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Challenges of International Science and Education in the Field of Aviation Transport Safety

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The aviation safety issue has been one of the most urgent challenges since the first day of flight operations. Aircrafts, avionics, engines, and navigation, communication and surveillance aids have changed and developed, but the problem has never lost its relevance. The main purpose of ICAO is to ensure the safe and orderly development of all aspects of international civil aviation. ICAO develops Standards and Recommended Practices. They are set out in 19 Annexes to the Convention on International Civil Aviation. The new ICAO strategies are the basis for the further sustainable development of global civil aviation. The paper paid special attention to the civil aviation hazards monitoring and risks management in the context of global aviation development trends.The paper deals with challenges of international education and introduces practical experience of the National Aviation University according to the new technologies in transport and aviation education, and trends of international cooperation with the International University of Logistics and Transport in Wroclaw in this sphere.

Key words: aviation safety, international education, cycles of education, hazards, risks, safety management system, scientific research activity, innovations.

1. INTRODUCTION

According to strategies ICAO realization of aviation safety, the management system is regulated on three hierarchical levels - Global, Regional and National [1].

The Global level is based on *Standards and Recommended Practices* (SARPS) of International Civil Aviation Organization (ICAO). ICAO Aviation Safety Management System is grounded on management commitment and consists of three main directions of civil aviation development – safety, effectiveness and efficiency.

The Regional level (which is based on activities of Regional aviation organizations, such as EUROCONTROL, European Civil Aviation Conference (ECAC), European Aviation Safety Agency (EASA), etc.) adapts *Standards and Recommended Practices* of ICAO to regional features and requirements.

The National level (which is based on activities of national aviation organizations, such as National Supervisory Authorities (NSA), Civil Aviation Authorities (CAA), State Aviation Administration (SAA) and national aviation & transport universities and training centres, such as the National Aviation

University, Kyiv, Ukraine and the International University of Logistics and Transport in Wroclaw, Poland). At this level, implementation of 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. The National Aviation University and the International University of Logistics and Transport in Wroclaw pay special attention to the field of aviation safety, and for many years have developed joint scientific and educational activity in this sphere. Global, regional and national levels are hierarchically interconnected and mutually consistent.

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 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 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.

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. The organizational factor is understood according to the following maxim - if in an emergency a person commits a catastrophic error, not only the person is guilty, but the system is guilty as well, which allowed the person to make such a mistake and did not provide him/her additional protection means.

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

Clearly aware of this trend, ICAO emphasized the need to change the global approach to aviation safety. A new Annex 19 to the Convention on the International Civil Aviation "Air Safety Management" was proposed. A combination of Standards and Recommended Practices from six different Applications are proposed in order to:

- strengthen the role of the state at the highest level (coordination between all resources and all stakeholders);
- ensure the existence of a legal basis in one document;
- develop harmonized standards that can be applied to different resources;
- improve the identification and development of future needs;
- organize a specialized ICAO expert group on aviation safety cooperation, together with the European Union, European Agency for Safety and Other Regional Aviation Organizations;
- ensure a global approach through the implementation of new ICAO civil aviation strategies [1].

A new definition of aviation safety was proposed, "Safety - a state of the air transport system, in which the risk is reduced to an acceptable level due to the continuous processes of hazard identification, risk management, and is maintained at this level, or decreases further" [2].

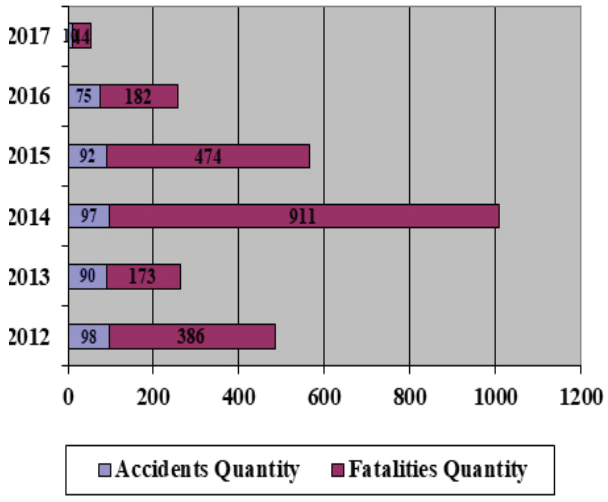

Fig. 1. ICAO Accidents Records 2012-2017 (Scheduled commercial flights) [4].

