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Education and research activity of The Institute of Aviation Technology of The Mechatronic and Aerospace Department of The Military University of Technology for aviation

Abstract: Military University of Technology in Warsaw (MUT) is a military, engineering university operating over 60 years (since 1951). MUT educates students as well as cadets and conducts scientific researches for the needs of the Polish Armed Forces and national economy as well as defence sector. The Institute of Aviation Technology of the Faculty of Mechatronics and Aerospace is a part of Military University of Technology and conducts activities for the military and aviation industry. The Institute is a successor of the former Faculty of Aviation, which was founded in 1951. The Faculty was established for the training of the military aviation engineers who could maintain the jet-engine aircraft, entered the service in 60. of the previous century. Recently, the Faculty provides the higher education in the field of Aerospace Engineering for both military (cadets) and civil students. The scientific and research activities of the Institute are focused on numerical aerodynamic as well as tunnel investigations, airframe structure strength simulation, determination of thermophysical properties of aviation materials, and on-board avionics systems as well aviation armament. Integrated part of the Institute is the Training Centre of aviation maintenance personnel, certified with EASA Part-147 requirements. and it base on a certificate issued by the Civil Aviation Authority.

Keywords: Institute of Aviation Technology; Aviation staff; Aerospace engineering

History of The Institute of Aviation Technology

The Contemporary Institute of Aviation Technology (ITL) of the Faculty of Mechatronics and Aviation is a continuator of the activity initiated by the Aeronautical Faculty of the Military University of Technology as one of the five faculties established at the time of the establishment of the Academy in 1951. Since September 1952, it has become the Faculty of

Air Forces. The need to establish, at that time, an organizational unit of a university dedicated to the education of aviation engineers resulted from the introduction of jet-powered aircraft to the Armed Forces. The turbine jet engine was at that time a completely new quality, which resulted in the need to replace the aviation technicians of that time with engineers - graduates of the Military Technical University. It also found a reflection in the organizational structure of the faculty they constituted:

- Department of Aerodynamics and Aircraft Construction,
- Department of Operation and Repair,
- Department of Aviation Equipment,
- Department of Air Armaments,
- Department of Theory and Design of Air Engines.

The first commander of the Aeronautical Faculty was płk mgr inż. Paweł Moskowoj and his composition was composed of 128 militaries and 18 civilian employees. The main task of the Faculty was to train engineers servicing aircraft and support the operation process. It should be emphasized that unto this day, the Academy is the only university in the country that provides education for military air technical staff (engineering and air service personnel) at the academic level. In 1959, a faculty structure was introduced at the university. In this way, most of the departments educating engineers (in addition to the Department of Aeronautical Equipment) for the air force found themselves in the Faculty of Mechanical Engineering. In the following years, supersonic aircraft (MiG-19 and mass MiG-21) were introduced in the military aviation, which constituted another new quality and forced changes in the education programs of engineers and increased the demand of the air force for engineers. As a consequence of qualitative changes, in 1968 a non-permanent Institute of Aviation Technology (ITL) was established within the Faculty of Mechanical Engineering. The first head of the Institute was płk doc. dr inż. Hipolit Grzegorzcyk, and in its structure was created:

- Department of Aerodynamics and Airframe Construction,,
- Department of Aviation Engines and Thermodynamics,
- Department of Operation, Technology, Production and Repair of Aircraft,
- Department of Automation and Aeronautics of Precision Mechanics.

As part of the next reorganization, in 1984, the cathedral structure was replaced by a factory structure consisting of:

- Department of Aerodynamics and Flight Mechanics,
- Aircraft Structures and Strength Department,
- Air Drives Department,
- Thermodynamics Department,
- Aircraft Equipment and Automation Department,
- Plant for Operation and Repair of Airplanes and Helicopters,
- Technical Squadron.

In mid-1990, the Institute of Aeronautics was transferred in full to the Electromechanical Department. After the next WAT restructuring in 1994 and the Faculty's name changed to the Faculty of Armaments and Aviation, a new Airborne Aircraft Plant was added to ITL (created on the basis of the former Air Gun Department) and some other plants were combined. In 1998, due to the decreasing number of recruited candidates for professional soldiers (cadet officers), the training of "civil" students was started at extramural studies, it was an attempt to maintain the didactic potential of the faculty.

