - employee authorized body on civil aviation, which is empowered to verify the state of the subject and object of aviation and which has a certificate of standard pattern. Depending on the activities they are divided into: state inspectors on aviation security, government inspector's airworthiness of inspectors flight operation.

According to the Order [3] the posts of inspectors aviation oversight Airworthiness of Aircraft (hereinafter - the state inspector of airworthiness) may be in the following areas: airworthiness of such aircraft; approval of maintenance organizations, approval of aircraft equipment; Approval developers aircraft; Approval of continuing airworthiness management; issuance and review of certificates of airworthiness, continuing airworthiness monitoring and maintenance program; issuing certificates and personnel Approval of maintenance training.

State inspector on the basis of official identification and the special task of checking guided [3,4,5] has the liberty to check the work of subjects and objects of aviation activities, including foreign ones, in Ukraine Operations to oversee aviation safety and compliance with aviation regulations.

State inspector on the basis of the official certificate and a special task for an inspection shall have the right to draw up reports and to consider cases on subjects of aviation activities in the event of their offense in the field of civil aviation and individuals in case of exercise of an administrative offense, in violation of the rules relating to safety, rules of conduct on the aircraft, the rules of international flights fire safety in air transport and to impose on them an administrative penalty in accordance with the air Code of Ukraine and the Code of Ukraine on administrative Offences [4].

State inspector will document all the results of their actions in the prescribed form and a report in due time of its head of the branch or the head of the temporary working group / committee. Inspection orders issued in duplicate attached to the act of inspections and must have a registration number corresponding inspection report.

DONE act inspections in two copies, one of which is sent to the control inspection and the management of the continuing airworthiness of aircraft depending on the type of the inspection, and the second copy of the guide operator and / or maintenance organization.

Acts inspections are recorded in a log book acts inspection management inspection or continuing airworthiness management depending on the type of the inspection report.

Within seven working days after the inspection to make test results to the software system Unified Information System of the State [5].

State inspector of airworthiness conducts inspections in the field of airworthiness for the conditions of appropriate training in areas Inspector of Aviation Safety, except for aviation security.

Integration of Ukraine in the international community to contribute to the continuous improvement of legal, organizational, economic and social measures applied in the process of staff and ensuring its effective functioning. In order to implement high quality functional responsibilities Inspector airworthiness held a special professional - oriented training which includes: theoretical training in the fields; the order of the documents and equipment; practical training (training on the job) and is conducted under the supervision of public officers (instructors).

Special professional - oriented training includes the participation of the candidate as an intern in the certification and inspection under the supervision of Inspector (instructor). Detailed volume training of state inspectors in areas contained in the management of the structural units. Advanced training (retraining) state inspectors performed in certified schools every 3 years. In the event of interruption of duty Inspector of more than six months should undergo training under the supervision of Inspector (instructor-senior). Each stage of the preparation must be confirmed by a certificate and / or order.

Mandatory component in preparing qualified to carry out inspections of operators and maintenance organizations have knowledge of legal documents:

1. Constitution of Ukraine; Air Code of Ukraine; The Labor Code; The Law of Ukraine "On Principles of Prevention and Combating Corruption";
2. Convention on International Civil Aviation (Chicago, 1944) and its annexes;
3. Regulations of the State Aviation Service of Ukraine approved the Decree of the President of Ukraine on April 6, 2011 № 398/2011;
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15. Basic Course "Public Safety Inspector (Airworthiness)-18,701 engineering audit (ISO 19011).

Safety Management System (SMS), quality system, training on aircraft type. And the study of regulations on the subject of governance:

Documents ICAO airworthiness, technical requirements and accepted methods of compliance: PART 145, - PART 66, PART 147, JAR OPS 1 / Order 684 (PSE), - PART M (M / G, M / F), PART 21 ; Registration PS, SLP, Permission for onboard R / C Administrative Procedures (Handbook).

Conclusions.

Normative - legal regulation of inspections operators and maintenance organizations are organizing influence of the state, carried out by applying the set of normative - legal acts by which certain activities from the application of a single balanced approach in the work of inspectors airworthiness the division of responsibility between public authorities and business aviation activities, policies and operational procedures to ensure safety, identifying and eliminating hazards and controlling risks to ensure safety to minimize loss of life, material, financial, environmental and social losses.

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Improvement of Legal Regulation of Inspectors' Oversight over Ukraine's Civil Aviation Safety

An issue of improvement of legal regulation of inspectors' oversight of *Ukraine's civil aviation safety is still urgent nowadays. The issue under consideration is explored by researching and analysis of the current legislation of Ukraine concerning the grounds for and the procedure of the audit and inspection of the subjects of aviation operations.*

An important factor affecting the safety of civil aviation of Ukraine is a factor of stability and efficient functioning of the public authorities that regulate aviation operations, including civil aviation.

State regulation in the field of Ukraine's civil aviation safety is aimed at ensuring the protection of air transport and the performance of all the requirements of ICAO's safety-related Standards and Recommended Practices.

According to Paragraph 1 Article 10 of Air Code of Ukraine [1] aviation safety consists of flight safety, aviation security, and environmental safety, economic and informational safety.

In order to ensure the civil aviation safety the authorized body on civil aviation issues subject to provisions of Paragraph 2 Article 10 of Air Code of Ukraine [1] shall provide for the range of measures aimed at preventing of any aviation accidents, amongst which the next are of high importance «**4) providing for the scheduled and unscheduled inspection, inspecting the subjects and objects of aviation operations…»** and **«8) Imposition of fines and taking the other measures to ensure the aviation safety».**

So far, according to Paragraph 1 of the Resolution of the Cabinet of Ministers of Ukraine «On Approval of Regulations on the State Aviation Administration of Ukraine» dated October 8, 2014 №520, hereinafter - the «Regulations on the State Aviation Administration of Ukraine» [2] the authorized body for civil aviation is State Aviation Administration of Ukraine.

Exactly State Aviation Administration of Ukraine (SAAU) is the only state body responsible for safety operation of civil aviation. One of the main functions of the SAAU is the definition and distribution of tasks among experts providing state supervision and control over the compliance by subjects of aviation activity with aviation related legislation, including Aviation Rules of Ukraine.

It should be noted that currently in the regulatory field of Ukraine there is no systematic legal framework aimed at establishing a mechanism of audit and inspection of the subjects of aviation.

It is impossible to consolidate the efforts of state inspectors and persons authorized to conduct inspection to ensure the safety of civil aviation without corresponding legal framework, developed in accordance with ICAO's safety-related Standards and Recommended Practices as for inspection and audit of the subjects of aviation.

Experts of the SAAU provide the inspection and audit under the provisions of Air Code of Ukraine, Regulations on the State Aviation Administration of Ukraine and other legal acts regulating the activities in the sphere of civil aviation in Ukraine.

Despite the quite large number of legal acts governing the civil aviation of Ukraine, the main legal act in the field of civil aviation is still namely the Air Code of Ukraine.

Though the Air Code of Ukraine does not contain a special title on regulation of the conduct of inspection and audit of aviation subjects.

Article 16 of the Air Code of Ukraine [1] only states that state inspectors and persons authorized to carry out inspection under authorization document and a special task for an inspection shall conduct audit, certification, state supervision and control in compliance with the legislation, including aviation rules of Ukraine and are personally responsible for objectivity and disaffection of the inspection.

According to Clause 1.3. of the Regulations on Aviation Oversight State Inspector of State Aviation Administration of Ukraine, approved by Order of the Ministry of Transport and Communications of Ukraine, dated February 09, 2010 №68 [3] (hereinafter – «the Regulations»), state inspector – is an officer of the authorized body on civil aviation entitled to inspect the activities of the aviation activity subject and state of the aviation activity object, having the standard-issue authorization document.

Section II of the Regulations determines the classification of the positions of state inspectors.

So, according to Clause 2.1. of the Regulations there are following activity-specific positions of state inspectors:

- aviation safety oversight state inspector;
- airworthiness of aircraft aviation oversight state inspector;
- flight operations aviation oversight state inspector.

But, in order the above inspectors, being in the appropriate office specified in Clause 2.1 of the Regulations, were entitled to conduct inspection in their field of activity, they shall have a special authorization document (a kind of «license» or «permit»), which is referred to in the Annex to the Regulations where «the authorization document number is a personal number of state inspector, consisting of a five-digit number where the first digit identifies the activity type of the inspector, and the remaining four - serial number:

10000 - flight operations state inspector;

20000 - airworthiness state inspector;

30000 - aviation safety state inspector».

Such Authorization document is issued to the state inspector for up to 1 year term.

Thus, the Regulations explicitly provides that the airworthiness state inspector shall inspect in the sphere of airworthiness, and flight operations state inspector in the sphere of flight operations, and only after a corresponding training – as an aviation safety state inspector, except for aviation security.

Clause 4.1. of the Regulations states that training, retraining and refresher training of activity-specific state inspectors shall be carried out by certified in Ukraine educational institutions of civil aviation and international organizations. As a rule initial training of inspectors is carried out by the institution certified by ICAO - the ICAO Training Institute National Aviation University.

The fact of the training enables the airworthiness state inspector or flight operations inspector to carry out inspection as the aviation safety state inspector.

Thus, the classification of the positions of state inspectors allows them to carry out inspection and audit, taking into account the focus of their activity, which should provide a high-level control and oversight over the engaged aviation activity subjects.

At the organization of control and oversight the experts of SAAU should at first use the latest information technology, not to carry out inspection and audit pursuant to practice and experience of previous decades and materials of official investigations carried out with their participation. SAAU shall provide inspectors with appropriate regulatory instruments for verification of Safety Management System (SMS) of aviation activity subjects, in particular, the appropriate Manual and/or Instructions on procedures for conducting inspection or audit of aviation activity subjects, including the remote one.

We can share the conclusion of B.N. Dudyshkin that an internal investigation is a type of administrative process – positive enforcement in the field of safety of transport operation. Since it stands out among the other positive procedures for its specific characteristics [4; p. 40].

The object of legal relations within official investigation in the field of civil aviation, under Paragraph 4 Article 119 of the Air code of Ukraine [1], is the fact towards which the investigation is being conducted and the fact that resulted in ascertainment of guilt and the decision on bringing the subject of aviation activity to responsibility. It is impossible to make a decision on imposition of penalties or relief of the subject of aviation activity of liability without such internal investigation.

Therefore, establishing the fact of law violation in the field of civil aviation the experts of SAAU need to evaluate each of a set of interrelated legal relationship and a selected law violation.

Examining the causes of the law violation experts of SAAU need to obtain all the necessary evidence to confirm the relevant fact. Such evidence can be explanations of witnesses, the analysis of data obtained from Ukrainian State Air Traffic Service Enterprise, interpretation of data recorder and etc.

Thus, SAAU will have all legal grounds to establish fault and the decision on the existence or lack of grounds for bringing the subject of aviation activity to responsibility only based on the results of internal investigations conducted with participation of experts of SAAU (which should be issued as a separate act), a documentary set of documents on the results of the inspection or audit, including the remote one, and the relevant Minutes.

Currently there is no regulatory legal act, providing for obligatoriness of instruments of investigation when carrying out audit and inspection of subjects of aviation activity, which results in the fact that experts of the State Aviation

Administration of Ukraine establish the guilt of a subject of aviation activity and bring it to responsibility without the availability of all necessary evidence.

Summary

An important direction of improvement of legal regulation of inspectors' oversight over the civil aviation safety is the development of regulatory-legal acts particularly regulating the order of carrying out of inspection and audit of subjects of aviation activity by state inspectors of the State Aviation Administration of Ukraine and persons entitled to conduct audit.

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Analysis of the peer-reviewing process of the manuscripts being submitted to the research journal TRANSPORT

The paper presents a short history of the science journal TRANSPORT. In addition, the topics of published scientific papers and the structure of the editorial board are presented. The reviewing process of submitted manuscripts and its peculiarities are described.

Introduction

At present, transport is one of the key branches playing a crucial role in the development of economy. Reliable and properly organized transport services are required for a professional performance of industry, construction and agriculture. The public mood and efficiency of work also largely depend on the valuable functions of a carefully chosen transport system. A steady increase in transportation is accompanied by growing demands for a higher quality of transport services and optimum efficiency of transport performance. Currently, joint efforts taken by the transport experts and governing institutions of the country are required to develop and enhance the performance of the national transport system conducting theoretical and empirical research. Scientists are publishing their research findings in various scientific journals and TRANSPORT journal (*http://www.transport.vgtu.lt*) is one of them.

Brief History of the Journal

The research journal TRANSPORT has been published since 1986 under various titles:

- 1986–1991 – Proceedings of the Higher Schools in Lithuania: Автомобильный транспорт / Automobilių transportas (Automobile Transport);
- 1992–1994 – Proceedings of Vilnius Technical University: Transportas / Transport Engineering;
- 1995–2002 – Research Journal of Vilnius Gediminas Technical University and the Lithuanian Academy of Sciences: Transportas / Transport Engineering / Транспорт;
- 2002–2005 – TRANSPORT.

Since 2011, research journal TRANSPORT is published by Vilnius Gediminas Technical University in partnership with Taylor & Francis and Lithuanian Academy of Sciences.

Over time, the title of the Journal changed, but despite various periods and publishers, the research journal TRANSPORT has remained a flagship among the journals of the Baltic Region and in the world.

Aims and Scope

The journal continues to offer scientific papers on transport engineering, transport management and transport economics aiming to find the best solutions that would make all traffic participants safe, process fast and use technology smart and friendly to both customer and environment.

Therefore, papers are welcome on the following fields of research: transport policy; fundamentals of the transport system; technology for carrying passengers and freight using roads, railway, inland waterways, sea and air transport; technology for multimodal transportation and logistics; loading technologies; roads, railways, airports, ports; pipeline transport; industrial and technological transport; agricultural motor vehicles; traffic safety and environment protection; motor vehicles: design, manufacture and exploitation; transport energetics; fuels, lubricants and maintenance materials; teamwork of customs and transport; insurance; transport information technologies; transport economics and management; transport standards; transport educology; transport history. Beside papers, the journal also publishes review papers and book reviews.

Structure of the Editorial Board

Since the beginning of the history of the journal, the status of the Editorial Board evolved from national to international. Currently, the Editorial Board has 46 members from 19 countries. 15 members carry out research in transport engineering and transport management fields and represent the largest Lithuanian universities and companies, while 31 members are from research institutes or universities from other countries.

Description of the Peer-Reviewing Process

TRANSPORT is a peer-reviewed research journal. To peer-review manuscript submissions, the research journal uses the interactive system *ScholarOne Manuscripts* (formerly known as *Manuscript Central, http://mc.manuscriptcentral.com/stra*).

All peer-reviews are double-blind. Using double-blind peer-review system, neither reviewers' nor author's identities are revealed to the other party to ensure the quality of research published in the Journal.

Analysis of the Peer-Reviewing Process

All manuscripts submitted through *ScholarOne Manuscripts* are peer-reviewed by members of the Editorial Board or appointed experts. The minimum number of score sheets (peer-review forms filled by reviewers for each submitted manuscript) amounts to 3 and the average number of score sheets (peer-review forms) is 3.6 in 2011–2016.

Decision ratios of submitted manuscripts in 2011–2016 (source: TRANSPORT *ScholarOne Manuscripts*, data until 31 July 2016) are presented on Fig. 1, acceptance ratio – on Fig. 2 (source: TRANSPORT *ScholarOne Manuscripts*).

A distribution of authors by countries (co-authors), who published papers in the research journal TRANSPORT, during the one artificial year of the period 2011–2016, is presented on Fig. 3; a distribution of papers by countries, published in the research journal TRANSPORT, during the one artificial year of the period 2011–2016 is presented on Fig. 4 (source: TRANSPORT *ScholarOne Manuscripts*).

Percentage distribution of score sheets (peer-review forms), submitted by reviewers, by countries during the one artificial year of the period 2011–2016 (source: TRANSPORT *ScholarOne Manuscripts*) is presented on Fig. 5.

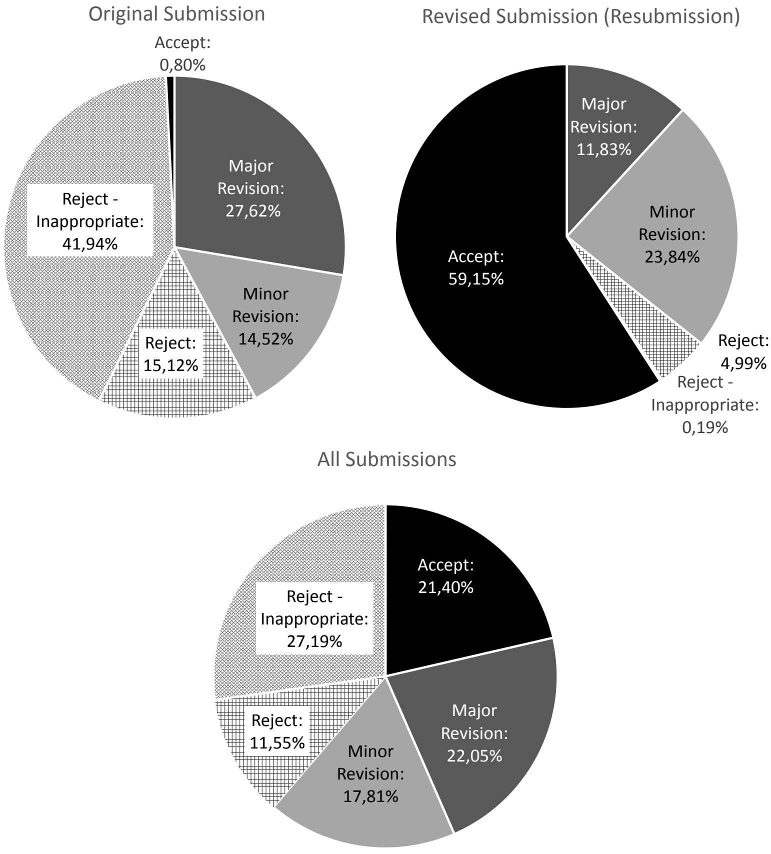

Fig. 1. Decision ratios of submitted manuscripts in 2011–2016 (*note:* ‘revised submission’ follows ‘minor revision’ or ‘major revision’ after ‘original submission’)

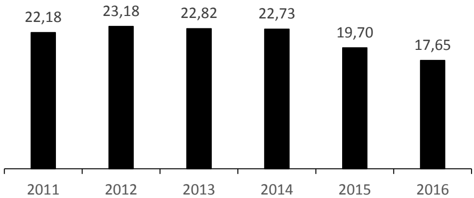

Fig. 2. Acceptance ratios (in percent) of submitted manuscripts in 2011–2016

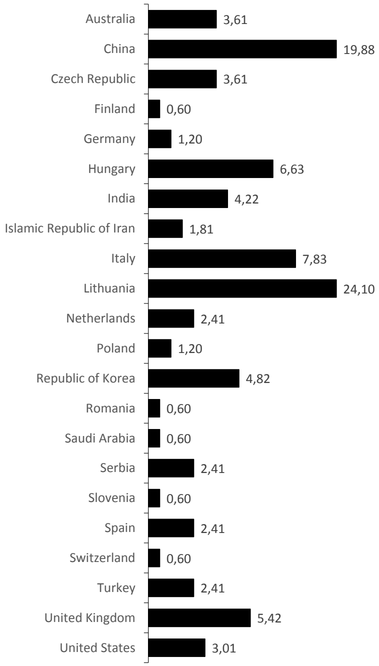

Fig. 3. Percentage distribution of authors (co-authors), who published papers in the research journal TRANSPORT, by countries, during the one artificial year of the period 2011–2016

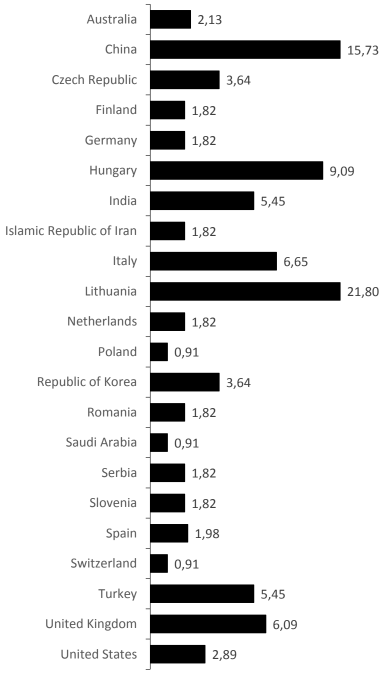

Fig. 4. Percentage distribution of papers, published in the research journal TRANSPORT, by countries, during the one artificial year of the period 2011–2016

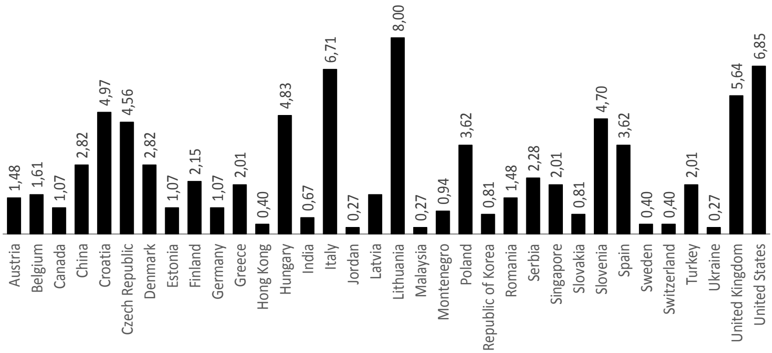

Fig. 5. Percentage distribution of score sheets (peer-review forms), submitted by reviewers, by countries, during the one artificial year of the period 2011–2016

Conclusions

Over time, the title of the Journal changed 4 times but despite various periods and publishers the research journal TRANSPORT has remained a flagship among the journals of the Baltic Region and in the world.

