1. Contemporary Challenges of International Science and Education in the Field of Aviation Safety and Security

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1.1 INTRODUCITON TO AVIATION SAFETY AND SECURITY SYSTEM

Air transport industry plays a major role in the 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, security and environmental protection on a global basis.

ICAO's Strategic Objectives are strongly linked to 15 out of the 17 United Nations Sustainable Development Goals (SDGs). The Organization is fully committed to work in close cooperation with States and other UN Bodies to support related targets. Development of global civil aviation safety and security 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 the level of safety and security of the aviation system. Having all the above mentioned issues in mind, the search for new methods to assess the aviation "safety space" seems topical and important for future civil aviation development.

The regulation framework of aviation safety and security system is regulated on four hierarchical levels - Global, Regional, Intergovernmental and National.

The Global Level of Aviation Safety and Security System Regulations covers the International Civil Aviation Organization (ICAO) and consists of *Standards and Recommended Practices* (SARPS) in the field of aviation safety, aviation security and environmental protection; regulation framework of global non-governmental aviation organizations (International Air Transport Association (IATA), International Federation of Freight Forwarders Associations (FIATA), Airports Council International (ACI), International Federation of Air Line Pilots' Associations (IFALPA), International Federation of Air Traffic Controllers' Associations (IFATCA) and others.

The Regional Level of Aviation Safety and Security System Regulations covers ICAO European and North-Atlantic office (Paris); regulation framework of regional intergovernmental aviation organizations (such as European Civil Aviation Conference (ECAC), European Aviation Safety Agency (EASA), European Organization for the Safety of Air Navigation (EUROCONTROL) and other);

The Intergovernmental Level of Aviation Safety and Security System Regulations covers aviation safety and environmental protection provisions of Intergovernmental air transportation agreements; features of bilateral security regime are represented in an Intergovernmental aviation security agreement and other.

The National Level of Aviation Safety and Security System Regulations covers National aviation organizations, such as National Supervisory Authorities (NSA), Civil Aviation Authorities (CAA), State Aviation Administrations (SAA). This level is strongly supported by national aviation educational - training - scientific centres, such as National Aviation University, Kyiv, Ukraine and the International University of Logistics and Transport in Wroclaw, Poland. At this level, the implementation of aviation safety and security training standards is provided. It should be underlined that higher education and research institutions play a significant role in the development of training programmes, technology, and regulations for the aviation safety and security system.

1.2 DEVELOPMENT OF GLOBAL AVIATION SAFETY MANAGEMENT SYSTEMS

If you dive into history, you might find out that the first post-war decades were marked by a very high accident rate. Almost every thousandth flight had serious safety problems. At the same time, in the list of the main causes of events, the first place was occupied by aviation technology refusal. At this stage, the most effective tool for confronting disasters was the reactive methods - the investigation of aviation accidents and serious incidents. These methods made a valuable contribution to the modernization of the aviation technology. The joint activity of specialists from many countries of the world has led to the fact, that technical factors mostly lost their critical character.

The achievements of aviation designers, scientists and experts during 1970s – 1990s reduced the probability of a disaster to one per 100 thousand flights. This period was marked by the active development of the ICAO Standards and Recommended Practices within the framework of the 18 Annexes to the Chicago Convention. Among the main methods that are widely used at this stage, it is possible to identify the proactive approach. Proactive methods are based on the analysis of the structure and activities of the organization and identifying vulnerabilities. At the same time, the critical element of the system was shifted from technical to human factor. Research in the field of human factor has received unquestionable priority [1].

The further development of aviation safety tools included approaches to the predictive method. The predictive method captures the characteristics of the system, which is manifested in real-time in normal operational conditions. In these conditions, the role of the human factor has changed and comprehended. The concept of organizational factors was proposed. As the organizational factor, the following maxim is understood - if in an emergency a person commits a catastrophic error, not only this person is guilty, but the system is guilty as well, which allowed a person to make such a mistake and did not provide him/her with any additional protection means.

The complex application of the above-mentioned three methods has allowed to increase the global safety level, the highest in aviation history, to 1 disaster for 10 million flights. These Fig.s are evidence of the undeniable progress of the world's aviation safety system. However, unfortunately, the Fig.s do not always fully reveal the actual picture. According to the forecasts of the leading world civil aviation organizations, every 15-20 years the number of flights is estimated to double. Thus, reducing the probability of an accident, unfortunately, does not eliminate the likelihood of human losses [2, 3, 4].