The year 2003 was a breakthrough for both the university and the department, because the decision of the then authorities of the Ministry of National Defense, WAT was to be transformed into a civil university and cease educating cadets. Admittedly, civilian students have been enrolled in full-time studies. Abandoning the training of candidates for professional soldiers meant that the vast majority of the military personnel were released. Although some of them took up a job as civilian university teachers, many of them left the WAT for good. In the same year, the department's name was changed to the Faculty of Mechatronics, so that the faculty clearly identified with education for the needs of the civilian sector.

After an unsuccessful experiment with the recruitment of civilian graduates to the army and an attempt to replace them with graduates of the Academy in the technical structures of the army, in 2008 the recruitment of candidates for professional soldiers was resumed. In the following years, the number of students and cadets of the air direction was systematically growing. In 2012, the decision was made to change the faculty's name to the current Faculty of Mechatronics and Aviation, thus training and aviation technology was articulated in its name.

Currently, the institute is headed by prof. dr hab. inż. Aleksander Olejnik, and it consists of:

- Department of Construction and Exploitation of Aircraft,
- Department of Aerodynamics and Thermodynamics,
- Avionics and Air Armaments Department,
- Department of Safety Engineering.

The Department of Aircraft Construction and Exploitation specializes in tasks related to strength analysis of selected elements of aircraft structures and drive units. The activities of the Department of Aerodynamics and Thermodynamics are mainly related to the numerical and experimental determination of aerodynamic characteristics of flying objects and the study of thermophysical characteristics of selected elements of aerostructures.

The Avionics and Airborne Aviation Department is composed of a team of highly qualified specialists, experts in the field of avionics and aviation equipment, on-board computer systems, navigational and power equipment, and aircraft control systems.

The Department of Safety Engineering in the field of aeronautics realizes education in the field of airborne warfare systems, aerial sights, ejected armchairs, aerial weapons (including plots and missiles) and safety and reliability of aviation technology. The plant is also responsible for education in the field of security engineering. Education in this field includes knowledge of security threats (natural, civilization and terrorism), machine safety problems, construction, technical devices and installations, security systems design and legal regulations.

Aeronautical education

Currently, aviation training at the Military University of Technology is carried out at the Institute of Aeronautics for both military and civil aviation. Historically, aviation training has been realized in the form of specialties (in engineering and master's studies) in the following fields: mechanics, mechatronics (since 1998), and since 2006 in the field of aviation and astronautics. The teaching and research staff of the institute conducts didactic classes in major, specialist and profiling subjects for the following specialties: airplanes and helicopters, avionics, aerial propulsion, and aerial weapons. The studies are conducted for both "civilian" students (in addition to airline weapons specialties), as well as candidates for professional soldiers, as seven-semester engineering and three-semester master's studies.

The high quality of education was confirmed by the certificate of the State Accreditation Commission (2014), the Accreditation Committee of Technical Universities

(2016), including the Euro-Ace Master. In order to enter the so-called, The European Educational Area has made efforts to create a certified flight training center for technical personnel in accordance with the requirements of EASA Part-147 and Part-66. Having met all the requirements set by the European Aviation Safety Agency (EASA) and the national aviation authority, i.e. the Civil Aviation Authority in Warsaw, the Institute was the first in the country to receive the European Part-147 training certification certificate (Figure 1). On this basis, in 2010, the vocational training system was introduced formally at the Institute, including courses and post-graduate studies for aviation needs.

Education in the field of aviation and astronautics is carried out in the field of aerospace and aviation techniques and is directed at the students' knowledge and practical skills in their design, modeling, construction, manufacturing, and operation. Studies enable to learn about technologically advanced devices using the latest technologies and materials, advanced electronic systems, microprocessors, and extensive diagnostic systems.

The Institute of Aeronautics for air forces provides education in such specialties:

- airplanes and helicopters,
- avionics,
- aviation equipment.