The Editorial Board of the research journal TRANSPORT is international. It consists of scientists from Lithuanian institutions (32,6%) and from foreign ones (67,4%). According to the recommendations of international journals editions, there should be less than 30–35% of scientists from the same country in the Editorial Board.

To peer-review manuscript submissions, the research journal uses the interactive system (obligatory to international journals). All peer-reviews is double-blind (recommendable to international journals).

According to percentage distribution of authors (co-authors), who published papers in the research journal TRANSPORT, by countries and according to percentage distribution of papers, published in the research journal TRANSPORT, by countries, the attention has to be paid to the Lithuanian (21,80%) and Chinese (15,73%) scientists who are publishing the largest amount of papers. According to the recommendations of international journals editions, this rate does not exceed 25–30%.

Acceptance ratios of submitted manuscripts vary within the 17,65–23,18% limits in five years. The observed decreasing tendency of acceptance ratio means that the reviewers are working more carefully with submitted manuscripts. According to the recommendations of international journals editions, the acceptance ratio has to be kept to a minimum and range up to 25–30% of the submitted manuscripts.

The success of the journal depends on the relevant researches, which are published in qualitative journals after peer-reviewing, also the acceptance ratio, the percentage distribution of the scientists, who submit manuscripts, by countries, reviewers and etc.

UDC 629.7.072.8

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Application of modern computer technologies in systems of preparation of communication aviation experts

The analysis of efficiency of existing aviation trainers apparatus of communication and feature of their application for training is resulted. New concepts of a computerization of vocational training of aviation experts by means of "total" computer-assisted systems of preparation on the basis of modular construction of means of training are considered.

Last decade training simulator building and practice for application of aviation training apparatus of communication have a number of problems and difficulties [1].

Problems and difficulties and increasing of cost of complex aviation training apparatus of communication of the traditional centralized architecture, constructed by a principle of the "simplified" imitation. At such architecture of complex aviation training apparatus of communication their modernization is complicated, technical operation demands considerable expenses that updating of training park brakes.

Problems and difficulties and increasing of the aviation complexes simulated in aviation training apparatus, increase the software volume of onboard complexes and avionics systems. Besides, by theoretical preparation of experts dominating until recently by means of traditional means of training there was a rupture between pertaining theoretical preparation and practical training preparations. The experts who have passed theoretical training, had at transition to training preparation a feeling of insufficiency of the knowledge, their separation from real requirements and did not understand difficult "organism" of aviation training apparatus, mechanisms of their functioning.

The disadvantage of existing system of preparation, including trainings on aviation training apparatus of communication, limitation of databases of means of training of traditional type was also.

These disadvantages and difficulties have caused working out and realization of new concepts in training simulator building and computerizations of vocational training of aviation experts. In particular it is incarnate a tendency of transition from creation of separate training apparatus of communication to creation "total" computer-assisted systems of preparation of experts on the basis of modular construction of means of training from the micro-computer and local networks of the micro-computer. In them the micro-computer, microprocessors, single-crystal computers are the hardware modules of means of training of modular structure. However the modular structure of training becomes a progressive method only under condition of working out and realization, "fast" algorithms of imitation of various processes and systems [1]

The modular structure provides possibility concerning easy modernization of aviation training apparatus of communication and escalating of their imitating possibilities, reduction of terms of working out, reliability increase, decrease in expenses for technical operation of aviation training apparatus, sharp reduction required areas for placing, depreciation of aviation training apparatus.

Implementation of these concepts will create a new generation of highly technical training. However a necessary condition for this purpose is essential development of theoretical bases of aviation training apparatus and systems of a computerization of vocational training in general. The matter is that till now in the field the complete theory is not present. There are only theoretical bases of separate simulators, fragments of means of training and the skilled data [1].

The problem is highly complex computerization of training can not be solved without an organic process matching education and training with the natural structure of cognitive and sensorimotor human activity. This requires both substantive and formal descriptions of such structures. The latter is associated with the use of the latest methods of optimal control theory. Therefore, the modular structure of technical training becomes a truly progressive method only if the synthesis of new fast algorithms for the simulation of different processes and systems.

Another very perspective direction aviation training with the help of computer technology are integrated training system (a set of reference and training systems).

Assigning of complex training system as follows: the total volume of training knowledge of the appointment construction and operation of communication systems; management training from regular resources management systems complex radio engineering systems in operation; Learning to manage these systems in an emergency; ensuring sustainable knowledge and skills; development of the necessary responses to perturbations of various kinds; ensuring optimum interaction of instructors and trainees. Creation of educational and reference system is carried out according to the following algorithm: defined area of expertise; created a scenario; collects materials on the script and layout, integration of textual and illustrative information; typeset and create interactive animations; integrated teaching ready-reference system, providing a predetermined fullness of presentation material (text and illustrations) on a given subject area [1].

The work of teaching and help system is organized on the basis of multimedia technologies. These technologies provide: a predetermined fullness of presentation material; free choice of the direction of the study (at the expense of flexibility hypertext); presentation of text and illustrations; view videos explaining the device communications systems of work; animated presentation of illustrative material (allows interactive communication with the student of the course); sound material studied; printing set the course for in-depth fragments of independent studying, tests of knowledge and modes independent exam.

Educational and reference system can serve as a reference in the practical activity of the student [1].

Full testing of conceptual logic and motor skills with on-board communication equipment is made in the mode of use of mathematical and computer models (mathematical models of systems of communication, radio navigation; computer animated models of standard panels, keyboards, control and management; Mathematical models of the emergence of complex emergency situations; staff model systems onboard complex control algorithms, etc.). The combination of these models forms the training systems of the whole complex on-board equipment of the aircraft [1].

In training mode with mathematical and computer models of the learner have the ability: to trace the operation of the systems of systems in normal mode and changes in their work when changing technological modes; to control operation of the control system of complex engineering to simulate disturbances; select and implement with the help of computer models of standard controls the desired mode of operation of technological systems; to follow the work of on-board equipment under the action of complex emergency situations and eliminate these situations, following defined procedures; be convinced of correctness implementation of action by registering the student actions and comparing them with the reference; receive an assessment of action on the part of the instructor.

Complex training system can be used in two ways. Firstly, the educational and reference system in educational institutions and businesses to obtain the necessary technology management skills of any complexity. Secondly, as the actual training systems: to develop sustainable logic and motor complex technology management skills (aerospace, aviation, nuclear and thermal power plants, petrochemicals, etc.).

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Problems to create model of education manager

Professional career of education manager confronts in front of man the high social, psychological and physiological requirements, because "people management is one of the most difficult types of work, which actualize its subject-object properties that are directly related to communication."

Education manager- a man at the same time, the individ (representative of the human race) and the individual. In its combination the individual properties and the properties of the individual personality create individual of each person.

In our view, the most clearly presented the relationship between individual characteristics and personality was developed by N.M. Kolomynskym in his model of the individual personal properties of an education manager (head) as the subject of administrative activity.

Among a number of requirements that they put the present in the activities of the manager, it is advisable to allocate some varieties that are characterized by a focus on the specific skills inherent for effective managers: diagnostic, prognostic, design, coordination and regulatory (organizational) communication, motivational, emotional and volitional, evaluation, cognitive (Gnostic), linguistic, moral, physiological, physical.

The above requirements outline a set of skills that are necessary professional head of educational institution to perform management functions. These are: diagnostic, prognostic, design, organizational, communication, comparative evaluation, gnostic, emotional and volitional .In each of these groups can be determined the most important psychological component that is professionally important qualities (PIQ). Thus, a group of diagnostic abilities, as the study shows - is analytical and synthetic thinking ability; group forecasting and design - design ability, anticipation; group and organizational communication - altruism, empathy, reflection, group comparative evaluation - critical intelligence, comparison; Gnostic group - flexibility and depth of thought (academic ability); group of emotional and volitional - social energy, internality, etc. Studies have proven that it is the presence of these qualities combined in a unique ensemble focus on organizing human activity is a psychological basis for the successful implementation of its functions an education manager and the perception him by his subordinates as the leader of the team. The questionnaire of teaching staff of the education system on personality traits that interfere a leader to lead, found that the most significant are the negative features are as follow:

1) According to inspectors opinion, the heads of departments of education (district and city) - rude, tactless - 34%; incompetence - 21%; inability to organize the department - 18%; lack of rigor - 10%; lack of initiative, the softness of nature, subjective attitude towards people and their deeds - 8%; inability to pursue

the case: the inability to defend the interests of the team; arrogance, conceit, lack of discipline - 6%; formal, superficial attitude to work - 3%.

2) Directors of schools - shyness - 38%; diffidence - 32%; lack of competence - 15%; no principles, conceit - 7%; inability to pursue the case - 5%; distrust to the team members - 3%.

According to approach that was expressed by following specialists S.L. Rubinstein, B.G. Ananiev, V.S. Merlin, the overall structure of human relationships and the development of its properties include the relationship of identity as individual, the subject of activity and personality. In general terms, an education manager personality - a special presence. unique characteristics, traits, qualities, properties. In terms of "depth psychology" to individuality belongs not only conscious but also unconscious in the individual.

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On the issue of establishment of the project of happy person

Sometimes happy life understood as an objective, pre-programmed process as "good fortune." In ancient Greece the fate was personified, and it impacted names Adrasten, Ananke, Ate, Atropos, Moira, Tyuhe (Tyhe) Heymarmene. In ancient Rome called fate Parky, Fortuna. Mentioned contemporary mythology characters often were considered not only goddesses of fate and happiness. According to this point of view, some people just have to be happy. This is not the only concept in which the concept of "happiness" characterizes all human way of life. Most of the concepts used this term to characterize its individual parts, episodes, the individual facts of life.

About the impossibility of unambiguous interpretation happiness wrote many thinkers. Thus, according to the German philosopher Immanuel Kant (1724-1804), there can be no happiness in relation to the imperative that is ascribed to do what makes happy. Often according to these arguments are not talking about happiness as a manifestation of moral consciousness, but of its objective basis, that is what makes people happy. Happiness is correlated with the meaning of life. Almost everyone finds in happiness the ultimate goal of their efforts. Sometimes happiness is understood as fortuna, that means random, often undeserved receiving benefits (winning the lottery, receiving inheritance, finding treasure). And if in the real sense of happiness a person experiences satisfaction with their lives, in this case, bring the joy of real objects that change her life for the better. So have been right Roman Stoic philosopher Lucius-Annaeus Seneca. Happiness is a state of being and satisfaction with their lives. To achieve this should not be a success in the areas of life in society. The main thing is achievement at the main and determining.

In time periods of happiness man perceives the world differently. There are factors of happiness, their two groups, which creates a subjective and objective man himself and which are beyond his will. Subjective factors - human belief, his hobbies and interests, and more. Objective - a natural environment, human health, appearance, temperament. Happiness - the highest state of of internal conditions of human existence, completeness and meaningfulness of life, the realization of their human purposes. The objective basis of happiness is the measure of human virtue, the totality of the factors that determine its well-being (health, material wealth, luck, etc.); satisfaction with their lives, his understanding, the pleasure of the achieved goals and dreams; a special mental state, a complex set of human experiences the highest satisfaction with their lives. "Happiness - according to John. Locke - in its full value is the highest satisfaction, to which we are capable, and destruction - the highest of suffering." We can live meaningful, creative life but not experience such intense feeling that there is a sense of happiness.

The project how to achieve happiness includes requirements and efforts: the presence of his desire to achieve; intentions clear - if we know what we want we can have it all; conviction - people reach that can reach; action plan to achieve the goal -

developed strategy and action plan devised; patience and perseverance - it's needed to be persistent; faith - it's need to think positively and believe in success.

With happiness is connected the achievement of the goal. These images are accompanied by feelings of foreboding happiness, it affects the achievement of life goals and motivates people to work. Namely happiness as a result of these activities can make a person passive for some time. Man to be focused on universal values can be happy. One of the prerequisites of happiness is personal fulfillment. Each has its individual life plans that wants to implement in their work, because happiness of each person is individual and unique. Man's ability to experience a feeling of happiness and nature of the experiences depend on its outlook (ideals, understanding the meaning of life, the destiny of man) and many other subjective factors (temperament, character, life experience, skills, it can realize). People with cheerful nature perceive the life otherwise than gloomy nature people. The desire of happiness is another main source of energy to achieve meaning in life personality. Man can not be happy without understanding the meaning of life.

The project happy people envisages mutual consistency of the main forces of the human soul together, harmony with others, harmony with the environment, the friendly attention to what surrounds us, from high and significant up to the smallest detail of life.

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Public activity of student organizations abroad

Public activity of higher educational institution - is the realization of democratic principles in the structure, functions, forms, methods of joint activities of public institutions, professional organizations and associations of higher education institutions; commitment of public universities, based on voluntary establishing its community socially important duties administration, faculty, staff and students taking to account a specific region and the political and social situation of the state.

Public activity of student youth - a job outside the university, focused on the tasks of a public nature among the population, meet the pressing needs of social life, namely, political and educational, cultural, industrial and educational work. To the forms of public activity is belong a charity, creation of student public organizations.

Charity, and benefaction - selfless assistance to those in need who are not related to the benefactor. Charity is based on a voluntary and professional work of philanthropists, charitable organizations and foundations focused on support and improve society, its individual segments or individuals.

Student public organizations - an association engaged in multifaceted activities and occupy a prominent place in the youth movement in Ukraine. Student organization - one of many social institutions that can accelerate the formation of social activity of youth. They occur at the initiative of students and contribute to solving urgent problems of boys and girls. His activities attracted the attention of the student government bodies and the public to the needs of students, encourage the optimization of finding ways to improve the state youth policy, stimulating the society changing taking to account demands and needs of young people.

Scientists M. E. Murray, K. Ryan are focused on examination of traditional approaches to the educational process at American universities and the development of new teaching and educational programs.

Extracurricular work of American colleges and universities aimed at the education of students in the system of student organizations, through their active public work, which focuses on the formation of a tolerant member of the multicultural society of charity that fulfills the mission of "service to society" and guided by such moral values as good conscience, truth, honesty, justice, commitment to social harmony, high respect for the law, tolerance, patriotism and willingness to defend the country, the desire for national unity.

Modern development of the public sector in the United States shows the actual formation of the homonymous economic field, so it is significant. Thus, in 1999, the American public fund owned assets amounting to more than 330 billion dollars and more than $ 20 billion [1] distributed annually to support educational, humanitarian and cultural activities. [3] If in 1986 the amount of donations in the US was 83 billion dollars in 1996, the same item of expenditure was 150 billion, and in 1999 - already 190 billion dollars. This shows that charity is part of the American culture and an expression of confidence in the individual and his initiatives. In terms of total separation of these funds shows that 43% were for the Church and for religious purposes, 14% - to education, 9% - for health care, 9% - for other services designed for people, 6% - for art and culture, 3% - on the environment, 1% - on international affairs and 15% - for other cases.

Public activity of student organizations is the attraction of students to the "free labor", which is mainly realized through the use of the program "service - learning». This program combines academic activities of students with provision of necessary services within a community unites education and social work to further enrich the professional experience of students, encouraging them to public activity and strengthen communities for the common good.

Application methods "Learning and Service" in the colleges and universities in the US began in the XIX century, but most promoting its use can be seen in the 1960s, 1980s and today. The civil rights movement in the 1960s, the formation of the Peace Corps in 1961 and the creation of VISTA (Volunteers in Service to America) in 1965 was the impetus for the education of active, conscious young people who wanted to change the world. Thus, there is a need for a program that would combine teaching students with their employment and solving the real problems of their future profession. Thus, in 1969, American educators met in Atlanta, discussed the necessary components of the new program, analyzed its strengths and weaknesses and emphasized its obligatory use in the educational process of all US universities. So, the conclusions of the conference in Atlanta were declaring:

- all US universities should encourage students to participate in community volunteer work and convince them that perform public tasks are an integral part of academic learning;

- all universities, along with US private organizations, local, regional and national authorities should provide financial assistance to students who wish to engage in social activities;

- students, private and public employers and educational institute authorities are required to participate in the planning and implementation of community service for the local community.

Ukraine, its educational system, feels an influence of culture, values, social norms of training and education of foreing countries, one of which is the United States.

The Law of Ukraine "On Public Associations", which regulates the activities of non-governmental organizations came into force in 1992. Today in Ukraine there are more than 40,000 such organizations. It would seem that social movements are becoming more influential and important. However, all the experts say about weakness and non-formation of civil society in Ukraine. Recently, according to researchers, the work of only 5000-6000 Organizations was prominent [2].

The combination of educational activities with the public work is one of the effective methods of modern public upbringing, which should be widely used in extracurricular activities of higher education institutions.

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Influence realities of today on the formation of bases training future managers of marketing activities

The realities of the present, characterized by the competition of economical systems for gaining of world market environment, foresee implementation of the aspects of specialists' training, its structural and organizational components. At the same time at different levels of the analysis of basic information flows to assess the characteristics of marketing activities of non-commercial transfer of educational technology that foresee the identification of priorities within the opposition and interaction of strategies, the fighting of meaning in the formation of future professionals.

Despite the variety of types of states in the world, the current state of understanding of the market environment involves the use of conceptual approaches to liberal values, the cornerstone of which is to obtain a predetermined rate of profit. For the latter to compete for mastery of commodities and services are used high-tech products and related concepts of innovation, intellectual property and technology transfer.

Basis of such approach is taken by the highest management of the country with his understanding of specific national features. This basic information streams arising from the speeches at the highest international level that are heard from the stands of global international forums, there is the concept of progress, sustainable development, the priority of international law over national law, and in the total transfer sovereign rights of this or that state to the transnational structures of decision-making and management. And in the struggle of meanings and in view of the above principles is applied Protestant influence in the area where the population is a priority for basically the traditional Orthodox, partly Catholic Christianity, and to a lesser degree other concepts.