1.3 THE ROLE AND PLACE OF LEADING AVIATION AND TRANSPORT UNIVERSITIES IN THE PROCESS OF AVIATION TRANSPORT SAFETY & SECURITY MANAGEMENT SYSTEMS IMPLEMENTATION (NATIONAL AVIATION UNIVERSITY EXPERIENCE).

1.3.1 NATIONAL AVIATION UNIVERSITY – ONE OF THE LEADING AVIATION UNIVERSITIES IN THE WORLD

The National Aviation University (NAU) is the largest aviation university in Ukraine and one of the leading aviation universities in the world. During 87 years of its existence, the University has trained tens of thousands of specialists from more than 140 countries, and continues to provide training in promising areas and various specialities. 3 institutes, 10 faculties, ICAO Institute, 15 research institutes and centres, 7 colleges and academies, 2 lyceums and gymnasiums function under the auspices of the University. The University has trained thousands of Specialists and Masters, Candidates and Doctors of Science for civil aviation and national economy. Nowadays, the University provides high-quality education for 25 thousand students from more than 45 countries.

ICAO methodologies are widely used in the teaching process at the University. In addition, educational courses include practical recommendations, and are based on documents of the European Civil Aviation Conference (ECAC), the European Aviation Safety Agency (EASA) and EUROCONTROL. The National Aviation University takes an active part in many international programs with foreign universities, training centres, associations and companies. NAU co-operates with foreign scientific and training institutions of Germany, France, Poland, Spain, Azerbaijan, Belarus, Lithuania, Latvia, Italy, Georgia, Vietnam, South Korea, India, China, Turkey and other countries. For practical training the University has deepened relations with the following leading companies and organizations of Ukraine: "Antonov", "Ukroboronprom", Airport "Boryspil", Airport "Kyiv", Ukraine International Airlines, State Space Agency of Ukraine, enterprises of state and municipal property, private sector, etc.

The University has got all necessary facilities and equipment: 14 buildings, training aerodrome, a unique hangar, radio equipment and aviation ground equipment facilities, aerodynamic and training complexes, the State Museum of Aviation; 75 airplanes and helicopters; 42 aircraft engines; aircrafts, unmanned aerial systems and ATC tower simulators; 240 on-board systems; test benches are used in the training process. The scientific and technical library has about 3 million books [7].

1.3.2 ICAO INSTITUTE OF THE NATIONAL AVIATION UNIVERSITY – REGIONAL LEADER OF SAFETY AND SECURITY TRAINING

The Institute is named after the International Civil Aviation Organization (ICAO), which was established to ensure the effective and regular development of the global air transport system, as well as the development of regulatory framework for safety in aviation. The first steps of cooperation between the National Aviation University (NAU) and ICAO began in the 80's, when seminars and workshops were conducted at the NAU under the auspices of this organization. The University participated in the implementation of ICAO programs: specialists training, recurrent training of military pilots, development and translation of ICAO materials. In 1996, the ICAO European Regional Aviation Security Training Centre was established at the National Aviation University due to its reputation all over the world. The Centre received an international certificate, which permits to conduct training of all aviation personnel categories employed by aviation companies in the area of aviation security. In 2002, the National Aviation University opened the ICAO European Regional Training Centre for state inspectors involved in flight safety and airworthiness. The both centres implement the ICAO methodology

using the Standards and Recommended Practices. Specialists training are carried out in accordance with the module system in Russian and English languages in Ukraine and other countries. The training is performed by highly qualified, ICAO certified and experienced experts. To ensure the coordination of aviation safety training and recurrent training, the ICAO Institute was established in the National Aviation University in 2003. The Institute includes the ICAO European Regional Aviation Security Training Centre, and the European Regional Government Safety Inspectors Training Centre, as well as national training centres. National Training Centre "Aviation English" provides training and testing of flight crewmembers and Aviation English raters/examiners.

Fig. 1. Activities of ICAO Training Institute of National Aviation University

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety.* Logistics and Transport, 38 (2018)/2, pp. 23-32.