This education is directed to the students' knowledge and practical skills in the construction, manufacture, and operation of aircraft and space objects. It is based on thorough knowledge of mechanics, aeronautical materials and technologies, electronics and electrical engineering, microprocessor technology, automation and control systems, applied computer science and modern advanced computer techniques. Table 1 presents the number of recruitment of students of military studies in individual specialties in 2012 ÷ 2018. This means that for the needs of the Ministry of National Defense and Air Forces about 170 students and ... civilian students were educated at the Faculty of Mechatronics and Aviation. The direction of aviation and astronautics is accredited by both the State Accreditation Commission (from 2014), as well as the Accreditation Committee of Technical Universities (since 2017).

Table 1. Number of recruitment of cadets and civilian students in aviation specialties in 2012 ÷ 2018.

No.	Speciality	The number of cadets	Number of civil students
1.	Airplanes and helicopters	83	140
2.	Avionics	52	120
3.	Aviation equipmnet	35	-

In the field of planes and helicopters specialty, the studies prepare students to work in the aviation industry using advanced technologies, in technical databases of civil aviation and the Polish Air Force. Students gain practical knowledge in the field of computer systems supporting the design, manufacture, and operation of aircraft.

Education in the avionics specialization prepares students to work in research institutions, design, and construction, aerospace manufacturing plants as well as civil aviation bases and the Polish Air Force. They have practical knowledge about aviation, digital avionics systems and the ability to design and model them.

In the aviation specialization, however, aviation training prepares students to work in research and development centers and in the air bases of the Polish Air Force. Students gain

practical knowledge about devices and special systems of aircraft: air weapons (guided and unguided rockets, aerial bombs, artillery-shooting weapons) and systems necessary for combat use of particular types of weapons, as well as ground-based servicing devices.

Using the scientific and research potential and experience in the field of staff training for air forces, the Institute of Aeronautics conducts education at post-graduate studies and specialist courses. Currently, the training offer includes postgraduate studies in "Aviation Management and Securing Aviation" (code: 1103174) and the following improvement courses:

- „Management of the aircraft operation and maintenance process "(code: 8103019),
- "Risk management in the operation of aircraft technology" (code: 8103022);
- "Methodical improvement of the Air Force instructor team" (code: 8103033);
- "Construction and operation of aircraft" (code: 8103052);
- "Managing the process of continuous airworthiness of aircraft" (code: 8103054).

Table 2 shows the number of participants of the above-mentioned courses and trainings implemented in 2013 ÷ 2017. As can be seen from this list, more than 720 soldiers of the professional engineering and aviation service have used all forms of professional development (SIL).

Table 2. The number of participants in refresher courses and trainings conducted at the Institute of Aeronautics in 2013-2017.

No.	The name of the course	Number of participants
1.	Aviation management and security of aviation activities	214
2.	Management of the aircraft operation and maintenance process	124
3.	Risk management in the operation of aircraft technology	275
4.	Methodical improvement of the Air Force instructor team	72
5.	Construction and operation of aircraft	18
6.	Management of the process of continuous airworthiness of aircraft	19

Postgraduate studies in "Aviation Management and Securing Aviation Operations" prepare SIL officers to carry out tasks at the tactical and operational level and to deepen the knowledge of students in the field of security and management in aviation. They are conducted in the field of technical sciences. According to the assumptions, the studies are conducted for three personal groups, the passenger corps of the Air Force, i.e.:

- meteorological - 22F;
- radio engineering - 22G;
- engineering and aviation - 22J

Therefore, in the programs and educational plans, three independent specialized modules dedicated to each group were separated. Due to the above division, these studies are conducted at the Faculty of Mechatronics and Aviation (aviation and aerospace engineering group 22J) with the participation of the Faculty of Civil Engineering and Geodesy (meteorological group 22F) and the Faculty of Electronics (22G radio engineering group). Specialist modules are supplemented with a general module, in which the content of education common to all personal groups of the Air Force personnel corps is carried out. This module is implemented at the Aviation Military Academy in Dęblin.