Traditionalism and basically sociologization of attitudes of the general public regarding the joint management of the economy, and liberal views of management to manage the higher level of the country is in conflict, which manifests itself in the imbalance of information flows. This in turn leads to cognitive dissonance of middle managers, who in a state the latter essentially being between a rock and a hard place, no longer perform their functions efficiently to ensure the free movement of goods, services and labor to obtain advance given rate of return profit and a just distribution of its share to the social needs of the population.

So there is a gap of natural relations for sustainable development, which is linked via the formulated by author the basic tenets of the concept of the five D, namely desinformation, debilization, deindustrialization, degradation, depopulation. Detailed analysis of each of the postulates gives clear understanding of future negative consequences of each of them at some point, the vision of its prevention, and in the case of establishing - the ability to input of the preventing events, to bring the situation in the state stabilization and output it to the positive trend, and all abovementioned are the foundation of formation requirements for training professionals, particularly managers in marketing activities.

In this context, formed the theoretical and methodological basis of training future managers to marketing activities as a pedagogical problem, the aim of which is to deliver knowledge of a particular network layer, on the one hand, to clearly formed the vertical of global governance, on the other hand, as well as the harmonious combination of these not equivalently big parts for holistic perception of the world through the essence of the concept of training, grounding of aim-principles, characteristics and analysis of content of training future managers as the subject of marketing activities.

UDC 378.001.895 (043.2)

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Innovation in Higher Education as a Condition for Integration into the Common European Educational Space

The position that the effectiveness of the training of future specialists depends on a complex of pedagogical conditions, including those productive methods and technologies that provide achievement of targeted educational goals, and obtaining of educational content according to national and European standards and principles of quality assurance with a view the requirements of the labor market, was substantiated.

The Law of Ukraine "On Education" adopted by the Verkhovna Rada of Ukraine in 2016 defines the international integration and the integration of the educational area into the European Higher Education Space as one of the state priorities in the higher education area under the preservation and the development of the achievements as well as the progressive traditions of the national higher school [1]. This process is multifactorial and involves the introduction of the European standards and principles as well as mechanisms of quality assurance to meet the requirements of the labor market for the specialists' competencies, to guarantee quality, correspondence of the national educational sector with the European higher education, to promote the cooperation with the European educational institutions. An important condition for the integration of the national systems of higher education to the common European educational space is the ability of schools to provide qualitative educational services. The modern higher education establishment should not only ensure the organization of educational process and getting higher education by the students based on their interests and abilities, but also to perform innovative methodological work.

Therefore, an innovative part of the educational process is especially significant. It is designed on the basis of the modern methods and techniques of teaching as well as the organization of the students' research work, aimed at the formation of the future professionals' core competence.

Professional competence is featured by the extensive knowledge of fundamental and professional disciplines, highly developed skills of lifelong self-education, high level of handling professional technology, ability to concentrate and effectively apply knowledge and skills as well as synthesis methods to solve non-standard problems that arise in the professional activity [2, p. 92]. A necessary condition for the development of the future professionals'creative potential is to encourage students' divergent thinking aimed at the variability of the search for the optimal solution of training and production problems. The basis for the formation of divergent thinking is autonomy in educational and cognitive activity, criticism, the ability to accept new ideas and recognize one's own mistakes.

In the teaching practice of a higher vocational school, a variety of methods and forms of teaching and learning of students is applied. They are classified according to various criteria, for example, didactic purposes, methods of teaching, level of activity of the educational process subjects, the degree of their involvement in productive activities. The traditional methodological systems of training future professionals consider a student as an object of educational impacts. A crucial role in ensuring the effectiveness of the educational process is played by a teacher who is the main source of knowledge assimilated by a student along with a textbook. Teaching methods that provide such educational models are called reproductive (for instance, traditional lecture, explanation with demonstrations, reproductive survey). Reproductive tasks usually do not provide students' independent activity, and their solution is ensured by a sample.

Innovative training is organized in the way to make students most involved in the cognitive activity, demonstrate autonomy and creativity in solving educational problems. A feature of interactive learning is permanent active cooperation of all subjects of the educational process. Modeling true-to-life situations is covered; different ways of activity focused on the common solution of problems are followed. Interactive training promotes the formation of the professional competence, skills, and abilities which are important for the future production activities, values, atmosphere of cooperation, and interaction. In this way, the role of a teacher whose functions vary qualitatively from the source of right knowledge to the coordinator of pupils' cooperate teaching and learning fundamentally changes [3, p. 7]. Interactive learning technologies are classified by the form of educational activity they implement: pair (each participant of the educational process works with a teacher or another student), front (one teacher trains a group of students), group or cooperative (subjects of the educational process actively teach each other), students' individual (independent) work [3, p. 13].

Educational technologies, methods and forms of active learning, which are oriented at the means of computer support for the courses, educational resources in the Internet are widespread. For example, the technology of the mass open social learning provides for not only the use of open online courses (video lectures and broadcast of teaching a huge number of people), but also the organized peer learning network. Under the growing share of students' independent work, the so-called "inverted" exercises, which provide for the independent studying of the theoretical and lecture program, and the thorough consideration of the tasks and the exercises on the corresponding topics in a classroom can be quite efficient. The technology of storytelling ensures proper logical structuring of academic topics, applying appropriate effective methods, applications and services that make it possible to represent a theme not only in the form of lectures and presentations, but also, for example, a comic book or SMS messages. In a developed information educational environment, a bricolage is becoming quite popular; it is an organization of study that does not require a classical textbook as any information resources are used along with the specially designed tools, such as textbooks.

The effectiveness of any educational technology is predetermined by the didactic conditions that cover a wide range of factors: from the logistical support of the educational process to the level of the development of the students' key and core competencies which start to be formed at the comprehensive secondary educational schools.

An effective type of interactive learning is situational modeling (simulation or role-playing). Their goal is the student's acquisition of skills and abilities, taking part in the functioning of the public institutions, which are related to their future professional activities and decision making. Students are suggested a description of a situation that is developed on the basis of the sufficient and reliable information. If the situation requires consideration of different positions and the need to choose, it is advisable to consider such key points as the general context of dilemmas, analyzing the peculiarities of the offered choice, availability of equivalent arguments of the polar choices, the clear demand on the choice of the solution variant.

The effectiveness of a business game largely depends on the availability of the sufficient information and clear guidance for the participants of the small groups, that provides an opportunity for the students to play the upcoming roles impressively and to acquire the skills of professional activity, that is, to learn. In order to achieve the planned educational purposes it is necessary to provide enough time for the students' self-study of the simulation situations, the choice of methods for its analysis and interpretation, selection and preparation of comments, justification of the solution choice. In the small groups, preliminary discussions about the content and the implementation details of the business game are quite constructive. It provides an opportunity to study various aspects of situational simulations, exchange experiences, forecast the possible mistakes and identify the ways to avoid them.

Teacher's readiness to implement innovations is important in ensuring effective implementation of innovative technologies. In particular, the level of professional, technical, information and communication competence, academic mobility and academic freedom of a teacher are significant. Modern educational technologies include the increase of self-learning, which in its turn, raises some new requirements for its self-educational competence, initiativeness, motivation for training and learning activities.

Under the trends of the European vocational education, which is considered as a factor of sustainable economic growth, a special value is given to the adaptation of educational programs to the needs of students, flexibility of training offers and their module nature, an increase of the level of informal and spontaneous learning [4, p.7-9]. These objectives correlate with the capabilities of innovative technologies, which focus on the productive teaching and learning of an individual, stimulating thinking, cognitive area, active life philosophy. Accordingly, effective implementation of innovation in the higher education brings it up to the European standards.

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Contemporary Approaches of Foreign Students Propaedeutic Preparation

The paper under consideration deals with the urgent issue of mastering professional competence of foreign students in the high establishments. The necessity, the specific role and some propaedeutical (pre-university) problems of foreign students training to study at the Technical University of Ukraine have been analyzed on the theoretical as well as on the practical levels.

Training of foreign students in higher educational institutions of Ukraine is a process that differs in certain specific and is in direct proportion to the propaedeutic training that is undertaken at the preparatory faculty (PF) for foreign nationals. The feature of the first-year foreign nationals is that having received education in their home country, they should be for one academic year to learn the language of general subjects to the extent that allows them to continue getting a higher education in high institution of Ukraine.

Sustainable development and operation of propaedeutic training in modern conditions involves clarifying its role and goals, as well as focusing on the formation of its content. Propaedeutic training, which is one of the steps of a continuous system of higher education, has its specific features that determine the activities of preparatory departments. It is important to point that a foreign citizen arrives to study in the condition of stress and tension, so it is necessary to create such psychological and pedagogical conditions for him, in which he is able to take an active position and modify to the subject of learning from a passive observer. This is exactly one of the main peculiarities of propaedeutic study at the university. As a result, learner’s role in modern terms can be expressed as the transformation of acquired knowledge and skills into shaping of the mental personality traits, ensuring the successful continuation of studies at the university.

To convert previously obtained knowledge, developing new skills necessary integration propaedeutic foreign students present a holistic, complete pedagogical process technology, which should be distinguished:

Training of foreign students in higher educational institutions of Ukraine is a process that differs in certain specific and is in direct proportion to the propaedeutic training that is undertaken at the preparatory faculty (PF) for foreign nationals. The feature of the first year of foreign nationals is that receiving education in their home country, they should be for one academic year to learn the language, which will study general subjects and to the extent that allows you to continue getting a higher education institution in Ukraine.

Sustainable development and operation of propaedeutic training in modern conditions involves clarifying its role and goals, as well as focusing on the formation of its content. Propaedeutic training, which is one of the steps of a continuous system of higher education, has its specific features that determine the activities preparatory schools. Please note that a foreign citizen coming to study in stress and tension, so it is necessary to create such psychological and pedagogical conditions in which he is able to take an active position and a passive observer as the subject to reveal learning. This is one of the main differences propaedeutic study at university. Hence its role in modern terms can imagine the transformation of acquired knowledge and skills in shaping the mental personality traits, ensuring the successful continuation of studies at the university.

In order to convert previously obtained knowledge, to develop new skills, it is necessary to present a propaedeutic study of foreign students as an integrated, completed pedagogical process, technology of which should be distinguished as:

- goal-setting, clear system of subordinate objectives;
- a problem of common result and the particular results for each goals;
- forecasting, predictability of results;
- variation in methods of learning process;
- the possibility of individual learning process in tempo, the level of difficulty of mastering the information that is ensuring the personal zone of proximal development;
- constant that does not hurt the student’s feedback of the correcting nature.

General propaedeutic studying of foreign students can be seen as converting of the acquired knowledge and skills on the basis of psychological, national personality traits, personal orientation in the environment, that grants the successful prolongation of studies at the university.

Prerequisite conditions of quality learning with regard to general subjects by representatives from different regions of the world are mentality, psychological condition and other characteristics of their national identity, because psychological difficulties are important as well as meaningful, language, teaching and organizational ones. Consideration, forecasting and planning of aforementioned problems allow to formulate objectively, vary educational goals and develop a strategy to solve them for foreign citizens arriving to the social environment, that is a set of social and (or) social environmental conditions, circumstances, situations that affect their behavior. Applying such terms, social environment can be viewed at the macro and micro levels.

Macro one is a new country, city, living conditions. Micro is a limited educational process and the community, that is, preparatory department for foreign citizens – a kind of social environment (society), which has its integrated structure and is determined with the appropriate social teaching settings. Hence, the primary area of socialization occurs through psychological mechanisms which, in turn, have an individual character and depend on the regional characteristics of the student. So, it is important to remember that with the arrival every newcomer student overcomes through social adaptation: the process of active personal adaptation to changes in the environment in different ways. In fact, at this initial moment, the role of preparatory faculty teacher is to assist the foreign citizen to enter a new macro and microenvironment, because they have different kinds of adaptation: biomedical (to the climate, food, time zone, environmental factors); adaptation to all components of the educational system: information and worldview (teaching disciplines, organizational forms and methods of educational activity) and psycho-pedagogical (educational group, to its social and psychological climate, to monitoring system, selfpreparation); socio-cultural (to other cultures); communication (all types of communication).

It is believed that during any adaptation genetically determined resources of the body are activated. For example, climate change is a very serious irritant to humans, which often leads to exacerbation of chronic diseases, high blood pressure, headaches, sleep disorders. In sharp fluctuations in air temperature, atmospheric pressure (increase or decrease) the person may experience deterioration of psychological state (mood variations, discomfort, apathy, depression).

At the stage of pre-university training, international students must adapt to the special factor, which is a learning process, because the education is the main goal of the foreigners arrived into the Ukrainian universities. Adaptations to foreign nationals of high school at the stage of pre-university training - is adapting to the new educational system components: information and ideological, psychological and pedagogical. This adaptation is happened under the influence of certain expectations on the part of preparatory faculty lecturers as well as foreign students.

In the first year, the state of concern, tension, sometimes fear and anxiety is typical for them. They are experiencing a state of emotional and psychological stress, accompanied with the state of anxiety (the human condition, characterized by subjectively experienced emotional stress, anxiety, concern, nervousness, frustration, anticipation of something evil). This is a relatively stable individual feature that provides insight into the human propensity to anxiety: his tendency to perceive a wide range of situations as threatening ones and react to them as different levels of anxiety.

High Performance anxiety measures are typical for novice students during initially study at PF, and are especially expressed among African, Arab and Asian students. Usually, people with false self-evaluation (low or too high), are closed in themselves, who often feel uncomfortable in the group who are considered as a highly anxious student. These people need special attention and caution in setting goals and objectives of their activities. Working with such students, it is undesirable, as the prevention, to emphasize extra time on the importance of results or constantly target them to good results.

To adjust the mental state of students, who come to study, equilibrium theory is of the interest, that is based on the emotional reinforcement of the favorable psychological climate groups and individual students. If positive attitude and Carnegie thesis "desire to show" is followed during studying, it helps to eliminate destructive factors in learning, allows to react to any students’ reactions in a proper way, stimulates the development of their personal qualities.

It should be noted that the term "mental state" is a generic description of the emotional, cognitive and behavioral aspects of the psyche of the subject in a certain period of time. Mental states include displays of affection (mood, emotions, anxiety, euphoria, etc.), attention (concentration, distraction), will determination, confusion), imagination (dreams) and others. The mental state is determined by external factors impact, human well-being, his individual psychological characteristics. Sometimes quite minor factors can affect at the deteriorating mental state of the student in class, particularly if the teacher during class often looks at some of the students and pays less attention to others (and they can sit in the audience side), that could cause an offense.

Long-term observations of the mental state of students in the classroom in different regions showed sharp differences between African countries, Southeast Asia, Latin America and the Middle East. Formed ability to control your mood, find ways to conscious correction is more typical for students from Vietnam, China, India, Bangladesh, Nepal. On the contrary, very frequent mood swings, that are typical for members of the Middle East, Africa, can have pathological origin and can be conditioned by such properties as increased anxiety, instability, emotionality. It should also be noted that in the preparatory faculty of natural sciences studying, compared with the first course of high school, students are taught in small groups (12-16 people). The small group - a group in which social relations are in the form of direct personal contacts. Signs of such groups are: cooperation and mutual understanding; pursuit of common purpose; rise and assertion of group consciousness, rights, customs and habits.

We also should point out that ethnic study groups, that established in the pension fund have the following features: direct contact between its members, interpersonal interaction and mutual influence; common goals, activities, feelings; attention and common interests, motivations and attitudes, values and norms, rights and group roles; specific localization in space and time known as resistance.

Interpersonal relationships in the group and compatibility of its members create a psychological climate that is more the result of cooperation than the compatibility. Cooperation satisfaction from the activity arises with interpersonal relationships, while compatibility is mainly content through communication.

Ethnic study groups psychological climate is being created for a more or less long period (week, month), and effects on the emotional state. The emotional state produces mood that creates a psychological atmosphere. The main factors that contribute to a heightened state of anxiety in the study group are: 1) students belonging to the same country; 2) psychological incompatibility of foreign students; 3) lack of proper contact with teachers.

Integral characteristic of the unity degree and homogeneity, which can serve as an indicator of the frequency or degree of opinions coincidence, estimates with respect to the objects (people, events), which is the most significant for the group as a whole. A small group is characterized by common values, rules of conduct, common interests.

The systematic study of foreign students' mental and regional features gave the possibility to develop a strategy for managing the educational process at the preparatory faculty. The survey showed that the greatest assistance and support in adjusting to life and study in the first year for beginner-students is provided by the compatriots (50%), teachers' pension fund (40%) and employees of the dean (10%).

Thus, in order to make foreign students' adaptation successful, the educational environment should create interpersonal interaction and mutual understanding between teachers as well as students; students, beginners and seniors; students in the group at the faculty that represent different countries and cultures.

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Innovative Trends in Training Highly Qualified Specialists of Phd Degree on the New Model of the Third Cycle in Engineering Education

Modernisation of curricula in academic disciplines identified as priorities by the Partner Countries, using the European Credit Transfer System (ECTS), the three cycle system and the degrees recognition by the International Tempus-Project implementation "New Model of the Third Cycle in Engineering Education due to Bologna Process" (NETCENG).

Social and economic environment of the new century, the development of the world science, the University`s restructuring, the opening of new specialists training fields, on one hand, and involvement of highly qualified scientists of relevant scientific activity directions, on the other hand have led to significant restructuring of the University science, its subjects broadening, appearance of research complex on social, economic and humanitarian issues. Significant impetus was in research connected to modern information technologies, use of possibilities of space industry. The development of the University science is the logical continuation of significant achievements of earlier generations of scientists.

In Ukraine there are the following laws and legal instruments governing the procedures of highly qualified personnel training:

– Decree of the Cabinet Ministers of Ukraine "On approval of the training procedure of higher education applicants Ph.D. and doctorate in higher education (research) institutions", 23 March 2016, No.261 – A procedure for preparing of higher education applicants Ph.D. and regulation of the process the postgraduate programs implementation due to European standards;

– Decree of the Cabinet Ministers of Ukraine "Licensing Conditions carrying out educational activities of educational institutions", 30 December 2015, No.1187;

– Law of Ukraine "On scientific and technical activity", 26 November 2015, No.848;

– Law Of Ukraine "On Higher Education", 01 July 2014, No.1556-VII;

– Decree of Cabinet Ministers of Ukraine "On approval of the awarding of academic degrees and awarding academic rank of Senior Scientist", 24 July 2013, No.567, and other.

In accordance with current legal and regulatory framework Doctor of Philosophy – an educational and at the same time the first scientific degree and which is acquired at the third level of higher education on the basis of a master's degree. Degree of Doctor of Philosophy is awarded to a specialized academic council of a university or research institution as a result of successful implementation of a competitor of higher education relevant education and research programs and dissertation public defense at the specialized academic council.

A person is entitled to receive a PhD while studying at postgraduate study. Persons who are professionally engaged in scientific, technical or scientific and educational activities for primary employment are eligible to receive a PhD out of graduate school, especially when you are in a creative vacation, subject to successful implementation of relevant education and research programs and public defense of the thesis in specialized academic council.

Standard period of PhD training at the postgraduate study is four years. The scope of the educational component of education and research training programs for PhD is 30-60 ECTS credits.

Academic institutions can train PhD on their own educational and scientific program according to the received license to appropriate educational activities. Academic institutions can also prepare PhD in educational and scientific programs, consistent with the higher education institution. In this case, the scientific component of this program is carried out in a scientific institution, and the educational component – in higher education.