Recurrent trainings and upgrading trainings for various specialists are conducted at the National Centre for Aviation Safety. Since 2003, about 13 thousand employees of aviation administrations, airlines, airports, aviation enterprises, flying clubs and aviation educational establishments from Ukraine and 77 countries of the world have been trained and retrained in the training centres. The high prestige of the ICAO Training Institute is confirmed by the constant increase in the number of students and scope of activities. In 2012, the international certificates were issued to more than 2,000 aviation experts from 34 countries, namely Armenia, Azerbaijan, Belarus, Belgium, Bulgaria, Germany, Georgia, Iraq, Ireland, Jordan, Spain, Kazakhstan, Congo, Kyrgyzstan, Latvia, Lithuania, Malaysia, Moldova, Mongolia, the Netherlands, New Zealand, Russia, Syria, Tajikistan, Turkmenistan, Turkey, Uzbekistan, Ukraine, France, Croatia, Montenegro, Sweden and Estonia.

The effective business relations between the Institute and ICAO have been extremely successful in carrying out a large number of joint activities on aviation safety issues at the international level. Among these measures the World Congress "Aviation in the 21st century", International and European regional seminars on the new format flight plan (FPL), on the implementation of a mechanism of continuous monitoring of aviation safety, and on air traffic safety, and training courses under the auspices ICAO.

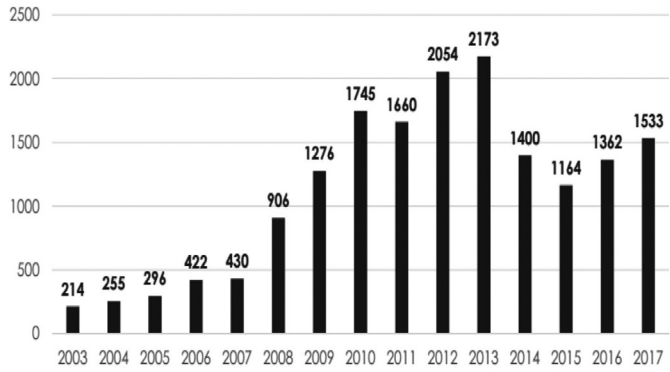

Fig. 2. The number of air transport employees, who were trained at ICAO Institutein period from 2003 to 2017.

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

The ICAO Training Institute effectively cooperates with the aviation administrations of many countries regarding the regionalization of international training programs and recognition of national aviation specialists training programs based on the implementation of best practices. The ICAO European Regional Training Centre (NAU) received a certificate of the European Civil Aviation Conference and was included in the network of training centres of the North European region [7, 8].

1.3.3 SCIENTIFICALLY INNOVATIVE ACTIVITIES OF THE NATIONAL AVIATION UNIVERSITY IN THE PROCESS OF IMPROVING THE AVIATION TRANSPORT SAFETY LEVEL

It is not possible to imagine the process of improving the aviation transport safety level without the usage of large-scale new innovative technologies. To optimize scientific activity at the University, five scientific majors of top priority were determined:

- Aviation and Space Technologies.
- Information Technologies.
- Ecological Biotechnology.
- Energy-Saving Technologies.
- Science of Materials.

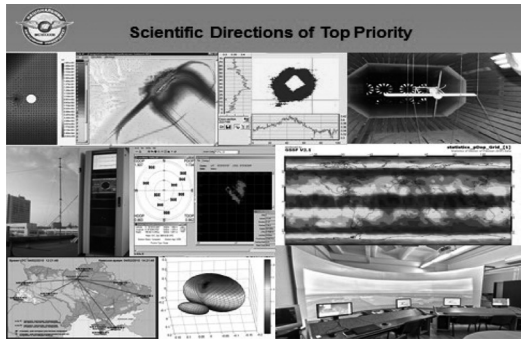

Fig. 3. Scientific majors of top priority of National Aviation University

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

The features of today are extremely fast and intense process of robotic systems for special purposes, which are associated with the formation of an idea of the place, role and tasks undertaken by unmanned aircraft devices [9, 10]. Currently, the National Aviation University, together with ICAO, participates in the development of recommendations in the very important direction "Flight over populated areas" as for manned as well as for unmanned aviation.

The creation of unmanned aircraft systems is one of the priorities of the global civil aviation. In this regard, the National Aviation University conducted a perennial work on the principles of design and creation of experimental remotely piloted aircraft systems. In the research and production centre of National Aviation University of unmanned aviation "Virage" the line of UAVs have been developed: one-engine M-3 "Border", M-6 "Skylark"; two-engine M-7, M-7D, M-7V5 "Sky Patrol", drones (the UAV) and UAV with an electric motor "Eye" (see Fig.4). These types of UAVs are used for aviation specialists training purposes. Unmanned aerial vehicle (UAV) is used for aviation activities in different branches of economy. It can be used for cartography and aerial photography, video surveillance in the real time, patrolling linear and other objects etc. The specified UAV is supplied with a ground control station [11].