Department conducts a training course "Management of the aircraft maintenance and service process". Its main purpose is to prepare SIL personnel to manage the operation of aviation technology, taking into account the requirements of uniform law and regulations,

both national and European. This course is intended for SIL personnel of the Armed Forces operating in the field of aviation technology. The aim of this course is to prepare officers and non-commissioned officers to manage the operation and servicing of aviation techniques in accordance with the requirements of aviation law and EU regulations: European Aviation Safety Agency and national: Civil Aviation Office and implementation of aircraft management and maintenance system in aviation of the Polish Armed Forces. It is intended for soldiers of SIL specialists responsible for organizing the operation process or performing aircraft servicing. This course is divided into two modules: general and directional. As part of the general module, course participants will get acquainted with the knowledge of subject modules at B1 / B2 license level in the EASA Part 147 Certified Aeronautical Training Center of the Faculty of Mechatronics and Aviation of the Military University of Technology. This part of the course ends with exams confirming knowledge in accordance with EASA regulations for individual knowledge modules. In the directional module, course participants acquire knowledge in the field of management of the aircraft operation process as well as advanced technology and aviation technology.

The course "Risk management in the aviation technique operation process" prepares SIL personnel to manage the operation of aviation technology, taking into account the risk requirements in the decisions made.

Improving the skills of the managerial staff in working with subordinates as well as lecturers and instructors to carry out training within the professional training system of the Polish Armed Forces is the main goal of the course "Methodological improvement of the Air Force instructor team."

The next training is "Construction and operation of aircraft". Its purpose is to supplement the technical knowledge of the aerospace engineering staff in the areas of aircraft operation. The course is intended for soldiers serving in SIL or planned to be designated for posts in SIL structures. As part of the course, the students are familiarized with the construction, operating principles and service standards of the aircraft and its on-board systems.

The teaching offer of the Faculty is adapted to the needs of the market and air forces. The answer to this kind of need was to launch the course "Managing the process of continuing airworthiness of aircraft". The organization of this course is a consequence of decisions taken by the Ministry of National Defense to purchase Gulfstream G550 and Boeing 737-800 aircraft. The main goal of the course is to prepare SIL staff to handle the above-mentioned aircraft, and, above all, complementing knowledge of the issue of managing the continuing airworthiness of aircraft. It is intended for professional soldiers of SIL specialists responsible for the continuing airworthiness of aircraft. As part of the course, students are introduced to, among others, with civil regulations for continuing airworthiness management.

The institute's scientific and research activity

The Institute of Aeronautics conducts wide-ranging scientific and research activity, the issues of which are focused on issues related to aviation. These include design, assessment of structural strength, determination of fatigue durability of the structure using computer-aided systems, tunnel and numerical determination of the flow field and determination of aerodynamic characteristics of flying objects, thermophysical properties of materials used in aviation, theoretical and simulation studies of heat exchange phenomena in technical and biological structures, analysis of thermal loads of structural elements, designing, modeling, identification of avionics systems and aerial mechatronic systems as well as modeling and forecasting of technical systems safety.

However, the most important pillar of the research and development activity of the Institute of Aviation Technology are research teams. These are Computer Aided Design,

Generation and Exploitation of Aircraft Operators headed by prof. dr. inż. Aleksander Olejnik, Thermodynamics and Heat Exchange Team headed by prof. dr. hab. inż. Janusz Terpiłowski, Aerodynamics and Object Movement Dynamics Team headed by dr. hab. inż. Stanisław Września and the Security Engineering Team headed by dr. hab. inż. Andrzej Skomra (until 2018).

The Computer Aided Design, Generation and Operation of Aircraft team deals with widely understood design and prototyping of manned and unmanned aerial vehicles. The main research trends in the team are: modeling of aircraft geometry and drive assemblies, reverse engineering processes applied to reconstructing the geometry of operated aircraft, determining their external loads, modeling structures for FEM analysis in static statics and dynamics, structural-aerodynamic aerodynamic modeling load-bearing systems. In the field of the scientific interests of the team there are also research and engineering activities such as stand construction static tests (strength and stiffness tests), ground resonance tests, tunnel and simulation tests of aerodynamic systems, optimization of designed structures and modeling, diagnostics and control of assemblies driving.

Thermodynamics and Heat Exchange Team deals with issues related to technical thermodynamics, thermal metrology, thermophysical properties of materials, mathematical modeling of heat and mass exchange phenomena, material engineering in the field of thermophysical properties of materials, computer-aided measurement process, reverse problems regarding thermophysical parameters estimation of solids and numerical modeling of complex issues of heat and mass exchange. Scientific activity of the team includes experimental studies of thermophysical properties (thermal conductivity, thermal diffusivity, specific heat and thermal expansion of solid bodies) in a wide temperature range, numerical calculations and experimental studies of heat and mass exchange in solid bodies (radiation and conduction heat exchange in optically active centers) and in porous and biological structures, research on thermophysical properties of explosives and rocket propellants, heat exchange studies in aerospace structures, including investigations of the process of icing of aircraft and experimental studies of temperature changes of objects in motion.