According to the new ICAO Aviation Safety Strategies, the Aviation Safety Management System is an orderly management approach that includes: the necessary organizational structures, responsibilities, policies and procedures. According to the systematic approach of ICAO, product / service provided by aviation organizations should be safe. In order to ensure this goal, new documents were adopted by ICAO. The widespread use of advanced proactive methods has provided for the identification of new hazards and threats that have been identified in the past [8].

The main strategic document for the implementation of the ICAO aviation safety system approach is the Global Aviation Safety Plan (GASP). GASP is a high-level policy paper on strategy and planning. The GASP defines a strategy for continuous improvement which includes the goals of the states that must be achieved through:

- introduction of effective management systems for aviation safety,
- implementation of Safety State Programs (SSP),
- development of advanced risk management [3].

According to the new ICAO strategies, each State requires the implementation of the aviation safety management system by the following aviation organizations: approved educational organizations; aircraft & helicopters operators; approved maintenance organizations; organizations responsible for design of aircraft type or manufacture of aircraft; air traffic service providers; operators of certified aerodromes. In current conditions, the development of a safety culture becomes of paramount importance. The safety culture is a set of sustainable values and safety provisions that are shared by all employees at all levels of the aviation organization. This is the level of awareness of each employee of the organization regarding the possible risks and hazards caused by their activities. The safety culture sets the framework for acceptable behaviour in the workplace by introducing norms and restrictions. It provides the basis for decision making by managers and staff.

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

The National Aviation University (NAU) is the largest aviation university in Ukraine and one of the leading aviation universities in the world. During 85 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. 10 educational research institutes, 2 faculties, ICAO Institute, 15 research institutes and centres, 7 colleges and academies, 2 high schools and junior high schools 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 European Civil Aviation Conference (ECAC), 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.

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

Fig 2. Activities of ICAO Training Institute of the National Aviation University [7].

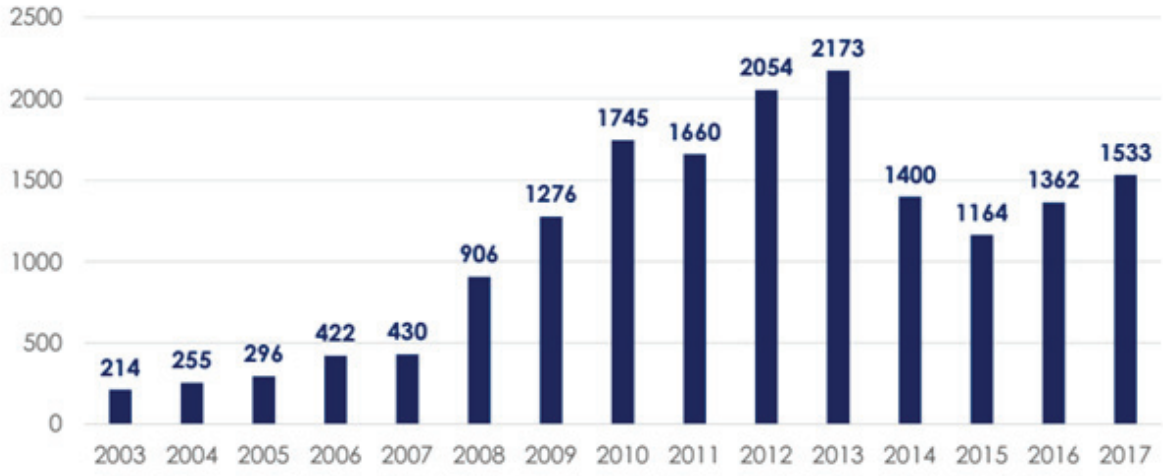

Fig.3 The number of air transport employees, who have been training at ICAO Institute in the period from 2003 to 2017 [7]

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.

Recurrent training and upgrading training of 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 the following can be mentioned the World Congress "Aviation in XXI 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.

The ICAO Training Institute effectively cooperates with the aviation administration 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].

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

It is not possible to imagine the process of improving 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 have been determined:

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

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 [5,6,10,11]. Currently, the National Aviation University, together with ICAO, participates in the development of recommendations for a very important major "Flight over populated areas" for both manned and 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 the National Aviation University of unmanned aviation "Virage" the line of UAVs has been developed: one-engineM-3"Border",M-6"Skylark"; two-engineM-7, M-7D, M-7V5 "SkyPatrol", 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 [9].