Certification of persons who are pursuing a Ph.D., is made permanent or one-time specialized academic council of higher education institution or research institution, accredited by the National Agency for Quality Assurance in Higher Education, based on the public defense of scientific achievements in the form of a dissertation.

Dissertations of persons who are pursuing a PhD degree, and opponents reviews published on the official websites of the relevant higher education institutions (research institutions) in accordance with the law. Documents on Higher Education (scientific degrees) – Diploma of Philosophy Doctor, with the qualification title, consisting information about a person acquired a degree, a branch of knowledge and specialty, and Diploma Supplement of European sample, containing structured information about the complete study.

The new strategy for the training of highly qualified scientific personnel at the National Aviation University has been developed due to the european third-cycle engineering education within the framework the International Tempus-Project implementation "New Model of the Third Cycle in Engineering Education due to Bologna Process" (NETCENG).

National Aviation University became a member of the International Consortium for the International NETCENG Project, that is accepted for execution during 2014-2017 years. This Project has been funded with support from the European Commission due the Tempus Programm, that is designed to support the modernisation of higher education systems in Partner Countries with regard to the Bologna process and European modernisation agenda for higher education.

The project goals and objectives is to ensure that the targeted Universities introduce pilot Doctoral Programs in Engineering in line with the Bologna Process, according to 10 principles of Salzburg and Bucharest Forum.

The specific project objectives are following:

– to develop, implement and accredit new core and transferable curricula including ECTS;

– to establish new structured Doctoral Programs in target area according to requirements of Labor Market;

– to develop innovative teaching/learning environment for Doctoral Programs;

– to bring the Higher Education Institutions of PCs closer to the Labor Market.

Target group is post-graduates, graduates, students, teaching, research, administrative staff; management of educational organizations, local community administration staff.

The Project performing includes the following Activities:

– Review current doctoral programmes and develop model for new structured doctoral programmes;

– Develop and accredit new core and transferable curricula;

– Establish innovative teaching/learning environment;

– Set up "Doctor Engineers in Labour Market (DLM) offices" to support Postgraduate alumnus with scientific degree in Labour Market;

– Sustainability through implementation;

– Quality control.

Principal outcomes and outputs of the Project are following:

– 8 new core and 3 transferable curricula developed, implemented, accredited;

– Innovative teaching and learning environment including Joint Web Platform, Doc Colloquium Rooms, Labs and Doctoral Summer schools established, equipped and open for operation based upon Master Classes and pilot operation conducted;

– DLM Offices to support Researchers in Labor Market based on pilot operation in function;

– Dissemination of project results.

Thus, the objectives of the project are to develop, implement, transfer and accreditation of training programs, including their adaptation system ECTS, installing new structured doctoral programs in the target area in accordance with the requirements of the labor market, the development of the learning environment for doctoral programs according to the Bologna process and bring Doctoral graduates of universities closer to the labor market and the urgent priority directions of science and technology. Therefore, the Project is in line with national priorities of Ukraine in the engineering field, considering the priorities of all partner countries universities, aimed at reforming the curriculum, the development and implementation of a new model of the third cycle in technical sciences.

The project partners have identifed by an analysis inquiring the priority to develop the third cycle programmes in Engineering which is logically related to the fact, that the first cycle BA and the second cyc1e MA in Engineering are already successfully implemented. Ukraine have joint the Bologna process so it have to tune our Doctoral Education System to various aspects of the Doctoral programmes of European Knowledge Society. An overview of the political decisions of the last few years shows that the objectives of the Project are shared in partner coutries.

International Project Consortium consists of 22 institutions from 6 countries, including 14 universities, of which 3 – Ukraine National Aviation University, National Technical University of Ukraine Kyiv Polytechnic Institute and Cherkasy State Technological University. Participating in the consortium partner institutions with different needs according to the stakeholder groups they represent, with varying experience of European projects, establishment of academic and non-academic consortium members in the project. The project will have an important impact in the process of modernization and reform, meets the academic, professional and social needs of target countries, developing plans targeted universities, institutional and socio-economic support and political priorities of the target countries.

During the project partner countries universities must be accredited new curricula and new teaching materials at the institutional level following close to the subject project courses and disciplines, "System modelling and simulation", "Navigation in Transport Systems", "Sensoric in research" "Power electronics and systems", "Mathematical modelling", "Satellite images processing techniques", "Robotic systems", "Materials Science and Solidification Processing".

The methodology of the project based on the following principles. The project represented all levels of key institutions, including universities, ministries of higher education stakeholders. These horizontal and vertical linkages are to provide high quality and efficiency in the performance of the work plan . Business plan consists of a series of stages, due to the implementation of which should be achieved measurable and tangible results are to be used in subsequent stages of the project. Activity for the duration of the project is to ensure its efficiency and stability. Particular attention is paid to project management and administration of each organization make up the consortium.

Great importance is the presence of perspective development plan of the University of introducing new subjects and research areas, close to the subject matter of the project departments targeted communications with stakeholders (the subject of the project) in the field of industry organizations, institutions of research and development activity, and related universities, given the presence of organizations interested in graduates with the academic title in the subject project.

Activities in the Project NETCENG:

1 – to establish new requirements and parameters of the third (education and research) level for the preparation of highly qualified scientific personnel and obtaining their Ph.D. degrees – in education and research programs in relevant fields;

2 – to develop own experimental model of educational program of the third level (applications for postgraduate study NAU), which includes the European system of transfer and accumulation ECTS credits specific to training highly qualified scientific personnel in the field of engineering and aerospace technology in accordance with the Bologna process with the appropriate specialty academic content;

3 – to develop educational and research programs on specific subjects and general subjects for professionals training (graduates and applicants);

4 – to establish new requirements for managers and trainers graduate educational programs of the third level;

5 – to develop a system providing communications graduate study subjects with the requirements of the labor market and improve employment opportunities for graduates with academic degree.

The Project NETCENG Realization at the NAU on the 1st Stage:

for the first phase of the Project implementation as the target units NAU defined The Air Navigation Institute and the Air Navigation Systems Department, where are trained bachelors, masters, and post-graduates in the closest to the project field: Air Navigation; Transport and Infrastructure; Air Traffic Control; Radioelectronics; Information Technology; et al, as well as post-graduate training in the specialties: 05.13.03 – Management Systems and Processes; 05.22.13 – Navigation and Air Traffic Control; 05.22.20 – Maintenance and repair of transport means (since 2016 Branch of knowledge – 27 Transport, Specialty – 275 Transportation Technologies (by the types)).

The Project NETCENG Realization in the NAU on the 2nd Stage (since September 2016) – the analysis of the training areas and specialties, courses and subjects that are close to the project theme for the 33 specialties engineering specialization postgraduate selected.

Disseminations & Sustainable Activities:

From the first till the last day of project life are planned activities on dissemination of information and ensuring of sustainability of project outcomes. Each target university will work out timetables for publications, information and sustainability ensuring events based on project activities especially by DLM offices. It is planned to invite representatives from stakeholders and universities outside the consortium to promote and disseminate the project outcomes. To involve new participants into the project activities there will be developed the “NETCENG Plus" agreement, namely: conferences & workshops; project web portal; involving stakeholders; finding and attracting sponsors; commercialization of results.

Conclusion

The new strategy for the training of highly qualified scientific personnel at the National Aviation University has been considered due to the European third-cycle engineering education within the framework the International Tempus-Project implementation "New Model of the Third Cycle in Engineering Education due to Bologna Process" (NETCENG).

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The relevance of teaching disciplines of audit of management activities while training the specialists in management

Proposed to include in the curricula of training managers the disciplines that provide study methodology of management audit on administration based on the existing regulatory and legislative framework of Ukraine.

The effectiveness of modern companies and enterprises is the most dependent on institutional factors, which in turn is related to the level of management measures. The level of company management provided not only the qualifications and competence of management, but also the constant analysis of results. Based on the analysis, measures and decisions concerning the improvement of activity are developed.

The most effective analyzes and decisions are made using the company internal audit, which is implemented through national and international standards on auditing. The system can operate in conjunction with an internal audit of the quality management system (if implemented in the company). Knowledge and understanding of standards and auditing standards, methodology and of its organization, the ability to identify the problem, generate findings and recommendations for improvements are necessary components of competence of the modern manager.

It is advisable to include the discipline of learning the basics of auditing the legislative, regulatory and methodological support in to the curriculums for specialties and specializations that prepare managers of different levels. Students should be familiar with the applicable National Auditing Standards [6] International Auditing Standards [7], the principles and activities of the Audit Chamber and international audit institutions Code of Ethics of the auditor [5], the Law on auditing and other local regulations on audit management (administrative) activity [3].

Ability to plan and carry out audits, prepare accounting documents are based on knowledge of the basic concepts of audit of, efficiency, economy and effectiveness. [1] The most concrete results of the audit when modern methodologies and techniques for the collection, processing and analysis of various types, including quantitative are used [2]. Mastering these methodologies - an important task of future manager.

For the organization and auditing it should be considered that the main purpose of audit of is to promote administrative efficiency, rational use of material, labor and financial resources in management for positive results in the development and functioning of organizations (companies, institutions) of different structural levels.

The main objectives of audit of management activity are:

- detection and prevention (prophylaxis) violations in the management of the organization (enterprise, institutions) of different levels;
- Evaluation of programs, policies and plans of the organization (company, institution);

- monitoring of the implementation of strategic plans;
- checking and evaluating of the effectiveness of methods of management;
- consultancy services for the organization of management, measures and methods for improving of management processes;
- providing recommendations to address problematic questions, analysis, law, management, marketing, finance, etc.
- determining of the audit results;
- evaluating of laboring and executive discipline and professional competence of staff;
- evaluating of the effectiveness of interactions administrative service with heads of departments at various levels.

Planning the audit based on preliminary assessment of the organization, defining specific objectives and purpose of the audit. Based on the aim it is determined objective data to the types of evaluation:

- information to describe the object of the audit;
- methods for evaluation and measurement of outputs and outcomes;
- methods of test hypotheses about the shortcomings of activity;
- information on the effectiveness of the functioning of the organization.

According to informativeness distinguish the following types of data:

- quantitative (hard) data concerning digital numbers and ratios;
- qualitative (soft) data concerning opinions and general observations on conditions or performance.

To collect both quantitative and qualitative data using special methods and appropriate means:

- method of poll people (using interviews, questionnaires for control groups);
- method of observation of people (support designated officials in the performance of work);
- method of studying physical objects (analysis of compliance office places for defined requirements);
- method of using written documents (clarity of documents and completeness of statistical data samples).

The most effective method of collecting information is a poll the people that realized on options: direct interviews, interviews with communication, written questionnaires.

Using questionnaires to collect information - one of the most sophisticated methods that provides the ability to obtain reliable information and to create conditions for data processing.

Effective process of management in the enterprise determines the performance of the entire enterprise. Evaluation of the management staff - is one of the most important components of management of managers-leaders.

Assessment is a system that has a complex structure and enables regulatory function on the activities and competencies of managerial staff (managers of different levels).

The requirements for professional competence of managers can be divided into two groups. The first group includes the knowledge and skills that ensure highly professional performance of management tasks:

- ability to ground and make decisions;
- proper awareness in a particular area;
- ability to use the management experiences of other areas;
- ability to manage resources, plan and forecast work;
- apply the means of improving management;
- ability to use modern information technologies and means of communication;
- ability to efficiently locate and select staff;
- ability to mobilize staff to the task;
- other knowledges and skills that are acquired during the study of management science, its laws, principles, methods and tools.

The second group of requirements for professional competence of managers is related to the ability to work with people and to govern themselves:

- high sense of duty and commitment to job;
- honesty in dealing with people and trust in partners;
- attitude of respect and care for people regardless of their status in the hierarchy of the company;
- ability to quickly restore their physical strength and mental condition, to critically evaluate their activities;
- ability to establish friendly relations with subordinates;
- consistency and tact in all circumstances determination;
- determination in decision-making and assertiveness, etc.

There are several groups of methods of evaluating the effectiveness of management.

First, by aggregating indicators are distinguished: the number of sales and profit figures.

Secondly, according to the system of performance management activities are distinguished:

- the amount of profit per manager;
- effective use of time;
- performance targets;
- the quality of work performed, etc..

The main result of the management audit is an audit report complying with the direction of the organization for which it is intended. The structure of the audit report includes the results of management activities (facts) on the assessment of the constituent elements of management.

To assess the effectiveness of the integrated management of any organization and structures may be recommended to use qualimetric approach that involves the following:

- construction of the hierarchical structure of common indicators;
- definition of absolute figures;
- determining absolute benchmark indices;
- determining weighting coefficients for performance indicators;
- determining the complex assessment of the management of the organization (object) [4].

The main purpose of the audit report is to form conclusions about the general state of the organization (object) and provide recommendations for improvement of management. Recommendations for improving the management should be clear to senior management and appropriate definitions for implementation in the organization.

Thus, based on the aforementioned competencies, knowledge and skills for auditing management activities is advisable to shape the curriculum, teaching and working curricula of disciplines that have to ensure the content of educational process the specialists of management.

The course should provide a complex system of lectures, practical and laboratory classes. Each of these types of exercises require students to persistent self-employment. In preparation of detailed answers to the questions for consideration, students must learn the relevant concepts and content regulations, learn to apply methods for evaluating the audit management process specific, chosen for analysis, enterprise.

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Application of the method of projects in the master's program of project managers

Propose a new approach to the use of a method of projects in the Master's program of training in technology of management. This work represents the examples of the method applying.

The need of acquisition by the students stable skills to work in projects especially pronounced when the participants are students of master's programs with little practical experience in this area.

It is known that the most valuable competence of the project manager is the ability to organize work teams. It seemed that the useful will be the "project method", which is considered as a form of practical work students. However, the standard method of application of projects in education the biggest drawback is that the position of project manager takes a teacher, supervisor, tutor etc. The student is on the position of performer who must fulfill a number of tasks and obtain results. This activity has some features of the project, but the project is not in the general sense. This use of "project method" does not make sense to apply to master's programs for managers of projects and programs, because the accent in this method focuses on the work of the performer firstly and secondly to attention is given to the subject area of activity, but not to managing of this activity.

So, we can indicate that there is a need of the method of projects in the master's programs in project management in a modified form. Modification of the method is that every student has to participate in the implementation of educational of projects in the role as head of activities and team member is the manager of a particular control functions.

The result of this activity should be performed training projects in an amount at least equal to the number of students in the academic group. Number of repetitions of student participation in the implementation of basic project management processes will be significant, because at all stages of the planning, risk management, for example, repeated with varying detail that, in fact, help acquiring skills.

The essence of the proposed method is as follows: an academic group is divided into subgroups, for example, of 4 persons. Each student receives / chooses a theme of activities for team the leader of which he is appointed. The Manager of activity should determine the social need that will suit to the activities. So subgroup of four members implements four different activities.

The Managers of activities formulate project ideas of activity. In our understanding - the idea of activity is the most significant results of activity. It is clear that, in general, there may be several options (alternatives) performance, which can meet the demand in full or in part. The Manager of activity should identify these alternatives.

After the formalization of alternatives the Managers of activities are obtained as a resource others participants subgroups. That is four subgroups of participants formed four teams that conduct certain activities. Each of the Managers should distribut the roles, that should perform the members of his team. The roles are distributed so that each participant receives all possible roles in subgroups.

For example, a subgroup is composed of four. The Manager of activity appoints his colleagues to the position of specialist in risk management, financial management, quality management. Thus formed the team that carries on activities on obtaining a certain result.

An example of scheme of forming teams in subgroup shown in Table 1.

Table 1.

Distribution of roles in subgroup

Activities/ Projects	Actors			
	Student 1	Student 2	Student 3	Student 4
Act 1	**Manager**	Risk management	Quality management	Financial management
Act 2	Risk management	**Manager**	Financial management	Quality management
Act 3	Quality management	Financial management	**Manager**	Risk management
Act 4	Financial management	Quality management	Risk management	**Manager**

To achieve the result the same period of time should be assigning to each team - according to schedule. All activities start at once. Each of student has try himself in all roles.

The Manager is responsibility for the result. His task is organization of the team, analysis of alternatives, the choice of the expected results, the analysis of alternatives to achieving this result, the choice of a particular way, the beginning of the project, project planning, preparation of status reports on project status reporting on achieving results and updating the knowledge base.

Specialist in Quality management has to analyze the requirements for performance, define standards which must be used during the Activities, assesses the degree of compliance with regulations, procedures, preparing status reports on compliance with standards, etc. prepares materials for inclusion in the knowledge base.

Specialist in Risk management carries out analysis of factors influencing the activity from the side of the habitat of activities, prepares a register of risks and proposals for responding to the risks, reports on changes in the register of risks in the course of the project, prepares materials for inclusion in the knowledge base.

Specialist in Financial management creates financial estimates for alternatives ways to achieve results and selected the desired result, creates a financing plan project generates status reports, provides an information for inclusion in the knowledge base.

Such distribution of roles allows each student to repeat the action of the Manager several times that allows you to consolidate skills in the Master's program. Thus, for the period of time allotted by curriculum for practical work, the number of repetitions of administrative actions and programs of project managers in project activities are increased.

The Life cycle model that used in each of projects, is selected by appointed Manager. Model analysis of alternatives and plans of the project depends on the type of activity and subject area.

A very important element of training in project-based management skills is to get a set of operational management of projects - Project Portfolio.

According to the proposed model of activities / projects of each of the subgroups can be considered as a separate Project Portfolio. The set of several different subgroups of the Portfolios can simulate a set of activities / projects of the organization. For this set of operational management activities need to create a Project Management Office. Among the students produce actors of the role of Project Management Officer. Assign PMO Manager,

The tasks Manager PMO are defined by project activities model, which sets the developer of training materials. Type of PMO is determined by the complexity of learning objectives and curriculum.

The number of students receiving tasks Administrator Project Portfolio depends on the quantity of academic groups. If, for example, academic team consists of 20 people, according to the proposed model, we get 5 Portfolios. So PMO of at least six people, PMO manager and five Project Management Officers. For the Managers who administer PMO, there could be a rotation so that each of the students play the role of Project Management Officers, in turn had performed the role of The Manager of PMO.

Summary

The use of a modified method of projects while training specialists in technology of management will increase the intensity of practical exercises,will lead to the formation of management skills.

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Quality Management (QMS) as a part of training in management

The need to include in to the training programm of specialists in management the special disciplines or themes that reveal the basic theory of quality management, information on international standardization of quality management systems and methodology of its operations is analysed.

After independence, Ukraine has an active policy of integration into European and international structures. Ukraine admitted to the International Organization ISO (01.01.1993) and 14.02.1993 - a member of the International Electrotechnical Commission IEC, that gives it the right along with the other 90 countries participate in the activities of more than 1,000 international working bodies technical committees on standardization and use in their work more than 12 000 international standards.

Ukraine confidently and progressively implements the world demands and trends, so synchronizes standards ISO (including ISO 9000) at State Standard [2]. This allows domestic enterprises to take timely requirements for quality management systems. By implementing these same standards, Ukrainian producers have the opportunity to enter international markets with products of reliable quality, thus confirming its competitiveness and competence.

The success of companies and businesses on market products and services is determined by degree of satisfaction of specific customers. Success of the company for which the study of customer requirements, the establishment with them direct and feedback connections becomes the basis of their strategic development. Planning, implementation of manufacturing processes should provide obtaining the result according to specific requirements, and in case of deviations - operative of corrective actions and improvements. The most effective such measures can be carried out within a quality management system (QMS) implemented in the company, which should be developed based on the requirements of ISO 9000 [3-5].

The degree of compliance with QMS requirements of the standard generally confirmed by the certificate of conformity, that for consumers are guarantee of their claims. For modern enterprises and companies implementing the quality management system is the only (non-alternative) way, for the success on the domestic market, and also to be able to sell its products at world prices.