The Aerodynamics and Object Movement Dynamics Team operates based on the knowledge and experience of the employees of the Aerodynamics and Thermodynamics Department. The main directions of the team's research include aerodynamics of terrestrial objects and flying objects as well as the dynamics of the movement of flying objects. The team deals with experimental and numerical tests of aerodynamic properties of airplanes, vehicles and other objects, determining the aerodynamic characteristics of aircraft and their components, performing qualitative and quantitative experimental investigations in the area of incompressible and compressible flows. The team specializes in numerical flow testing of viscous and heat-conducting gas for complex objects using proprietary software and the ANSYS calculation package with advanced simulation models including, among others, the use of mobile grids and dynamic grids as well as multiple reference frame, reciprocal plane and sliding mesh methods in applications for simulation of flows in rotating machines.

The Safety Engineering team in its research and teaching activities mainly deals with the technical security of the facility throughout its life cycle (in terms of strength, durability and reliability) and focuses on the study of operational conditions (in terms of service, management and forecasting of reliable use), searching for safe and effective ways to use the potential work resource of technical facilities. An important area of the Team's activity is also the development of methods for assessing the effectiveness of the operation of aviation weapon systems. In the field of his interests, the team performs research related to fatigue crack propagation modeling in the aspect of construction safety, probabilistic modeling of fatigue life and construction safety, assessment of strength, durability and safety of damaged structural elements, testing of technical systems exploitation in terms of their reliability,

efficiency and security, formulating requirements for security systems, praxiological safety aspects in technology, and modeling the dynamics of energy separation and the flow of inhomogeneous high energy centers in the field of forecasting security threats. In the research activity, the Team members also solve problems in the area of hazard analysis, risk assessment and proposals for actions aimed at achieving the level of acceptable risk.

The Institute for Research of Air Drives (LBNL) was organized at the Institute for research purposes as part of the POIG.02.02.00-14-022 / 09 project. The direct objective of the project is the modernization and construction of new integrated research infrastructure at the country's leading technical universities in the field of aircraft engine research and strengthening the research potential of the Air Navigation Test Laboratory WAT and the Aerodynamics Laboratory of Turbine Aerospace and Combustion at Warsaw University of Technology.

The laboratory conducts research work in the field of modern aircraft engines enabling:

- reducing the emission of harmful factors (exhaust gases, noise) in accordance with the recommendations of the European Commission (ACARE Vision 2020);
- reducing fuel consumption, and thus improving the competitiveness of the Polish aircraft engine industry;
- transfer of state-of-the-art global technologies, which will contribute to the implementation of the Sustainable Development policy.

The activity of the WAT Air Drive Research Laboratory includes aerodynamics of flows in engines, statics, and dynamics of engines and their components, testing of thermal properties of materials as well as construction and testing of magnetic suspensions.

In the field of flow tests in turbine jet engines, scientific and research works are carried out regarding aerodynamics of flow channels of turbines, as well as interstitial channels of nozzle and rotor rims, aerodynamics and aerodynamics of individual nozzle and impeller vanes and their palisades using characteristics obtained from weight tests of models in wind tunnels and numerical calculations.

In the field of statics and dynamics of air propulsion units, the Laboratory deals with numerical modeling of rotor assemblies and their components, eg the study of flutter blades phenomenon. The dynamic properties of the structure based on numerical models are determined, and the results will be compared with the results of experimental research. In the field of thermal measurements, gas - dynamic values in flow systems and thermal properties of materials used for the construction of turbine aircraft engines and energy gas turbines are determined. The equipment includes instruments for measuring thermal diffusivity, thermal conductivity, specific heat and thermal expansion of materials for other tests carried out in the Laboratory.

In the field of active magnetic suspensions, the Laboratory conducts unique in the country numerical and experimental research on the development of passive and active magnetic suspensions, their optimization, control, power supply, etc. The Laboratory also deals with the adaptation of magnetic bearings and their accessories for specific applications in aviation turbine engines.