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 the researchers of the International University of Logistics and Transport in Wroclaw the comprehensive work on assessing capacity and effectiveness of RPAS was conducted

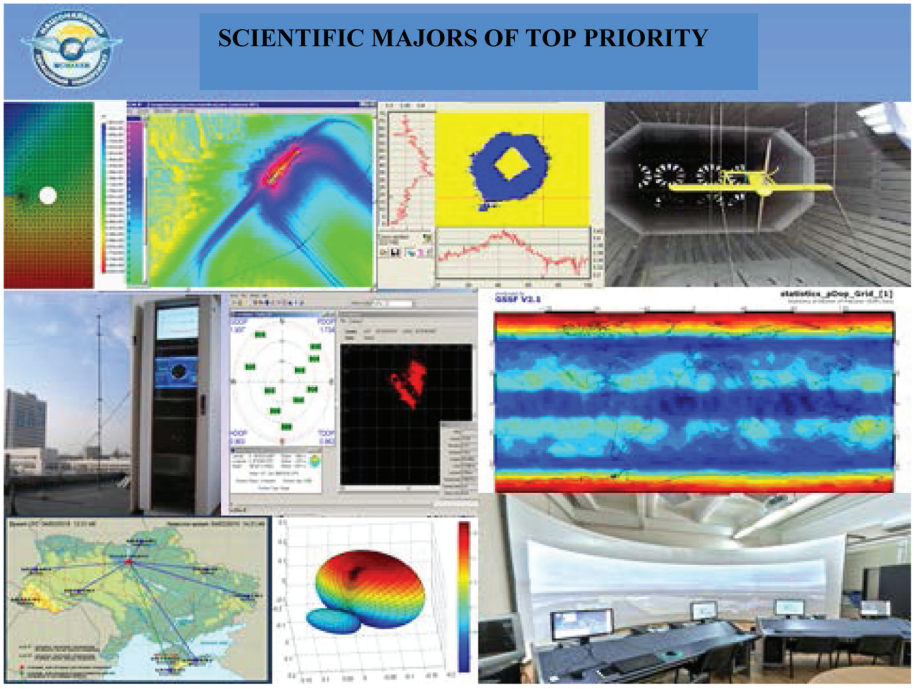

Fig. 4. Scientific majors of top priority of the National Aviation University

in order to solve logistical problems of territorial infrastructure [10]. UAV onboard avionics are also developed at our university [11]. The developed automatic flight control system allows to :

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

Fig.5. Multipurpose UAVs of National Aviation University

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

University has developed software and hardware facilities of an integrated inertial and satellite navigation system for unmanned aircraft vehicles. The integrated inertial and satellite navigation system for unmanned aircraft vehicles (IISNS) is 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 increasing their complexity require creation of the UAV robust flight control systems, which allow achieving high control performance during flight mission execution in conditions of internal and external disturbances. On the basis of the parametric

Fig.6. The automatic flight control system of UAV

Fig.7. Display of the ground test control station

as well as structural methods of the robust systems synthesis, the algorithms and programs for the UAV autopilot 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.

Educating aerospace specialists requires study of modern satellite technology. Scientific and Education Centre "Aerospace Centre" has been established at the 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.8).

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[9].

Environmentally safe jet fuels 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

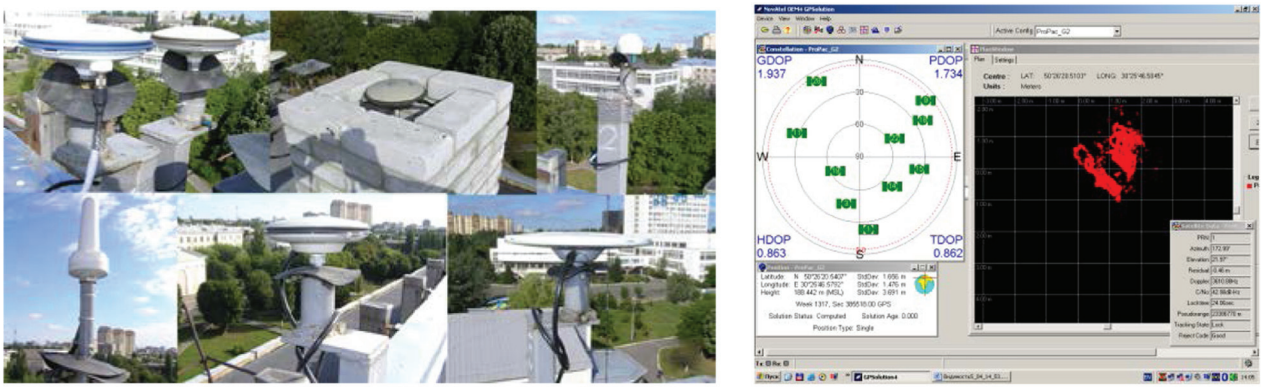

Fig.8. Aerospace Centre – Experimental Equipment

Fig.9. Airport Tower, Manned and Unmanned Aerial Vehicles Integrated Simulator.