Consumers impose the requirement of the certified quality management system as a basic condition for the contract. Often a certificate ISO is a requirement for participation in public procurement tenders and so on. Presents of the certificate of ISO in enterprises-exporters allows to increase the price of products that delivered, increasing profits.

Thus, future specialists must be prepared to perform professional tasks defined within the quality management system, which is already implemented or being implemented at the company. Future managers and managers of different levels should be ready to manage a part or an entire system of QMS. For such control the basic knowledge of quality management, knowledge of standards (national and international) with quality management, specific knowledge of quality management methodology are neccessary [1, 7].

In connection with the abovementioned it is necessary to include in the curricula of specialties and specializations, preparing managers at various levels, the discipline of learning the basics of quality management, international standards on quality management methodology development, implementation and operation of QMS, use of effective tools of quality management.

QMS is the basic foundation theory of universal quality management (TQM), which was developed based on the tenets of Edward Deming and principles of quality management, which include:

- QMP 1: Orientation to the consumer;
- QMP 2: Leadership;
- QMP 3: Involvement of staff;
- QMP 4: Process approach;
- QMP 5: Improvement (improvement, improvement);
- QMP 6: Decision-making based on evidence (evidence);
- QMP 7: Relationship Management [1].

TQM theory is to use to meet the challenges of the management the modern quality methods and effective management tools such as:

- Control card;
- Diagram (analysis) Pareto;
- Schemes causation Ishikawa;
- Diagram of kinship (KJ-method);
- Chart relations;
- Matrix chart;
- Method "turnouts diagram";
- Priority matrix (matrix of criteria), etc.

Development of quality management systems in accordance with the International Standard ISO 9001 starts with defining the strategy of the enterprise (the company), that is documented as "company policy of quality."

Under the terms of ISO 9001 the company should identify, analyze customer requirements with their subsequent transformation into characteristics of the product (service) [4].

Planning and production of products are made based on the definition the necessary resources (personnel, finance, infrastructure, materials, etc.).

For all activities defined results within QMS presented as a description of processes with the necessary inputs, outputs, resources and regulatory documents.

Modeling in managing of business processes is based on an understanding of "business process" as a logical, coherent, interconnected set of activities which uses resources, creates value and gives the result.

Modeling business processes - is an effective means of finding ways to optimize the company, to determine how the company works as a whole and as organized activities at each workplace. Under the methodology (notation) creation of models (description) business process means a series of ways in which real-world objects and the relationships between them are represented as models. For each object and Relations typical number of parameters or attributes that reflect the specific characteristics of a real object (object number, title, description, duration of (for functions), cost, etc.

Focusing on the use of the process approach and use systematic methods for determining and monitoring processes ensure that the requirements are understood and implemented taking into account the added value for the organization and other parties. While controlling processes using objective measurements, organizations can systematically manage continuous improvement and growth, paying attention to the main reasons for the existing problems and possible problems of execution process.

In order to develop processes using functional simulation methodology IDEF and technology SADT, which modern manager must possess in the course of administrative activity.

An important in QMS there is organizing and conducting internal audits, covering all activities of the company (the company). Every modern organization (company, company) should plan, execute and manage audit programs using appropriate methods and criteria to the definition of responsibilities, given the importance of the processes that were tested and the data obtained as a result of customer feedback.

Audits are organized according to the specific requirements of other specialized standards such as ISO 19011 [6]. The results of internal audits are used to analyze the overall activity of the company, its management and decisions on further improvements.

Note, that presented basic information on standards of quality management (QMS), the methodology and tools of quality management are strong arguments for inclusion in the curricula and training programs of future specialists in management the special disciplines that will contribute updating the content of their competencies, knowledge and skills.

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Theories of activity in concepts of P.K. Anokhin, O.M. Leontiev, S.L. Rubinstein

Management activities include important psychological aspect, the foundations of which developed in the concepts of P.K. Anokhin, O.M. Leontiev and S.L. Rubinstein. Effective use of the theory activity mental activity helps to activate people and entire communities to obtain optimal for management results.

One definition of Psychology describes it as a branch of psychology that produces psychological knowledge management activities. The concept of "activity" - a fundamental concept of psychology. In the most general sense, the activity is defined as a specific form of human activity, the content of which is feasible change and transformation of the world. The problem of the subject and its activity is developed in psychology mainly on methodological basis of subject-activity approach. Theory activity - the system of methodological and theoretical principles study mental phenomena. The main subject of research activities is recognized that mediates all mental processes.

The psychological theory of activity is based on the teachings of psychology luminaries (Z.Freyd, K.Yunh et al.) And expressed in psychological practice. In Soviet psychology, this approach began to emerge in the 20's. XX century. In 30-ies. Was offered two interpretations of the activity approach in psychology - S.L. Rubinstein (1889-1960), who formulated the principle of unity of consciousness and activity, and O.M. Leontiev (1903-1979), who together with other representatives of the Kharkov psychological school investigated the problem of community structure of internal and external activities.

On the basis of the activity theory of SL Rubinstein is an understanding of how to "move the subject to the object." Central to the theory of S.L. Rubinstein holds the thesis that in the course of a person not only identifies their specific properties as a person, but the formation of the psyche is determined by the object of "value activities therefore is that in it and through it established an effective link between man and the world, making life acts as a real unity and interpenetration of subject and object. " Accordingly, practical activity - a powerful means of creating a thinking [3].

One of the most important results of studies conducted in 30-ies., is elaborated by S.L. Rubinstein and later O.M. Leontiev, philosophical and psychological analysis of activity system on its main components: the purpose, motives, actions, operations, etc. First into the activity of the subject S.L. Rubinstein had found it significant psychological components and specific relationship between them. These are, in particular, performance, operation and action of correlation with the their purpose, motivation and conditions activity of the subject. Any one of these acts can not be clearly defined psychologically out of their attitude to the psyche (eg, the same movements can mean various actions and deeds) [3].

All the system of the ideas S.L. Rubinstein developed in great detail later in 1940 with the first edition of "Fundamentals of psychology." Here the purpose and motives have been described as the activities in general, and the system of its components operations. Unity of acts primarily as a unity of purpose of the subject and of its motives from which it comes. The motives and purpose have an integrative nature, expressing the general orientation of the individual. This - the original motives and ultimate goal. At various periods they generate different motives and goals that characterize certain actions [4].

The motive of human actions may be related to their purpose, as the motive is impulse to action or desire to achieve the goal. However, the motive may separate on the purpose and move to the same activity or on one of the results. In the second case, a by-product of action become their purpose (while doing a job, people can see their goal is not to make a deal, but in the public recognition).

The result that makes the purpose of actions under different conditions and may be achieved quite different ways or means. Since the action leads to results - to his goal in different variables conditions - it is a means of solving problems is complicated intellectual act [4].

O.M. Leontiev suggested to consider the work (which correlates with the motivation) as such, which consists of actions (that have their objectives) and operations (consistent with the terms), while the scientist laid in the basis of the individual the hierarchy of motives.

In the Studies Alexander Leontiev based on the structure of human activity hypothesis of the fundamental structure common internal and external activities. His work emphasizes that in genetic terms internal mental actions and operations start with the exterior, being the product of recent internalization. Internalization - the formation of the internal structures of the human psyche through the assimilation of external social activities. It is important to bear in mind that internalization is not the simple moving out of external activities in previous internal plan of consciousness, but also in shaping of that plan.

Considering the activity as the interaction between the subject and reality, acting on it, O.M. Leontiev notes that reflection of the reality in the humans' mind "is not the result of actions but interactions, that is the result of processes that as if go towards each other " [2]. In the theory of O.M. Leontiev proposed the structure of the block, which provides for the allocation of its own, actions and operations.

Point of view of O.M. Leontiev on correlation of work-action-operation and due to the motive, purpose-conditions been represented primarily in his work "The activities. Consciousness. Personality "[2]. In this theory the concept of strictly correlated with the concept of motive and action concept - the concept of purpose. Sometimes O.M. Leontiev also divides targets for general and specific, and then only the latter directly relates to the actions. Thus, at this point planned some rapprochement S.L. Rubinstein and O.M. Leontiev.

As a result, "utility outcome" and the problem of assessing this outcome is the central factor in research in the field of industrial and economic systems is the requirement of usefulness is obvious. If we have a "great system", ignoring the usefulness of results at each subsystem of the "big system" would lead to wasteful and full nonprofit of enterprise. That status value and utility of results for each subsystem of the enterprise and combining them with the final result can give a decisive judgment on how useful the end result and to what extent it profitable for large enterprise.

P.K. Anokhin on managerial case raises the same issues as on biological systems - which result should be obtained by the system? Therefore, the collection of all previous calculations and considerations should be (eg in case trade) framework afferent synthesis, leading to the decision and action selection with the best result.

According to the theory of functional systems P.K. Anokhina behavior is not seen as a response to external stimuli, but as a purposeful activity determined proactive reflection of reality. The basis of behavior are system processes that combine a purpose activity and physiological functions of different anatomical elements. Either the act of the nervous system is not one involving the center of excitement and are the result of complex excitation of different areas of the central nervous system. However reflex remains a core part of a functional system. Integrated excitation occurs through afferent impulses [1]:

- from conditioned stimulus that directly leads to a specific activity;
- environment in which a person is;
- memory;
- motivation.

These afferent stimulation through integrated afferent synthesis. Afferent synthesis - a multi-processing in the brain physiological various information for setting goals and achieving it. Processing afferent impulses leads to the creation of a specific association of various central and peripheral elements of the body - the specific functional system. Its complexity depends on the number of afferent impulses. The result is a synthesis of afferent impulses complex procured prior reflex action and represents the afferent control unit.

While opening nodal specific mechanisms of functional systems Anokhin highlights a number of important components simultaneously behaviour's structure - afferent synthesis, decision making, forming acceptor of the result [1].

The decisive components of afferent synthesis have appeared roughly all the main points of action - the dominant motivation, the factoring afferentiation, the starting afferentiation and also the memory. The basic condition afferent synthesis P.K. Anokhin believes simultaneous coincidence of all four members of this stage of formation of a functional system. Afferent synthesis that enables an answer to the question what kind of results will be obtained at the moment, provides goal setting, achievement of which will ensure the further deployment logic of functional system.

Decision making - one of the most important moments in the deployment system processes. The theory of functional systems P.K. Anokhina made a "decision" full participant in the process of forming an objective system of afferent synthesis, subject to currently dominant motivation and under correction memory is a selection of possible degrees of freedom in which excitation selectively directed to the muscles that engaged to this action.

In other words, any decision after the end of afferent synthesis, is the most appropriate choice of degrees of freedom in those components that should make the working of the system. In turn, the degree of freedom that remain economically enable it to carry out that action, which should lead to the programmed result [1].

General principles of functional systems can be used for optimal organization of certain types of management. According to them, the guiding principle of the system of production must be accurate parameterization result, but for optimal results of production activities required systematic organization of production and its units. It should be departments that assess the needs of production and operation environment and experience of production, ie analogues of afferent synthesis by P.K. Anokhin. Special significance of planning and evaluation of progress - analogues apparatus acceptor of the result of actions in functional systems [5].

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The problems of the use of intellectual property in the innovation system

Today in our country in more than 1100 scientific institutions and organizations work dozens of thousand of candidates and doctors. At the end of 2015 more than 26,000 are valid patents. All this indicates a significant innovation potential of Ukraine in accordance with international trends, and this should become a driving force for innovation development of economy.

According to the World Economic Forum in the 2014-2015 biennium according to indicators of technological readiness Ukraine ranks only 85th place among 144 countries (including the CIS countries having rates better than Ukraine, Moldova – 51st place, Russia – 59th, Kazakhstan – 61st, Georgia – 67th, Armenia – 71st, Azerbaijan – 72nd), for the innovative factors respectively: Ukraine – 92nd place, while Russia – 75th, Azerbaijan – 76th, Kazakhstan – 89th place. A considerable innovative potential on the one hand and extremely low production level innovation - on the other is indisputable evidence that this potential is very poorly used by industry. That is, between science and industry exists a gulf - and this is the problem for the state that needs immediate solution.

About the low efficiency of inventive activity in Ukraine that constitutes a threat the economic security of the state, following data indicate. In 2014 domestic applicants filed nearly 13 000 applications for inventions and utility models. However, non-payment of fees for maintenance of patents for inventions and utility models, invalidated 9,800 national patents owners (75%). The average term review of patent applications to patent is about 2 years. The economy of Ukraine for the year used about 4 thousand of Industrial property, including 1.8 thousand Inventions (about 7% of all existing patents), 2.4 thousand Utility models (6%), 393 Designs (4%). Consequently, most secure of protection for intellectual patent rights are not used in the manufacture and stoped its course of life immediately after working out and getting legal protection. Much of the potentially significant inventions obtained Ukrainian inventors (patents fugitives) are applied directly to the patent offices of foreign countries without previously submitting an application to the Patent Office of Ukraine and obtaining appropriate authorization. It means, that continues uncontrolled transfer abroad of scientific and design development, disclosure from Ukraine native applications for prospective inventions. Over the past 10 years Ukrainian applicants in foreign countries 12,154 patented inventions, including a patent in Russia - 47% in the US - 15.5 %, South Korea - 9 %, the EU - 8 %, Taiwan - 4%. During the same time to the Patent Office of Ukraine filed 3356 patent applications, which were then submitted to patent offices in other countries. Thus, with a small error we can assume that 8798 patents are "runaway patents," and such that violated the Law of Ukraine "On Protection of Rights to Inventions and Utility Models". The number of such patents are 22% of the total number of patents in Ukraine, but their potential "weight" definitely higher than this figure [1].

Probable cause of this situation is that today is not developed a system of economic incentives for the creation and commercialization of intellectual property in order to develop the market of these objects. The legislation does not set minimum rates of remuneration to inventors, authors for the creation and use of industrial property rights; not implemented mechanisms of state support for national patents subject of patent rights in foreign countries, established by the budget; No method of determining the amount of damage caused by the violation of rights to IPOs. There is not of development, based on the experience of foreign countries, assessment of piracy techniques for the use of various intellectual property rights.

The National Academy of Sciences of Ukraine (NAS of Ukraine) is an essential component of the national intellectual property system, the main scientific institution of national importance in the field of science and innovation. Based on the status of the NAS of Ukraine, its role in promoting the values of society, based on knowledge and effective use of the intellectual property is the lead**.** By the Institutions NAS of Ukraine annually implemented in various sectors of Ukraine's economy thousands of new developments, including advanced technology, including information, machinery, equipment, materials, automated systems and system software, database and knowledge base, plant varieties, guidance methods and standards. NAS of Ukraine attaches great importance to scientific and technological development of high-tech industries.

In Ukraine, the majority objects of intellectual property are created at universities and research institutions. Further, these objects are transferred to developers who develop on the basis intellectual property objects new products or production technology, then carried out production, and finally - its market implementation.

There are several barriers to transform intellectual property for innovative products. One of such is the imperfection of the national innovation system. National innovation system - a collection of national public, private and public organizations, as well as mechanisms of their interaction, in which the activities of the creation, storage and dissemination of new knowledge and technologies. The innovative system forms a system of relations between science, industry and society in which innovations are the foundation of the economy and society. The activity of Science Park NTU "Kyiv Polytechnic Institute" where sales of intellectual property are calculated over the past two years has tens of million and where the intellectual product comes to the production of high-tech products in the range from nano-satellites to drone is an example of functioning innovation system.

The desired outcome of the national innovation system is creating an environment in which intellectual property enables innovators and creators get economic benefit from their work and strengthen the country's economic achievements for the benefit of businesses, scientists, authors and society as a whole, and to enhance economic competitiveness.

Imbalance finance system innovation and manufacturing process technology serves as another barrier in the innovation system. Stages of the process of transformation of intellectual property in innovative products, such as: stage of research, which are created as a result of intellectual property and the development stage of a new product or technology, its production based on intellectual property and its implementation. The first two stages are the responsibility of science, and the other two - the responsibility of business [2].

Science receives, mainly from the state budget, approximately 1% of the funds necessary to implement the full innovation cycle. These funds spent on research. Then the science has not the resources to finance the second phase - development - which requires an estimated 10% of the total funds needed, especially to finance the third phase - production (100%).

Therefore, first step is to create public funds that would be funded applied research and support innovative small businesses. Part of solving this problem is proposed in the draft Law of Ukraine "On scientific and technical activity", which provides for the establishment on the site of the State Fund of fundamental research much more powerful National Research Foundation, which will fund grant based on both fundamental and applied research. As part of the program of the Government the Ministry of Education and Science of Ukraine developed draft amendments to four laws that govern the innovation and technology transfer.

The scientific institution may have a large number of publications, many doctors, modern scientific equipment, etc., but society will not receive any return on the results of applied research. That use of the imperfect evaluation criteria does not assess the effectiveness of scientific and technological activities of universities and specialized research institutions. Now the Ministry of Education and Science of Ukraine is working to create a more transparent system of evaluation criteria and scientific activities of applied research, which will be based on the results of the introduction of intellectual property to economic turnover. For example, for technical universities it will depends not only from the traditional number of publications and theses are protected, but first of all the number of license agreements created startup companies, the amounts received from this royalty payments [3].

USA achieved the greatest success in technology transfer, as they were able to build effective working model of commercialization of intellectual property, which optimally combines the efforts of the state, science and business in promoting scientific development in the industry. However, this does not always work in the United States was successful. The situation improved dramatically after the US Congress in 1980 passed two complementary laws: the law of Bayh-Dole Act and Stivenson-Wydler. Bayh-Dole Act gave for the universities, non-profit organizations and small businesses ownership of inventions created and funded by the government. An example of this, many universities to school managed to organize a kind of conveyor belt, which through licensing and the creation of start-up-companies "pushes" intellectual property created at the University for the state money in the industry, and royalties received from licensing again leads to disclosure, patenting and licensing. And this line has been successful in the US over 30 years. The state gives money to universities for research and requires them to return. Universities create intellectual property and transfer it to companies. Companies organize jobs and produce innovative products. Taxes of this come to the state budget, and part of the proceeds to state again directs funding for science. The key provisions of Stevenson-Wydler law is that inventions funded from the federal budget must be licensed for commercial use in the public interest [4].

Stevenson-Wydler law gave broad powers to the Ministry of Commerce in order to increase the role that technological innovation for commercial and government purposes, support technology transfer at the national level. Given the fact that federal laboratories are a significant number of commercially valuable technology that could contribute to the competitiveness of firms increasing under US law requires that each federal laboratory should create the office of technology transfer to identify commercially valuable technologies and their subsequent transfer to the private sector. Both laws are aimed at creating a favorable environment for the development of mutually beneficial cooperation between the private and public sectors. In addition to these laws the innovation in the US make many other regulations, however, often it is refering to the Buyh-Dole law, because it is generalizing [5].

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ICAO's view on MID region safety

Continuous improvement of aviation safety through a progressive reduction of the number of accidents and related fatalities to be in line with the global average, based on reactive, proactive and predictive safety management practices.

Aviation safety is at the core of ICAO's fundamental Objectives. The organization is constantly striving, in close collaboration with the entire air transport community, to further improve aviation's successful safety performance while maintaining a high level of capacity and efficiency. This is achieved through:

1. The development of global strategies contained in the Global Aviation Safety Plan and the Global Air Navigation Plan;
2. The development and maintenance of Standards, Recommended Practices and Procedures applicable to international civil aviation activities which are contained in 16 Annexes and 4 PANS (Procedures for Air Navigation Services). These standards are complemented by more than 50 Manuals and Circulars which are providing guidance on their implementation.
3. The monitoring of safety trends and indicators. ICAO audits the implementation of its Standard, Recommended Practices and Procedures through its Universal Safety Oversight Audit Programme. It has also developed sophisticated tools to collects and analyse a vast array of safety data which allows to identify existing and emerging risks.
4. The implementation of targeted safety programmes to address safety and infrastructure deficiencies; and
5. An effective response to disruption of the aviation system created by natural disasters, conflicts or other causes.