Fig. 4. Multipurpose UAVs of National Aviation University

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

Thus, are there any ways to solve the problem of integration, search, recognition and processing of satellite tracking, navigation and UAV-onboard avionics? Together with researchers of International University of Logistics and Transport in Wroclaw, Poland, the comprehensive work on assessing capacity and effectiveness of RPAS was conducted to solve logistical problems of territorial infrastructure [12]. UAV onboard avionics are also developed at our university. The developed automatic flight control system allows performing:

- automatic stabilization of the angular position of the UAV, the three major axes; automatic altitude stabilization of the UAV;
- automatic stabilization and control of true airspeed of the UAV's flight using control traction motor(s); automatic flight on the route;
- restrictions limiting regimes of the UAV;

- improve the performance of stability and controllability of the UAV;
- recording on the independent board flash memory and transmission to the ground navigation control station and telemetry data over a radio channel.

Fig. 5. The automatic flight control system of UAV

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

The University has developed software and hardware facilities of integrated inertial and satellite navigation system for unmanned aircraft vehicles. Integrated inertial and satellite navigation system for unmanned aircraft vehicles (IISNS) are intended for determination of navigation performances of moving object. The core of IISNS is Strapdown Inertial Navigation Unit (SINU) assembled on the Micro Electro Mechanical accelerometers and gyroscopes. SINU coupled with GNSS receiver, barometric altimeter and magnetometer. It allows: to prognosticate availability of optimum configuration of the both satellite navigation systems GPS and GLONASS; to estimate a factor of accuracy dilution of navigation performances; to implement calculation of coordinates, velocity and time on the basis of GPS and GLONASS signals.

Diversity of the modern UAV flight missions and their increasing complexity require the creation of the UAV robust flight control systems, which allow achieving high control performance during flight mission execution under action of the internal and external disturbances. On the basis of the parametric as well as structural methods of the robust systems synthesis, the algorithms and programs for the UAV autopilots control laws in the modes of the attitude, velocity and altitude stabilization, as well as for the guidance control, including the path planning and path following algorithms during the flight in the disturbed atmosphere, were created. The application of the parametric synthesis allows determination of the optimal tuning of the existing autopilots, providing the trade-off between robustness and performance, meanwhile the structural synthesis allows finding the perspective autopilots control laws, including the control laws with the elements of the artificial intellect.

Fig. 6. Display of the ground test control station

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

Learning of aerospace specialists requires study of modern satellite technology. Scientific and Education Centre "Aerospace Centre" has been established at National Aviation University to conduct fundamental, applied, experimental research projects and training courses. The Centre's activity is aimed at implementation of priority areas of science, engineering and technology-based global navigation satellite system and information technology (see Fig. 7).

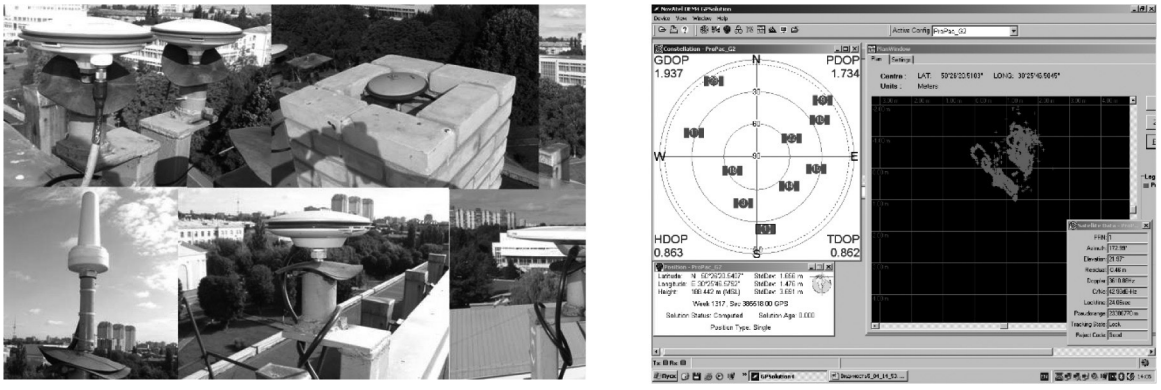

Fig. 7. Aerospace Center – Experimental Equipment

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

One of the most important directions of satellite navigation development is a solution of the problem of space debris. In this regard, the NAU conducted a complex research. The Navigation aids are the main part of service spacecraft for safe docking approach with the object to be utilized. A New approach to complex data processing obtained from different navigation systems is being developed. The ways of satellite navigation systems' signals processing in the unstable radio navigation field have been studied. The research on increasing the jamming resistance of satellite radio navigation equipment is in process [11].