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 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 into 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 known analogues, using of environmentally safe

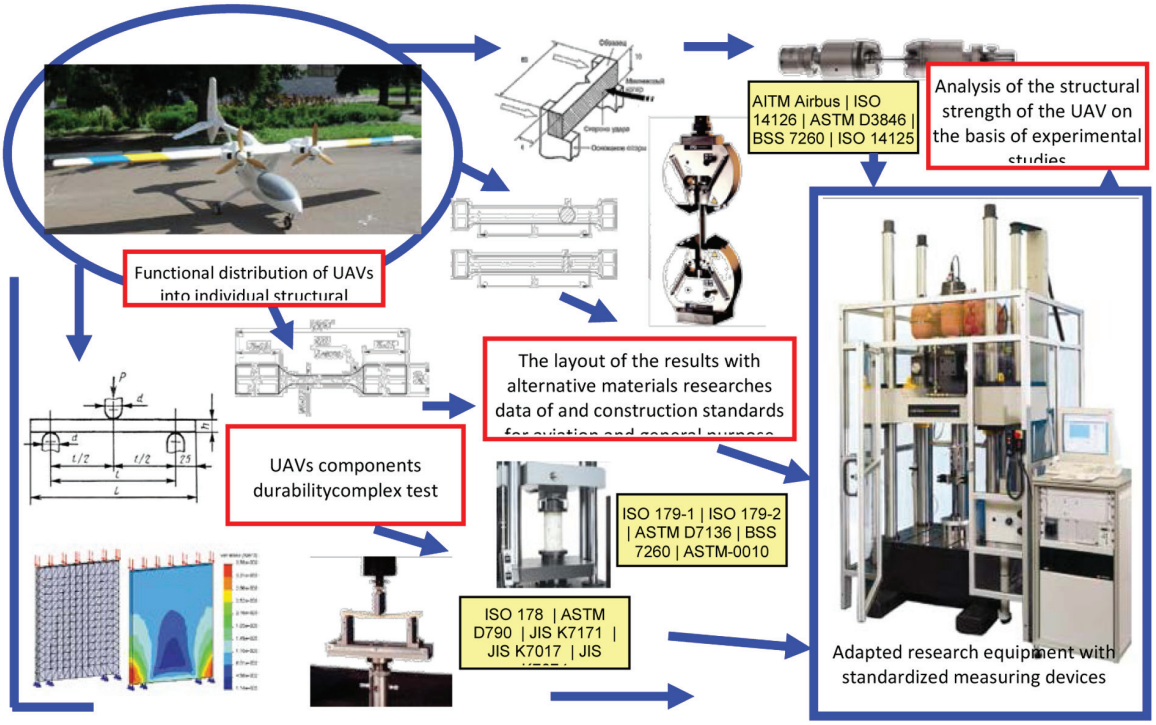

Fig.10. UAVs Components Durability Complex Test System

fuels may help saving 10–30% of mineral crude-oil feedstock and minimize negative impact of aviation on 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.9).

On Fig.10 we can see UAVs Components Durability Complex Test System which allows researches and students to design new types of UAVs.

5. 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 with a number of risks. At the same time, according to forecasts of leading world civil aviation organizations, every 15-20 years there is a double increase in 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. The National Aviation University and the International University of Logistics and Transport in Wroclaw pay special attention to the field of aviation and transport safety, and for more than 10 years have developed joint scientific and educational activity in this sphere. More than 30 joint international scientific-practical congresses and conferences, successful programs of mobility of professors and students, joint publications and innovation projects play a significant role in the improvement of aviation transport safety level.

Therefore, the National Aviation University and the International University of Logistics and Transport in Wroclaw have formulated recommendations for three levels of civil aviation transport regulation. For global level, it is the development of international standards and recommendations in the field of aviation and sharing best practices. For regional level, it is recommendations for adapting 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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