In all of its highly coordinated safety activities, ICAO strives to implement practical and achievable measures to improve safety and efficiency in all sectors of the air transportation system. This approach ensures that aviation's complimentary achievements of a remarkably safe and efficient air transport network continue to serve a fundamental role in supporting global social and economic priorities.

States and regions must focus on their safety priorities as they continue to foster expansion of their air transport sectors. The ICAO Global Aviation Safety Plan (GASP) establishes targeted safety objectives and initiatives while ensuring the efficient and effective coordination of complementary safety activities between all stakeholders. The GASP includes a framework comprised of measurable objectives, supported by Safety Performance Areas and associated safety initiatives. The MID Region safety objectives are in line with the global safety objectives and address specific safety risks identified within the framework of the Middle East Regional Aviation Safety Group (RASG-MID), based on the analysis of available safety data.

In the near term, States will ensure that they have the resources as well as the legal, regulatory and organizational structures necessary to fulfill their safety oversight obligations and in collaboration with all stakeholders achieve the following near-term objectives:

1) all MID States should establish an effective safety oversight system and progressively increase the USOAP-CMA Effective Implementation (EI) score with a baseline of 60% for all States by 2017, through, mainly the reinforcement of the entities responsible to carry out regulatory and safety oversight functions with qualified and trained technical staff, and/or the delegation of certain safety oversight functions to a Regional Safety Oversight Organization (RSOO);

2) reduce Runway Excursions and Incursions accidents in the MID Region by 50% by 2017, through establishment and activation of Runway Safety Teams (RST's), Aerodromes Certification, and implemetation of Airport Safety Managmennt System (SMS).

Action Plan is

- Establishment and support of local Runway Safety Teams.
- Establishment of Regional RST GO-Team.
- Effective reporting system to exchange and analyze safety information.
- Runway Safety Seminar/Workshop.
- Adopt specific regulations related to runway safety.
- Identify hazards and mitigation measures on runway excursions/incursions and unstabilized approach, and develop guidance material and specific training.

3) reduce In-flight Damage accidents in the MID Region by 50% by 2017, through the development of regional guidance, and conducting awareness training.

Action Plan is

- Identifying and understanding wild life habitat around airports, and methods used by the airport for controlling hazardous wildlife by assessing airports in the region.
- Establishing a regional guidance document that addresses key issues such as wildlife and vegetation.
- Convening a workshop for pilots and ATCOs to increase awareness on wildlife avoidance during flight.

4) reduce Loss Of Control In-flight (LOC-I) related accidents in the MID Region by 50% by 2017, through appropriate Standard Operating Procedures (SOPs) related to mode awareness and energy state management, and Advance Manoeuvers Training.

Action Plan is

- Upset Prevention and Recovery Training or AMT.
- Adopt ICAO UPRT Manual (2014).
- Develop legislative and regulatory framework that supports data protection for individual reporters and data providers.
- Utilize FDM , Voluntary Reporting and LOSA for trend analysis and identifying precursors.
- Emphasis on robust standard operating procedures (SOPs) and crew resource management (CRM) through training, monitoring and validation.
- Develop and implement Fatigue Risk Management Strategies.
- Encourage aircraft manufacturers to pursue innovation in practical and cost effective technology to mitigate LOC risks.
- Address ATC contribution to potential LOC events through guidance material,

awareness workshop, and training.

5) maintain the rate of Controlled Flight Into Terrain related accidents in the MID Region below the global rate, through pilot training, use of Fatigue Risk Management Systems (FRMS) framework, and implementation of PBN.

Action Plan is

- Develop a regionally customized CFIT training and guidance material provided to all air transport operators and Training Centers.
- Embodying FRMS within individual organizations' SMS.
- Implementing of PBN and APV operations (Approaches with Vertical guidance) in the MID region in a phased approach: 30% in Dec 2015 - 70% in Dec 2018 - 100% in Dec 2020.
- Mandating RNP-AR approaches for approaches with unacceptably high CFIT risk.

6) States with an effective safety oversight score (EI) over 60% proceed to fully implement SSP following a phased approach supported by high-level management with the availability of necessary resources and safety promotion through the provision of appropriate training, communication and dissemination of safety information and improvement of the safety culture.

Action Plan is

- Improvement of safety culture.
- Establishment of effective reporting systems which include mandatory and voluntary reporting systems.
- Safety training and awareness (SSP, SMS, etc), including highlevel management safety briefings.
- Internal & external communication and dissemination of safety information.
- Sharing of safety data at national and regional level.
- Sharing of best practices.
- ICAO SSP, SMS and ECCAIRS trainings, including CBT.
- Regional Seminars and Workshops on safety.

Conclusions

The MID Region Safety Strategy is to be endorsed by the MID States' Directors General of Civil Aviation. The MID Region Safety Strategy will guide the work of RASG-MID and all its member States and partners. The RASG-MID will be the governing body responsible for the review and update of the Strategy, as deemed necessary. Progress on the implementation of the MID Region Safety Strategy and the achievement of the agreed Safety Targets will be reported to the ICAO Air navigation Commission (ANC), through the review of the RASG-MID reports; and to the stakeholders in the Region during the MID Region Safety Summits.

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UDC 347.822.4

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Why the Air Marshal Service is important for Aviation Safety

To assure aviation safety, it requires implementing effective measures which help to prevent acts of unlawful interference. Taking into consideration that civil aviation has become a target for terrorist attacks lately, the establishment and development of air marshal services are extremely important in all civilized countries of the world.

Introduction

The Air Marshal Service was first established in the United States of America as a federal law enforcement agency. In 1961, President John F. Kennedy adopted an order specifying that federal law enforcement officers ought to be deployed to act as security officers on certain high-risk flights [4]. The Federal Air Marshal Service started on March 2, 1962 as the Federal Aviation Administration's (FAA) Peace Officers Program [1].

Before the terrorist attacks on September 11th, 2001, the Federal Air Marshal Service consisted of varying numbers of officers dependent on government funding. Although 50 positions were authorized by Congress, only 33 federal air marshals were active on the day that the terrorist acts were conceived. As a result of the September Eleventh attacks, President George W. Bush ordered the rapid expansion of the Federal Air Marshal Service. Many new hires were agents from other federal agencies, such as the United States Border Patrol, the Federal Bureau of Prisons, the Federal Bureau of Investigation, the Drug Enforcement Administration, and others. Greg McLaughlin, U.S. Federal Air Marshal Service Deputy Director, had been tasked with hiring and training 600 air marshals in a one-month period, the completion of which was an impressive feat that any government agency has not repeated. A classified number of applicants were later hired, trained, and deployed on flights around the world. As of August 2013, this number is estimated to be approximately 4 thousand persons [2].

It should be noted that the Air Marshal Service is more developed and efficient in the United States of America than in the rest of the world. That is why the American system of hiring and training air marshals is worth mentioning below.

Information regarding Air Marshal Career, Salary, and Training in the USA

Federal Air Marshals are armed Federal law enforcement officers who are deployed on international and domestic flights to protect passengers and crew against criminal and terrorist acts. They are under the direction of the Transportation Security Administration (TSA) and may also work with the FBI Counterterrorism Task-Force and other Federal anti-terrorism initiatives. To realize the significance of an air marshal service, it would be appropriate to provide the following details:

1.Air Marshal Requirements

Candidates must complete an application process that includes a preliminary screening and suitability assessment, mental health and psychological suitability screening, a panel interview (a type of screening meeting for job applicants involving the participation of a group of two or more people from the hiring institution), drug test, background investigation, medical and fitness evaluation.

Applicants must be under 37 years of age though there are exceptions made for veterans or those with significant past experience in a related field. A candidate must be a U.S. citizen and resident of the U.S. [3]

2.Air Marshal Education and Training

The Air Marshal training is a two-phase fifteen-week program. Phase 1 is the FLETC (Federal Law Enforcement Training Centers) basic Police Training Program. In Phase 2, students are instructed in international law, arrest procedures, communications, aircraft safety procedures, defensive measures, aviation first-aid and advanced firearm tactics.

Air marshals must achieve and maintain the highest pistol qualification score among all enforcement agencies. Following successful completion of training, new air marshals may be assigned to any of 21 field offices located in the U.S. where intensive training continues [3].

3.Air Marshal Salary

The salary for Air Marshals begins at approximately $40,000 per year. The salaries were raised after the 11th of September, 2001, when the TSA increased the number of Air Marshals to cover more domestic commercial flights. Air Marshals are entitled to the Federal employee benefit program [3].

4.Air Marshal Career Opportunities

Air Marshals have an expanding role in homeland security as the primary law enforcement arm within the Transportation Security Administration. A Federal Air Marshal must operate without backup and blend in with passengers. This is a unique position in law enforcement. Air Marshals may pose as airline passengers on flights for hours each day and up to 50 hours per week and yet must be capable of taking immediate action to protect the flight and passengers when required.

Federal Air Marshals usually travel in pairs. The majority of work hours are spent in flight without incident but Air Marshals rely on investigative techniques, terrorist behavior recognition, close quarters self defense skills and handgun accuracy (see Fig.1) to ensure the safety of airline passengers and the public [3].

Fig.1. Acquiring close quarters self defense skills and handgun accuracy in a Federal Law Enforcement Training Center.

Air Marshals in action

There were a lot of disputes and arguing pertaining to dress codes that air marshals had to adhere to. In 2002, the policy was put in place by the U.S. Federal Air Marshal Service, a branch of the Department of Homeland Security. It said air marshals should wear "conservative" business attire such as sport coats and slacks. Due to this policy, some federal air marshals worried that they were too easily noticed. They told the supervisors if the casual traveler could spot an air marshal, so could a potential terrorist. The biggest fear among some air marshals was that terrorists would specifically target them and use their weapons to hijack a plane [5]. Hereafter the former FBI agents employed by the Department of Homeland Security took the initiative and made some proposals concerning the effective functioning of the Federal Air Marshal Service, which were taken into account, in particular working undercover and tactical training (see Fig.2).

The implication of the experimental policy proposed and put into practice is the following: to ensure the safety of passengers and crew members during the flight, air marshals should have a premeditated disguise in order to make it impossible for criminals and terrorists to recognize them as law enforcement officers. In other words, an air marshal can pretend to be anyone who will raise no suspicion. For instance, a biologist reading a book about butterflies, a football fan wrapped in the flag of his favorite team, a clown entertaining kids with his funny wig and juggling with three colored balls for them, or a young married couple quarrelling from time to time while flying; it does not matter what they do, but it is vitally important that their attention is permanently concentrated on the passengers in the cabin, especially those who look suspicious, as well as on any suspicious activities onboard. None of the wrong-doers must have a clue that air marshals are in the passenger cabin. Otherwise, the law enforcement officers may be attacked when they least expect it and probably terminated.

Fig.2. Federal air marshals perform tactical training at the William J. Hughes Technical Center in Pomona, New Jersey, USA.

It is necessary to emphasize that criminals and terrorists who commit acts of unlawful interference onboard are more bold and self-assured without knowing that there is a force present to set back and prevent their unlawful intentions. Consequently, they turn to be more vulnerable to a sudden strike carried out by representatives of law enforcement. If a group of terrorists with knives or toy guns in their hands walk along to the cockpit, they can be disarmed, restrained, and even shot to kill (see Fig.3), because they would never imagine this biologist or this football fan or this jealous husband being a specially trained person working undercover. The outcome of such measures is that terrorist acts and attacks are prevented, and analyzing the case of September 11th, it can be assumed that this tragedy might never have happened if the U.S. Air Marshal Service would have operated properly and effectively those days.

Fig.3. An Air Marshal is in action shooting a criminal with a handgun and releasing a hostage onboard.

Conclusion

The Air Marshal Service has regained the special significance due to the events occurred on September 11th, 2001, and also known as terrorist attacks in Washington and New York. This service is more developed and efficient in the United States of America, but the other countries of the world, namely their governments, are recommended to establish and develop similar services authorized to assure the safety of passengers and crew members onboard.

The importance of the Air Marshal Service for Aviation Safety can barely be overrated. When passengers feel safe and protected in flight, they trust airlines more, air travelling becomes more popular, airlines' benefits significantly increase, and funding invested in the area of aviation might be raised to the greater extend.

Mitigation of risks relating to terrorist acts and attacks with aircraft involved is another argument which confirms the necessity of an air marshal service in any civilized state. To annihilate the dangerous environment consisting of vicious criminals and terrorists who threaten Aviation Safety is the priority task that the states and their law enforcement agencies as air marshal services are obliged to perform, and the positive result must be achieved at any cost in order to save thousands of lives in the future.

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Aviation safety management system: problem of balanced allocation of resources

Increasing of civil aviation safety level is one of principal objectives of world air transport development. Present research paper discusses approaches to assessment of the "safety space" of civil aviation activity.

The air transport industry plays a major role in world economic activity. One of the key elements to maintaining the vitality of civil aviation is to ensure safe and sustainable civil aviation operations. International Civil Aviation Organization (ICAO) sets the Standards and Recommended Practices (SARPs) necessary for aviation safety on a global basis [1, 2]. Development of global civil aviation safety system unites leading international and regional, intergovernmental and non-governmental organizations, research institutions and universities in order to improve global civil aviation safety level. But contemporary challenges of world air transport make it necessary to continuously increase level of safety and security of aviation system.

Considering, as before mentioned, search for new methods to assess the aviation "safety space" seems topical and important for future civil aviation development. Research paper is devoted to the subject and is a logical continuation of the author's several publications on the issue of development of aviation safety [3 - 10]. The peak values observed at the beginning of the curve illustrate the fact that accidents, being rare events, need to be considered in the light of a meaningful number of flights, reasonably at least a million flights per year (see Fig1.) [11].

At present time, aviation is an ultra-safe system, (i.e. a system that experiences less than one catastrophic safety breakdown every one million production cycles).

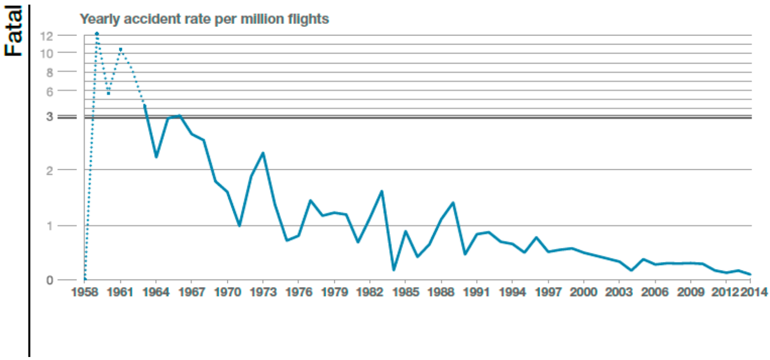

Fig 1. Yearly accident rate per million flights [11].
(Source: Commercial Aviation Accidents 1958 – 2014. A Statistical Analysis. Airbus S.A.S.)

. Accidents are rare occurrences, consequently their number may vary considerably from one year to the next. As a consequence, on the Fig.2, a 10 year moving average is used by Airbus experts i.e. for any given year, the accident rate is the average of the yearly accident rates over the 10 preceding years. The result of safety aviation activity is a virtually stable absolute number of accidents despite a massive increase in exposure [11].

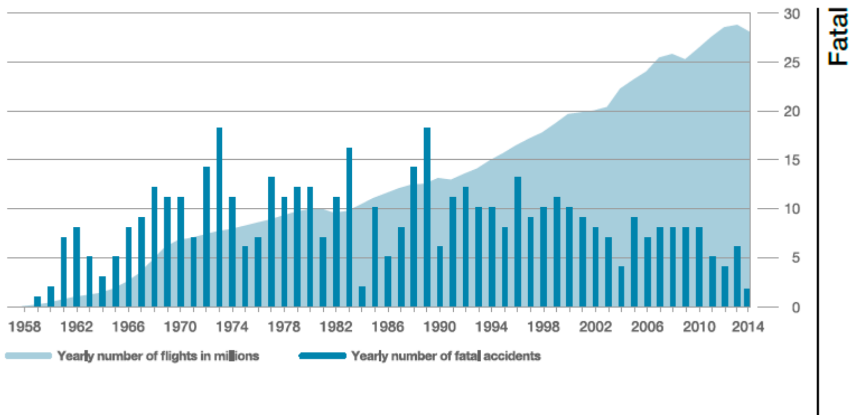

Fig 2. Yearly Accident Rate Comparing With Number of Flights [11].
(Source: Commercial Aviation Accidents 1958 – 2014. A Statistical Analysis. Airbus S.A.S.)

The graph below shows the constant increase in passengers carried over the year and a ratio metric related to the number of fatalities by the number of passengers carried on a specific year [12].

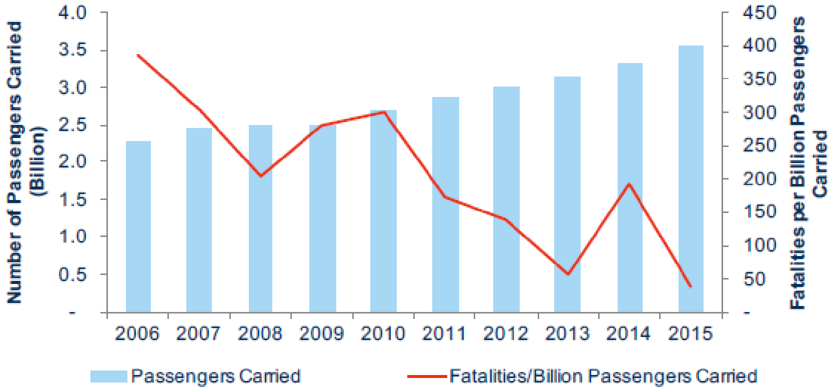

Fig 3. Number of Passengers Carried and Fatalities per Passengers Carried [12]. (Source: IATA Safety Report 2015).

But, unfortunately, we can never state that aviation activities will be absolutely safety. Philosophy of liberalization gradually developed and engulfed more considerable aviation markets during many years. This tendency resulted in the substantial increase of international air routes level of competition. But the idea of free competition is not an ideal and can demonstrate stagnation and negative tendencies on different stage of realization in changing conditions. No doubt, on the certain stage their competition is advantageous for a customer, passenger or cargo owner. A competition requires from an airline constantly perfecting conditions: high level service and fare policy flexibility. However ongoing growth of airlines aircraft operating costs provokes companies to maintain permanent regime of resources economy, which in same time results in the decline of service quality and in some case to the decline of the acceptable level of safety. From the other side, permanent exploitation on verge of profitability or unprofitable routes in general actually put normal existence of airline under a threat [13].

In this situation the main trend of contemporary aviation activity is adoption of a business-like approach to the safety management. Aviation Safety Management System (SMS) includes business management instruments to the management of safety. The development of business management instruments as aimed at the development of the aviation "safety space". Within "safety space", the aviation organization can provide operational activity, with the assurance that it is within a space of maximum resistance to the safety risks of the consequences of hazards. The main boundaries of "safety space" are production and protection (see Fig. 4) [2].