Contemporary direction of research innovative activity is environmentally safe jet fuels, which are intended for use at aircrafts of civil aviation, equipped with gas-turbine engines. The developed bio-additives from

camelina oil allow substituting up to 50% of conventional diesel fuel and up to 30% of conventional jet fuel with renewable energy source. This will contribute to decreasing energy dependence of both Ukraine and Poland and reducing anthropogenic load on environment. The social effect of the project realization comprises integration of intellectual potential of Ukrainian and Polish scientist for solving global problem of depleting energy resources and reducing impact of exhaust gases emissions on atmospheric air. This will promote development of allied industries (aviation and motor transport constructing, chemical technology, agriculture). Implementation of high-quality environmentally safe motor fuels will promote resource saving, energy efficiency and environmental safety of transportation due to application of new effective bio-additives. The production of bio-additives according to the project has to be made of non-edible domestic feedstock. In comparison with the known analogues, using of environmentally safe fuels may help saving 10–30% of mineral crude-oil feedstock and minimize negative impact of aviation on the environment.

A significant role in the aviation specialists training is assigned to studies on simulators. A complex of Air Traffic Control and Flight Simulators was designed and operated at NAU (see Fig. 8).

Fig. 8. Airport Tower, Manned and Unmanned Aerial Vehicles Integrated Simulator.

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

In Fig. 9 we can see UAVs Components Durability Complex Test System, which allows researches and students to design new types of UAVs.

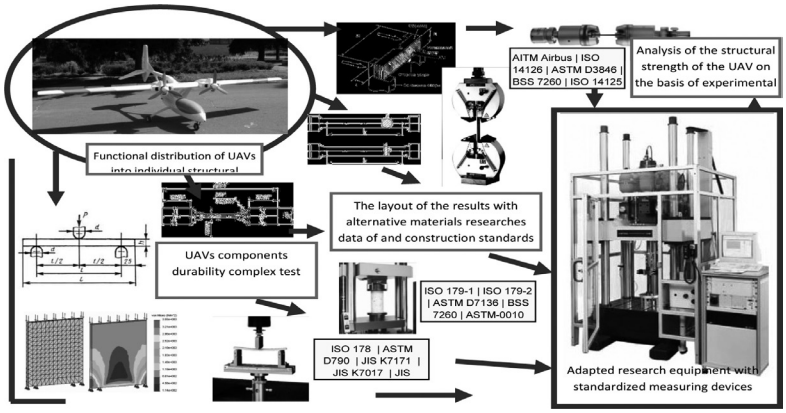

Fig. 9. UAVs Components Durability Complex Test System.

Source: Isaienko V., Bugayko D., Kharchenko V., Paweska M., *Challenges of International Science and Education in the Field of Aviation Transport Safety,* Logistics and Transport, 38 (2018)/2, pp. 23-32.

CONCLUSION

Civil aviation transport is an open system that is affected by a wide range of technical, natural, human and economic hazards. Each hazard leads to the potential consequences from a number of risks. At the same time, according to forecasts of the leading world civil aviation organizations, every 15-20 years there is a double increase of the number of flights. Under such conditions, the application of the new ICAO Civil Aviation Safety Strategies is considered to be the most effective instrument for ensuring the acceptable level of global civil aviation safety.

Higher education and research institutions play a significant role in the development of training programmes, technology, and regulations of civil aviation transport. National Aviation University and the International University of Logistics and Transport in Wroclaw, Poland have paid special attention to the field of aviation and transport safety and for more than 11 years have developed joint scientific and educational activities in this sphere, and that includes more than 30 joint international scientific-practical congresses and conferences, successful programs of mobility of professors and students, joint publications and innovation projects that play a significant role for improvement of aviation transport safety level.

Therefore, the National Aviation University and the International University of Logistics and Transport in Wroclaw, Poland, have formulated recommendations for three levels of civil aviation transport regulation. For global level, it is development of international standards and recommendations in field of aviation and sharing best practices. For regional level, it is recommendations for adapting of standards to regional features and requirements. For national level, it is implementation of the global and regional standards. Scientific innovative activity of universities aims to introduce innovative technologies in the field of aviation transport and the training of highly qualified specialists is the basis for its further development.

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