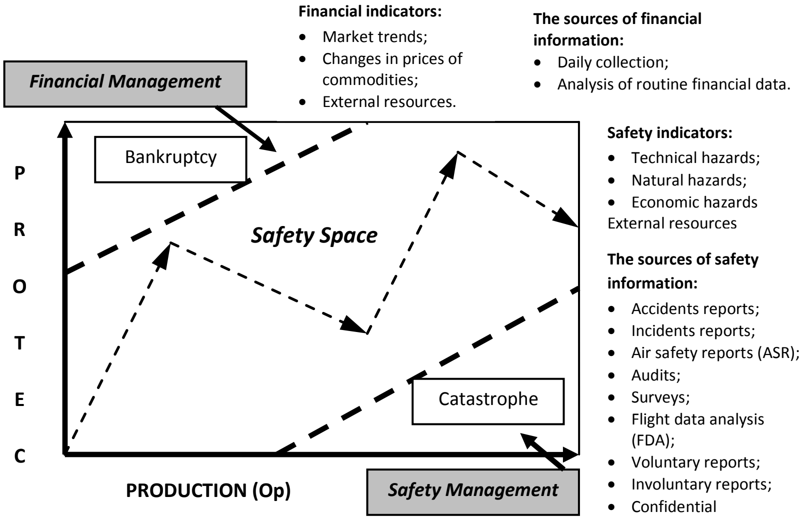

Fig 4. The safety space [2]
(Source: Safety Management Manual (SMM): ICAO).

From this point of view, it is very important to find the most correct methods of determining these boundaries, in order to prevent the problem of misallocation of resources of aviation organizations. There are two sides to the safety space, or two boundaries: the financial (production) boundary and the safety (protection) boundary [2].

The financial (production) boundary is defined by the financial management of the organization.

We can use following financial indicators:

- Market trends;
- Changes in prices of commodities;
- External resources [2]

The sources of financial information are:

- Daily collection;
- Analysis of routine financial data [2].

The safety/protection boundary of the safety space should be defined by the safety management of the organization. This boundary prevents incorrect allocation of resources, which may result in a catastrophe. We can use following safety indicators:

- Technical hazards;
- Natural hazards;
- Economic hazards [2]

The contemporary sources of safety information within Safety Management System are:

- Accidents reports;
- Incidents reports;
- Air safety reports (ASR);
- Audits;
- Surveys;
- Flight data analysis (FDA);
- Voluntary reports;
- Involuntary reports;
- Confidential communications [2].

Having considered the before mentioned information, search for new methods to assess the aviation “safety space” seems topical and important for future civil aviation safety, efficiency and development. There are various hypothesis tests, which can be found in the statistics textbooks. We present below an effective test, proposed by A. Wald [14], which, according to authors, can be very effective for improving the determining accuracy of the area of aviation organization, which is called “safety space”.

A hypothesis is a proposed explanation for a phenomenon. For a hypothesis to be a scientific hypothesis, the scientific method requires that one can test it. Scientists generally base scientific hypotheses on previous observations that cannot satisfactorily be explained with the available scientific theories. Even though the words "hypothesis" and "theory" are often used synonymously, a scientific hypothesis is not the same as a scientific theory.

A *statistical hypothesis* is usually a statement about a set of parameters of a population distribution. It is called a hypothesis because it is not known whether or not it is true.

For instance, consider a particular normally distributed population having an unknown mean value θ and known variance 1. The statement “$\theta = 2$” is a statistical hypothesis that we could try to test by observing a random sample from this population. It is called the *null hypothesis* and is denoted by H_0. Symbolically, we can express the null hypothesis as

$$H_0: \theta = 2.$$

A primary problem is to develop a procedure for determining whether or not the values of a random sample from this population are consistent with the hypothesis. This process is called *hypothesis testing***.** If the random sample is deemed to be consistent with the hypothesis under consideration, we say that the hypothesis has been "*accepted*"; otherwise we say that it has been "*rejected*."

The alternative to the null hypothesis, which the tester is actually trying to establish, is called the *alternative hypothesis* and is designated by H_1. For our example, H_1 is the hypothesis that "θ is less than 2" which can be written symbolically as

$$H_1: \theta < 2.$$

Let X be a random variable with the probability distribution f(x). Let the hypothesis H0 to be tested be the statement that the distribution of X is $f(x, \theta_0)$. Suppose that the alternative hypothesis H1 states that the distribution of X is given by $f(x, \theta_1)$.

If we denote a series of n observations by $X_n = (x_1, x_{2,} ..., x_n)$, then the probability of these n observations is given by

$$P_0 = \prod_{i=1}^{n} f(x_i, \theta_0)$$

if H0 is true

and

$$P_1 = \prod_{i=1}^{n} f(x_i, \theta_1)$$

if H_1 is true.

Current tests of statistical hypothesis assume

1)a doubt about true of the hypothesis
2)possibility of at least two outcomes:

- to accept hypothesis,
- to reject it

As distinct from current test procedure method of sequential tests of statistical hypothesis is supplemented by the third outcome: «don't know». In such a case the scheme of hypothesis' testing assumes the following form.

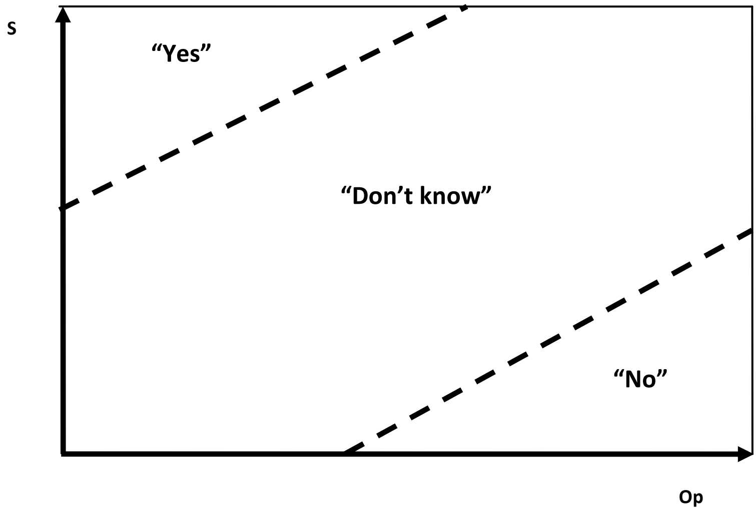

Fig 5. The scheme of hypothesis' testing assumes

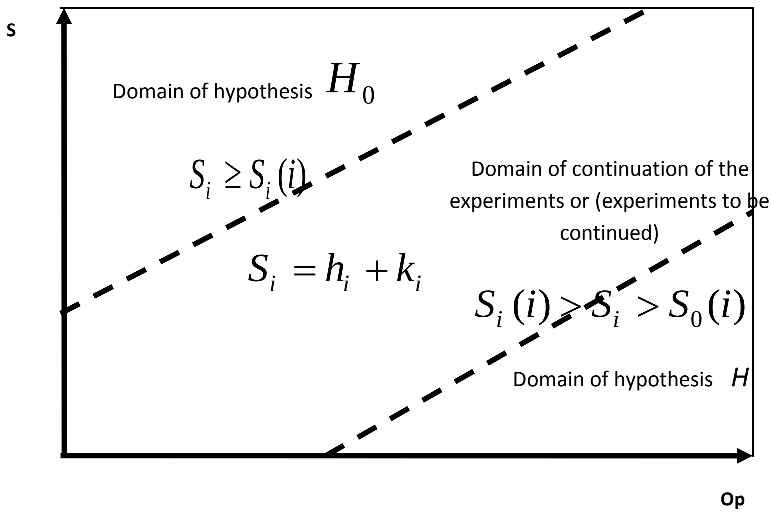

Fig 6. Explanation of sequential tests of statistical hypothesis

A number of steps ν is a random variable which depends on the «nearness» of the hypotheses (difference: $\theta_1 - \theta_0$), the values α and β and the probability of true or false of the hypotheses.

Practically by pre-assigned chosen values α and β and correspondence between values of the parameters θ_0 and θ_1 the expectation of the number of steps necessary to fulfill the sequential test procedure $M(\nu, H_0)$ to accept hypothesis H_0 if it is true; $M(\nu, H_1)$ - to accept hypothesis H_1 if it is true and $M(\nu)$ - at worst if $\theta = 0{,}5(\theta_1 + \theta_2)$.

Formulas for pre-assigned estimation of these values are shown in the table 1. The effectiveness of the sequential analysis is estimated by formula

$$E = 1 - M(\nu) : N$$

Apparently, that if $E > 0$, the sequential procedure is preferable in comparison with the current one if the restrictions allow.

Conclusion

Search for new methods to assess the aviation "safety space" seems topical and important for future civil aviation safety, efficiency and development.

Due to the different nature of the aviation hazards (technical, natural and economic) and diversity of safety information channels (accidents and incidents reports, audits, surveys, flight data analysis (FDA), voluntary and involuntary reports and confidential communications) we need investigate different approaches to solve this problem, including various hypothesis tests, for example Effective Test, proposed by A. Wald [14], which, according to authors, can be very effective for improving the determining accuracy of the area of aviation organization, which is called "safety space".

The next publication of authors will be devoted to A. Wald's Effective Test. It will allow offering more correct responses to aviation safety hazards and is a prerequisite to further reinforcement of global safety level of civil aviation.

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Air Cargo Supply Chain Overview

The air cargo supply chain is a combined set of interconnected parties, locations, procedures, and information exchanges that enables cargo to move from its origin to its destination by air. All parties have a shared responsibility to ensure that air cargo moves safely and securely through this chain.

Introduction

The air cargo supply chain is initiated by a seller (or 'shipper') and buyer (or 'importer' in the context of international trade) who wish to exchange goods between them via air. Many of these terms are used interchangeably in common usage; for example the term consignor is commonly used to describe the shipper. The shipper is the entity responsible for manufacturing and/or selling goods, and can be referred to as the exporter or the trader. The shipper will often engage the services of a broker or agent to manage the movement of the goods, including meeting the requirements of regulatory border agencies (e.g. Customs).

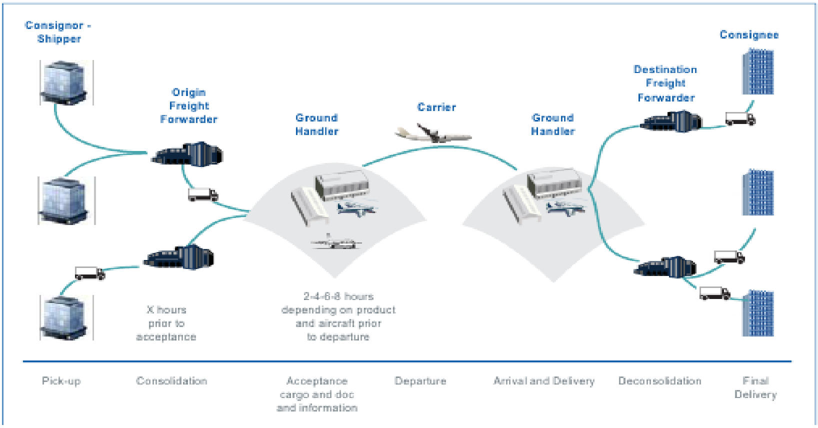

Fig. 1. Air cargo movement overview.

The shipper deals in a commercial sense at the other end of the supply chain with the buyer, or the importer in the case of international trade. The person who initiates the shipment may manufacture the goods or simply buy them for resale. The shipper (or 'exporter' in the context of international trade) fulfils the procedures and information exchanges related to the buying and selling of goods. The shipper will often engage the services of a broker or agent to manage its regulatory business, in particular the preparation of a goods declaration for Customs, but also the many potential licenses, permits and certificates that can be required by other border regulatory agencies.

Roles and responsibilities

Consignees

The consignee is the party who is designated on the invoice or packing list as the recipient of the goods at the end of the transport movement. Similar to the start of the air cargo supply chain, it is important to differentiate between the roles of consignee and buyer. The role of consignee relates to the transport of the goods, whereas the role of buyer relates to the trade aspects. In the international trade context, the buyer is also known as the importer. The buyer or importer will often engage the services of a broker or agent to manage its regulatory business, in particular the preparation of a goods declaration to Customs, but also the many potential licenses, permits and certificates that can be required by other border regulatory agencies. Although it is possible that one entity may combine the roles of buyer and consignee, it is important to differentiate between these roles because the information generated is different, becomes available at different times, and is used for different purposes.

Freight forwarders

Freight forwarders are part of the transport logistics process within the supply chain and their main task is to arrange for air shipments to be managed in such a way that they are ready for transportation by aircraft operators. Such arrangements might include the consolidation of cargo, as appropriate. A freight forwarder and logistics service provider may offer a service relating to the preparation, storage, carriage, and final delivery of goods, including the applicable documentary and facilitation formalities. A forwarder rarely acts as carrier of the goods in the transport chain. Usually, it is the organizer of multiple carriages in several modes of transport and other services that contribute to the building of a supply chain. Such carriage may be performed by single or multimodal transport means. Multimodal transports occur when air cargo services are combined with sea, rail, or pre-carriage trucking from the shipper or manufacturer to the airport of aperture and from the airport of destination to the consignee. Services offered by the forwarder may include consolidation, storage, handling, packing, or distribution of the goods. In addition the forwarder can provide a range of ancillary and advisory services in relation to the physical movement of the goods. These services will often include Customs and fiscal matters, declaring the goods for official purposes, procuring insurance for the goods, and collecting or procuring payment or documents relating to the goods.

Ground handlers

Ground handlers are subcontracted and act on behalf of freight forwarders and/or aircraft operators. This occurs when the freight forwarder or aircraft operator does not have the necessary facilities. Ground handling services can include the provision of warehouses to accept, handle, prepare, and tag cargo and mail, as well as loading/unloading, transit, and storage of cargo and mail. Ground handlers are responsible for dealing with operational aspects, based on the instructions of freight forwarders and aircraft operators. Once a consignment is ready for shipment, the freight forwarder will release the cargo and instruct the ground handler to deliver it to the aircraft operator.

Aircraft operators

Aircraft operators, also known as airlines and air carriers, provide air transportation for goods. A transport contract (air waybill) binds an aircraft operator with the relevant contracted parties for the safe and secure transport of cargo and mail from one location (e.g. the airport of departure) to another (e.g. the airport of arrival). The air cargo may be transported on passenger aircraft or all-cargo aircraft. In some instances, particularly for short distances, aircraft operators may also transport air cargo by road. The transport contract remains an air waybill, however, and the road segment is considered as a flight, with a designated flight number. This type of operation is known as a 'road feeder service'.

Express carriers

Express carriers combine the work of a broker, haulier, freight forwarder, ground handler, and aircraft operator into one single company or group, which is why they are also sometimes referred to as 'integrators'. Express delivery has thus become a specific business model in the cargo industry. Express carriers manage end-to-end multimodal supply chains spanning 220 States and territories. They operate sophisticated track-and-trace information technology systems, which allow them to monitor the progress of an individual shipment through their chain, from pick up to delivery. Express carriers typically transport high-value-added, time-sensitive cargo, with a time-definite delivery.

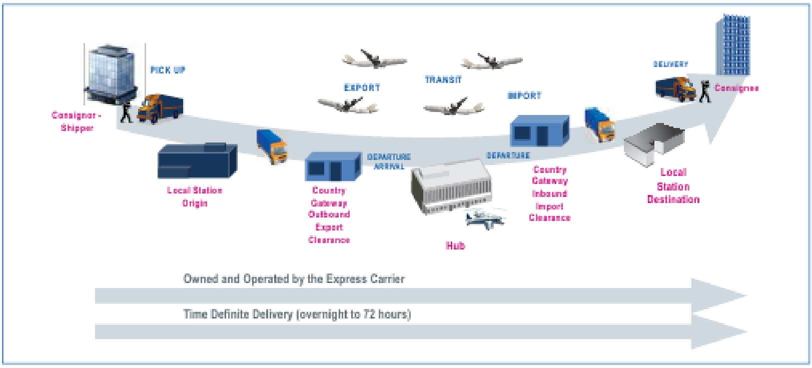

Fig. 2. The Express Model.

Conclusion

The air cargo supply chain is important for enabling cargo to move from its origin to its destination by air. The responsibility of all parties is to ensure that air cargo moves safely and securely through this chain. Air cargo movement and the Express Model have been considered and their significance for the effective performance of air cargo operations has been proven.

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Human Factors in Aircraft Maintenance

The safety of civil aviation is the major objective of the International Civil Aviation Organization (ICAO). It has long been known that the majority of aviation accidents and incidents result from less than optimum human performance, indicating that any advance in this field can be expected to have a significant impact on the improvement of aviation safety.

Introduction

One crucial aspect of an organization's safety culture is the ability to deal with human error. From an organizational perspective, human error should become a warning flag for regulators and managers, a possible symptom that individual workers have been unable to achieve the system goals because of difficult working environments, flaws in policies and procedures, inadequate allocation of resources, or other deficiencies in the architecture of the system. We must face the fact that because of human error, unwanted, un-willful deviations from the norms will take place. However, deviations in and of themselves are not the problem. The danger lies not in experiencing operational deviations, but rather in not having an adequate process of managing these deviations.

Problem Statement

Maintenance errors contribute to a significant proportion of worldwide commercial aircraft accidents and incidents and these occurrences are costly; yet until recently, little was known of the nature of maintenance errors and the factors that promote them.

The human element is the most flexible, adaptable and valuable part of the aviation system, but it is also the most vulnerable to influences which can adversely affect its performance. With the majority of aircraft accidents and incidents resulting from less than optimum human performance, there has been a tendency to merely attribute them to human error. However, the term "human error" is of little help in aircraft accident or incident prevention; although it may indicate WHERE in the system a breakdown occurred, it provides no guidance as to WHY it occurred.

Furthermore, the term "human error" allows concealment of the underlying factors that must be brought to the fore if accidents are to be prevented. For example, an error attributed to humans in the system may have been induced by inadequate design, inadequate training, badly designed procedures, and/or poor layout of job cards or manuals. In contemporary safety thinking, human error is the starting point rather than the stopping point in accident investigation and prevention. Ultimately, any safety audit must seek ways of minimizing or preventing human errors of any kind that might jeopardize safety.

Early efforts in Human Factors were directed towards the flight crew and demonstrated the dangers of ignoring the person as part of the socio-technical system. System-induced human errors, such as misreading altimeters or mis-selecting cockpit controls, have been reduced through better design to improve the interface between the pilot and the cockpit. Understanding the predictable aspects of human capabilities and limitations and applying this understanding in operational environments are therefore the primary concerns of Human Factors. Other early Human Factors concerns in aviation were related to the effects on people of noise, vibration, heat, cold and acceleration forces.

The understanding of Human Factors in aviation has progressively been refined and developed to include aircraft maintenance activities. It is now backed by a vast amount of knowledge which can be used to ensure that operators and maintenance organizations reduce errors during maintenance.

Consideration of Human Factors issues while performing maintenance operations

Many factors that can potentially compromise human performance can also jeopardize the safety and well-being of the aviation employee, particularly those performing aircraft maintenance tasks. Many of these factors which have implications beyond the prevention of aircraft accidents, e.g. industrial safety implications, are cited in this manual. However, notwithstanding the importance of such occupational safety and health (OSH) issues to the long-term effectiveness of the aviation system, the focus of this manual is on understanding how these Human Factors issues affect aircraft safety.

The safety and reliability of aircraft maintenance operations depend as much upon people as they do on the technical systems of aircraft, parts, tools and equipment. Nevertheless, accident and incident reports continue to show that aircraft maintenance engineers (AMEs) sometimes make errors, that aircraft maintenance organizations sometimes fail to organize and monitor their work effectively, and that these failures can have disastrous consequences. Furthermore, even when things do not go radically wrong, the evidence suggests that on a routine day-to-day basis, the systems which should ensure that work is accomplished to the highest possible standard are not functioning effectively. In response to new regulations which demand consideration of Human Factors issues of maintenance operations, many organizations are embarking on Human Factors programmes that involve training or incident investigation. Unfortunately, for a variety of reasons, these programmes are not always successful in achieving better ways of doing things.

Determination of Human Factors

Human Factors as a term has to be clearly defined because when these words are used in the vernacular they are often applied to any factor related to humans. One definition of Human Factors which is accepted by ICAO was proposed by Professor Elwyn Edwards and declares that “Human Factors is concerned to optimize the relationship between people and their activities, by the systematic application of human sciences, integrated within the framework of systems engineering”. Its objectives can be seen as effectiveness of the system, which includes safety and efficiency, and the well-being of the individual. Professor Edwards further elaborates on his proposed definition, indicating that the word “people” includes both sexes, and that “activities” indicates an interest in communication between individuals and in the behaviour of individuals and groups. Lately, this has been expanded upon to include the interactions among individuals and groups and the organizations to which they belong, and to the interactions among the organizations that constitute the aviation system. The human sciences study the structure and nature of human beings, their capabilities and limitations, and their behaviours both singly and in groups. The notion of integration within systems engineering refers to the Human Factors practitioner’s attempts to understand the goals and methods as well as the difficulties and constraints under which people working in interrelated areas of engineering must make decisions. Human Factors uses this information based on its relevance to practical problems.

A simpler and more practical definition has been published by the United Kingdom Health and Safety Executive: “Human Factors refer to environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work in a way which can affect health and safety.”

Human Factors is therefore about people in their living and working situations; about their relationships with machines, with procedures and with the environment around them; and also about their relationships with other people. In aviation, Human Factors involves a set of personal, medical and biological considerations for optimal aircraft, aircraft maintenance and air traffic control operations.

It can be helpful to use a conceptual model to aid in the understanding of Human Factors. One practical diagram to illustrate this conceptual model uses blocks to represent the different components of Human Factors. The model can then be built up one block at a time, with a pictorial impression being given of the need for matching the components.

The Human Factors Training Manual (Doc 9683) uses the SHEL model (the name being derived from the initial letters of its components: Software, Hardware, Environment, Liveware). This model is reproduced as Figure 1-5 and was first developed by Professor Edwards in 1972, with a modified diagram to illustrate the model developed by Captain Frank Hawkins in 1975. The following interpretations are suggested: liveware (human), hardware (machine), software (procedures, symbology, etc.), and environment (the situation in which the L-H-S system must function). This building block diagram does not cover the interfaces which are outside Human Factors (hardwarehardware; hardware-environment; and software-hardware) and is only intended as a basic aid to understanding Human Factors.

Conclusion

The safety of civil aviation can be jeopardized by Human Factors. The majority of aviation accidents and incidents occur due to human performance. One of the major objectives of the International Civil Aviation Organization (ICAO) is determine Human Factors and eliminate their influence on Civil Aviation.

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Considering the requirements of ECAC Doc 30 when training airport X-ray screeners

The training of screeners is relevant at any time. That is why leading organizations on regulation of aviation security are actively engaged in the development of standards and recommended practices on this issue at different levels.

Introduction

Ukraine, along with other countries, is concerned by the issue of aviation security personnel training. The main document that regulates the professional activities of screeners at the regional level is ECAC Doc 30.

It is necessary to consider some of the standards to which Doc 30 makes the main emphasis. Persons operating X-ray or EDS equipment or human reviewers of security scanners:

- Initial certification or approval

Persons operating X-ray or EDS equipment or human reviewers of security scanners should, as part of the initial certification or approval process, pass a standardized image interpretation test. [Ref Commission Implementing Regulation (EU) 2015/1998 Annex 11.3.2]

- Re-certification or re-approval

The recertification or re-approval process for persons operating x-ray or EDS equipment or human reviewers of security scanners should include both the standardized image interpretation test and an evaluation of operational performance. [Ref Commission Implementing Regulation (EU) 2015/1998 Annex 11.3.3]

- Failure to complete re-certification or re-approval

Failure to undertake and successfully complete recertification or re-approval within a reasonable timescale, not normally exceeding 3 months, should result in the related security entitlements being withdrawn. [Ref Commission Implementing Regulation (EU) 2015/1998 Annex 11.3.4]

- Certification records

Certification or approval records should be kept for all persons certified or approved, respectively, for at least the duration of their contract. [Ref Commission Implementing Regulation (EU) 2015/1998 Annex 11.3.5]

Recurrent training

- Persons operating x-ray or EDS equipment

Persons operating x-ray or EDS equipment should be subject to recurrent training consisting of image recognition training and testing. This should take the form of:

a) classroom and/or computer based training; or

b) on-the-job TIP training, on condition that a TIP library of at least

6,000 images, as specified below, is employed on the x-ray or EDS equipment used and the person works with this equipment during at least one third of his working hours. The results of testing should be provided to the person and recorded and may be taken into consideration as part of the recertification or re-approval process.

- Classroom and/or computer based training

For classroom and/or computer based training, persons should be subject to image recognition training and testing for at least 6 hours in every 6 month-period, using an image library containing at least 1000 images of at least 250 different threat articles, including images of component parts of threat articles, with each article captured in a variety of different orientations, and arranged to provide an unpredictable selection of images from the library during the training and testing; or the most frequently missed TIP images from the TIP library in use combined with images of recently captured threat articles relevant for the type of screening operation and covering all types of relevant threat articles if only used once for the training of a given screener over a three-year period.

- On-the-job TIP training

For on-the-job TIP training, the TIP library should consist of at least 6000 images of at least 1500 different threat articles, including images of component parts of threat articles, with each article captured in a variety of different orientations.

Airport Security Screeners' activities

Airport Security Screeners conduct screening of passengers, baggage, or cargo to ensure compliance with Transportation Security Administration (TSA) regulations. May operate basic security equipment such as x-ray machines and hand wands at screening checkpoints. On the job they:

- challenge suspicious people, requesting their badges and asking what their destination is;
- follow those who breach security until police or other security personnel arrive to apprehend them;
- monitor passenger flow through screening checkpoints to ensure order and efficiency;
- close entry areas following security breaches or reopen areas after receiving notification that the airport is secure;
- record information about any baggage that sets off alarms in monitoring equipment;
- locate suspicious bags pictured in printouts sent from remote monitoring areas, and set these bags aside for inspection;
- contact police directly in cases of urgent security issues, using phones or two-way radios;
- test baggage for any explosive materials, using equipment such as explosive detection machines or chemical swab systems;
- inform other screeners when baggage should not be opened because it might contain explosives;

- check passengers' tickets to ensure that they are valid, and to determine whether passengers have designations that require special handling, such as providing photo identification.

Fig.1. X-ray screeners in action

Conclusion

The training of screeners has regained the special significance, taking into account the challenges that take place nowadays, in particular, acts of unlawful interference, hijackings, conceiving terrorist acts, etc. To prevent all these illegal activities, leading organizations on regulation of aviation security ought to develop standards and recommended practices on this issue at different levels.

Ukraine, along with other countries, has been involved in aviation security personnel training performed in accordance with ECAC Doc 30, the main document that regulates the professional activities of screeners at the regional level.

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Lithium Batteries as Cargo

On 22 February, the ICAO Council adopted the recommendation of the ICAO Air Navigation Commission (ANC) that lithium ion batteries, UN 3480, be forbidden, on an interim basis, as cargo on passenger aircraft. The prohibition does not apply to lithium ion batteries packed with equipment or lithium ion batteries contained in equipment, UN 3481.

Changes to the Provisions for Lithium Batteries

1. UN 3480, PI 965, Section IA and IB. Lithium ion cells and batteries must be offered for transport at a state of charge (SoC) not exceeding 30% of their rated design capacity. Cells and/or batteries at a SoC of greater than 30% may only be shipped with the approval of the State of Origin and the State of the Operator under the written conditions established by those authorities. UN 3480, PI 965, Section IA and IB are forbidden for carriage on passenger aircraft. All packages must bear the Cargo Aircraft Only label in addition to the other marks and labels required by the Regulations.

Note: Guidance and methodology for determining the rated capacity can be found in the UN Manual of Tests and Criteria, 5th Revised Edition, Amend. 1 and Amend. 2, Section 38.3.2.3.

2. UN 3480, PI 965, Section II. Lithium ion cells and batteries must be offered for transport at a state of charge (SoC) not exceeding 30% of their rated design capacity. All packages prepared in accordance with Section II of PI 965 are forbidden for carriage on passenger aircraft. All packages must bear the Cargo Aircraft Only label in addition to the other marks and labels required by the Regulations. A shipper is not permitted to offer for transport more than one (1) package prepared according to Section II in any single consignment.

Not more than one (1) package prepared in accordance with Section II of PI 965 may be placed into an overpack. When the package is placed in an overpack, the lithium battery handling label and Cargo Aircraft Only label required by this packing instruction must either be clearly visible or the label must be affixed on the outside of the overpack and the overpack must be marked with the word “Overpack”.

3. UN 3090, PI 968, Section II. A shipper is not permitted to present for transport more than one (1) package prepared according to Section II in any single consignment. Not more than one (1) package prepared in accordance with Section II of PI 968 may be placed into an overpack. When the package is placed in an overpack, the lithium battery handling label and Cargo Aircraft Only label required by this packing instruction must either be clearly visible or the label must be affixed on the outside of the overpack and the overpack must be marked with the word “Overpack”.

4. Packages prepared according to Section II of PI 965 and PI 968 must be offered to the operator separately from other cargo and must not be loaded into

a unit load device (ULD) before being offered to the operator.

Accidents and incidents connected with dangerous goods

It would be appropriate to pay attention to a recent dangerous goods incident involving the carriage of a consignment of aircraft tires from Singapore that may not have complied with the Air Navigation Order (ANO) and the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air (ICAO TI). It is also necessary to emphasize that possible accidents connected with dangerous goods can cause damage to an aircraft. That is why preventive measures to ensure safety onboard are required.

Before transporting rechargeable lithium batteries, according to the FAA, carriers should evaluate the frequency and quantities of such shipments; proximity of batteries to other dangerous goods; and accessibility of these batteries to the crew in case of a fire.

Fig.1. An accident caused by lithium batteries onboard

Description of the Incident

On 29 March 2016, a consignment of 10 aircraft tires was offered for transportation to an airline from Singapore to Hong Kong. The tires were removed from various aircraft in Singapore and were tagged with unserviceable/removal labels at the time when those tires were removed from the aircraft. Prior to offering the consignment for transportation by air, the valve assemblies of all the tires were protected with covers and each tire was strapped to a pallet and shrink wrapped. However, neither the shipper nor its cargo agent had verified that the aircraft tires had met the requirements of the regulations (refer to paragraph 5).

When the consignment was offered for transportation, the airline's ground handling agent also did not verify that the requirements of the regulations were met prior to accepting the consignment for carriage by air on behalf of the airline. Upon arrival at the consignee's premise in Hong Kong, one of the aircraft tires exploded and a contracted staff of the consignee who handled the tire sustained fatal injuries.

Regulations on the Carriage of Tire Assemblies by Air Regulations and restrictions concerning the carriage of tire assemblies (not limited to aircraft tires) as cargo by air can be found in the List of Dangerous Goods and Special Provision A59 of the ICAO TI. Special Provision A59 specifies that: Tire assemblies are not subject to the regulations provided that:

(a) unserviceable or damaged tire assemblies, the tire is completely deflated; or

(b) serviceable tire assemblies, the tire is not inflated to a gauge pressure exceeding the maximum rated pressure for that tire. However, such tires (including valve assemblies) must be protected from damage during transport, which may require the use of a protective cover.

Consequently, and with reference to the List of Dangerous Goods, when the requirements of Special Provision A59 are not complied with (i.e unserviceable or damaged tire assemblies that are not completely deflated or serviceable tires that are inflated beyond its maximum rated pressure and/or are not protected from damage during transport) such tire assemblies are forbidden for transportation by air.

Conclusion

There are inherent hazards contained in dangerous goods articles and substances. Failing to comply with the regulations when offering or transporting dangerous goods by air may result in serious consequences.

It is necessary to remind shippers, cargo agents, ground handling agents and airlines to comply with the ANO and the ICAO TI when consigning and transporting dangerous goods by air; to, from or through Singapore. Staff who accepts cargo and dangerous goods on behalf of shippers and airlines are also reminded to be vigilant when conducting cargo and dangerous goods acceptance checks to ensure the transportation of dangerous goods by air complies with the relevant regulations.

Shippers, cargo agents, ground handling agents and airlines are also encouraged to share these information with relevant staff involved in the handling of cargo and dangerous goods. Cargo agents are also encouraged to share this information with its customers.

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FAA approaches to the method of determining the acceptable level of risk

Safety is the cornerstone of the mission that the Federal Aviation Administration (FAA) fulfills. The FAA has many programs to evaluate safety at every stage of a flight. Safety on the ground implies avoiding aircraft runway incursions and maintaining safe separation between aircraft and ground service equipment, which is just as important as safety in the air.

Introduction

The FAA's Safety Management System (SMS) is a formalized process that includes a safety policy, assurance, safety risk management and safety promotion, which fosters a positive safety culture. It helps identify any safety risks prior to implementation of all NextGen programs.

SMS is part of airspace redesign initiatives in locations such as Chicago, Houston, Las Vegas, New York and all Metroplex projects. The FAA also uses SMS in the development of Performance Based Navigation (PBN) procedures.

More than 7,000 NextGen PBN procedures are now in use. These enable aircraft to fly more precise approaches within coverage of ground-based or satellite-based navigation aids. With PBN, flight crews use advanced aircraft avionics to operate within tightly contained flight paths, which enhances safety.

The use of these procedures will increase significantly as part of NextGen. PBN procedures developed as part of NextGen include Required Navigation Performance approaches, Standard Terminal Arrival Routes (STAR) for arrivals, and Area Navigation (RNAV) for standard instrument departures.

Analyzing Risk

The FAA has continued to develop safety metrics and monitoring methods to ensure that risks remain at an acceptable level. The agency developed Risk Analysis Process (RAP) for airborne Loss of Standard Separation, which includes any pilot deviation from prescribed radar separation standards between two aircraft. The FAA also uses RAP for surface and service integrity to analyze current events in the NAS and to provide trending data for future NextGen enhancements.

For Technical Operations, the process is called Service Integrity Risk Analysis Process. This process is for collecting and analyzing service integrity events and technical hazards.

These stronger measurements of risk enabled the FAA to gather additional data about losses of standard separation in a manner that also encouraged reporting through ATO's voluntary safety reporting program for controllers and technicians. Sophisticated data collection, reporting and analysis capabilities enabled the FAA's new safety metrics.

Over the years, the Federal Aviation Administration (FAA) and the aviationindustry have dramatically increased the safety of air travel by managing and mitigating risks associated with flight. The aviation industry currently provides the safest form of transportation in the United States. However, the industry continues to have some accidents that can be prevented. Therefore, both the FAA and industry are working to continually improve the safety record of turbine-powered aircraft. Over the next few years, the FAA will encourage operators and certificate holders to develop Safety Management Systems (SMS). This safety protocol is described in Advisory Circular (AC) 120-92, Introduction to Safety Management Systems for Air Operators.

The Turbine Aircraft Operations Subgroup as part of the General Aviation Joint Steering Committee has developed a risk assessment tool for use in flight operations. In creating this tool, the Turbine Aircraft Operations Subgroup reviewed accident data, identified hazards, and used normal risk assessment development methodology. This tool provides a simple way to implement proactive risk management. An operator can use the risk assessment tool as a stand-alone tool but incorporating it into an SMS is preferable.

As discussed in AC 120-92, a hazard is defined as any existing or potential condition that can lead to injury, illness, or death to people; damage to or loss of a system, equipment, or property; or damage to the environment. A hazard is a condition that is a prerequisite of an accident or incident.

Every flight has hazards and some level of risk associated with it. It is critical that operators and pilots are able to differentiate, in advance, between a low risk flight and a high risk flight, and then establish a review process and develop risk mitigation strategies to address flights throughout that range. A risk assessment tool should allow operators and pilots to see the risk profile of a flight in its planning stages. Each operator should determine an acceptable level of risk for its flights based on the type of operation, environment, aircraft used, crew training, and overall operating experience. When the risk for a flight exceeds the acceptable level, the hazards associated with that risk should be further evaluated and the risk reduced. A higher risk flight should not be operated if the hazards cannot be mitigated to an acceptable level.

Risk assessment tool

The attached risk assessment tool has been developed for use in understanding different levels of flight risk and to allow operators and pilots to become familiar with this element of an SMS. It is important for operators to understand that risk has several elements that must be considered, including probability, severity, and weighted value. What is the probability of a particular event occurring? If the event does occur, what is the severity likely to be? And what is the weighted value of this type of event compared to other aspects of the operation? In the attached risk assessment tool, this work has been done so the operator has a simplified form of the tool. Each operator may want to add items that are unique to its operation using the additional resources provided. An operator can also change any item currently used in the tool provided it conducts a realistic assessment of the hazard being changed.

To use the tool, the operator needs to create numerical thresholds that trigger additional levels of scrutiny prior to a go/no-go decision for the flight. These thresholds should be created to help ensure that the safety standards of each individual operation are maintained. However, it is important that the operators create realistic thresholds. If every flight is within the acceptable range under any condition, it is likely that the thresholds have not been set correctly. While performing small operations (for example, where the pilot is also the chief pilot and owner), it is recommended to take into account strategies for appropriate consideration of elevated risk, which best fit these operations.

The following discussion provides a practical example of the five step process used to assess risk as outlined in AC 120-92.

Step 1. Complete a system and task analysis.
Step 2. Identify the hazards.
Step 3. Analyze the safety risk.
Step 4. Assess the safety risk.
Step 5. Control the safety risk.

Flight Risk Assessment Tool			
		Risk Value	**Flight Value**
Pilot Qualifications and Experience			
1			
2			
…			
	Total Factor Score - Section 1		
Operating Environment			
9			
10			
11			
…			
	Total Factor Score - Section 2		
Equipment			
36			
37			
…			
	Total Factor Score - Section 3		
	TOTALS		

Step 1. Complete a system and task analysis.

The captain is not highly experienced with less than 200 hours in type. The first officer has less than 100 hours in the last 90 days.

Step 2. Identify the hazards.

The runway is wet.

The flight will operate at night.

The destination crosswinds are greater than 15 knots.

Step 3. Analyze the safety risk.

The combination of the risk factors associated with this flight generates a risk value of 20 using the example risk assessment tool.

Step 4. Assess the safety risk.

Company policy requires that the Chief Pilot assess and approve any flight risk value greater than 15. Since the risk value of 20 exceeds the company operational threshold risk of 15, the Chief Pilot decides to operate the flight by reducing the flight risk value to a more acceptable level.

Step 5. Control the safety risk.

The Chief Pilot focuses on mitigating three hazards.

1. He decides to allow the scheduled captain to operate the flight.
2. However, he assigns the flight to a first officer who is more current and who has flown more than 100 hours in the last 90 days.
3. Further, the Chief pilot changes the destination airport to an airport with no crosswind expected.

By controlling the risk value of these three hazards, the Chief Pilot has reduced the flight overall risk value to 13 and elevates the operational level of safety.

Conclusions

The FAA recommends that operators and pilots get familiarized with the attached risk assessment tool and AC 120-92. They should then decide whether to use the tool as published or to modify it as needed for their own operations. Once an operator has established the parameters of the tool, it should create operational thresholds and begin using the tool to establish a "risk number" for each flight. This risk number should be used to control risk before a flight takes place. Over time this tool will become unique to each operator and can become a part of its complete SMS. The risk assessment tool cannot guarantee a safe flight. Safety is ultimately the responsibility of the pilot and operator. However, it does provide an additional tool to help the pilot and operator make sound safety decisions.

References

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