

University of Zagreb
Faculty of Transport and Traffic Sciences
Aeronautical Division

Undergraduate and Graduate study of Aeronautics

1. General Overview

Air traffic is a complex system, especially characterized by implementing aircraft transport means and equipment with the most advanced technical and technological solutions. Efficient and safe use of such complex means and equipment requires also specific highly skilled personnel. The complexity of the aviation system has been reflected also on the system of educating the highly qualified personnel: education for the manufacture and maintenance of aircraft, use of aircraft, control of air traffic, etc. The field of aeronautical sciences (*Aeronautical Science, Aeronautics*) provides acquiring of knowledge and the necessary skills for efficient use, organization and control of the air traffic process. There is almost not a single country without at least one study of aeronautics in the system of higher education, as a precondition for accepting, introducing into exploitation of new means, and consequently the development of new traffic technologies and procedures.

The Republic of Croatia is member of EUROCONTROL (*European Organization for the Safety of Air Navigation*), and in 2004 Croatia also joined the membership of JAA (*Joint Aviation Authority*). Thus, the Croatian aviation authorities have also accepted the liabilities in the area of aeronautics (regulations and control) which require specific highly professional knowledge.

The labour market requirements for the professionals with a completed **undergraduate** study of aeronautics are present in the public and private sector. The candidates who acquire the baccalaureate of aeronautics (pilots) have highest possibilities of getting employment at the airlines such as Croatia Airlines, Air Adriatic, Delta Air etc. The majority of working places include aircraft captains and their assistants, but also the managing posts that require aeronautical knowledge and experience: heads of quality control of flight operations, navigation flight planning, etc. One part of the experts is required by the Civil Aviation Authority (Uprava zračnog prometa) working in administrative and inspection tasks and in pilot training schools.

The candidates with the baccalaureate of aeronautics (air traffic control) can primarily find employment at the Croatian Air Navigation Services (Hrvatska kontrola zračne plovidbe), where there are 68 types of workplaces according to the job systematization, that require university undergraduate education: officer for international business, officer for strategic planning and development, department head for airspace management, head of air force operative activities, department head of the operative air traffic control, flight data processing operator, air traffic controller, etc. A number of the professionals are required at the Air Traffic Administration for administrative and inspection activities, and a number can be employed working on the dispatcher and planning tasks in airlines.

The candidates with the completed **graduate** study of aeronautics and with the pilot knowledge are primarily suited for the officer duties for the needs of the Croatian Air Force. Past experience has shown that such graduate students successfully get employment also in civil aviation.

In the USA there is a great number of studies of aeronautics, and for the sake of comparison we would like to highlight only two of them:

- *Embry-Riddle Aeronautical University* (www.embryriddle.edu)
- *University of North Dakota* (www.aero.und.edu/atc)

At the most distinguished aeronautical University, *Embry-Riddle Aeronautical University* there are two courses that we would like to take for comparison: *The Aeronautical Science degree program* leading to the title of *Bachelor of Science*. The study takes 8 semesters, and it has three courses: *Airline Pilot*, *Commercial Pilot* and *Military Pilot*. Practical training in flying is a component of the curriculum. Another comparative course is *The Air Traffic Management* which also leads to the title of *Bachelor of Science* and takes 8 semesters. At both courses the practical training within the study is performed according to the rules of the profession as defined by the Aviation Administration (*FAA- Federal Aviation Administration*) so that a student apart from the diploma may acquire also an adequate licence (pilot or air traffic control).

At the *University of North Dakota* there is a course for air traffic control, and the graduated students acquire the title of *Bachelor of Science in Aeronautics (with a Major in Air Traffic Control)*. As part of the study the students acquire in laboratory conditions also certain practical experience on air traffic control simulators. By completing the study the student fulfils the requirements for taking the state exam in order to acquire the air traffic control licence.

For comparison, here are some of the studies in the EU countries which are similar to the proposed model:

- *Czech Technical University in Prague: Faculty of Transportation Sciences* (www.fd.cvut.cz)
- *Žilinska Univerzita: Faculty of Operation and Economics of Transport and Communications* (www.utc.sk)
- *London Metropolitan University: Aviation Management* (www.londonmet.ac.uk)
- *City University London: Air Transport Operations* (www.city.ac.uk)
- *The University of Liverpool: Aerospace Engineering with Pilot Studies* (www.aerospace.liv.ac.uk)
- *Rzeszow University of Technology: Specialisation- Aeronautics* (www.prz.rzeszow.pl)

Some of the mentioned studies do not follow the study scheme accepted by us (3+2+3), but are rather similar to the previously mentioned US study concept taking 4 years.

The three-year study concept is implemented, for instance, at the *London Metropolitan University: Aviation Management* and at the *Žilinska Univerzita: Faculty of*

Operation and Economics of Transport and Communications. During the three-year study the student acquires all the necessary theoretical knowledge for the highest pilot licence (*Airline Transport Pilot Licence*), and practical training only for the basic pilot skills, the so-called *Private Pilot Licence - PPL* or for professional licence, the so-called *Commercial Pilot Licence - CPL*. After completing the study the student acquires the appropriate academic title (*Bachelor of Science*) and fulfils the requirements to take the exam for the state licence at the Croatian Air Navigation Services (Uprava zračnog prometa).

One may notice great diversity in the curricula of aeronautical studies. All the programmes necessarily contain minimum law-regulated contents (the so-called *JAA FCL - Flight Crew Licence, i.e. EUROCONTROL* requirements) that allow subsequent acquiring of the licence, whereas other courses within the curricula may be more oriented to “technology” or to “management”.

1.1. Previous experiences in implementing similar curricula

In 1992 the Faculty of Transport and Traffic Engineering, University of Zagreb, in cooperation with the Ministry of Transport, Croatian Air Traffic Control, Croatia Airlines Company and MORH (Croatian Ministry of Defence) started the study of Aeronautics with courses for: civil pilots, air traffic control and military pilots. Since air traffic is one of the most globally standardized and regulated transport branches, the curricula were already at that time harmonized with the international i.e. world regulations regarding education in the mentioned courses, which was our obligation as member of ICAO (*International Civil Aviation Organisation*).

Since the establishment of the mentioned curricula, about 100 graduate students of the Faculty of Transport and Traffic Engineering have been successfully performing their jobs at the Croatian Air Traffic Control. In Croatia Airlines more than 50 captains of big commercial aircraft of advanced technology have graduated at the Faculty of Transport and Traffic Engineering. In Croatian Air Force there are more than 100 officers – pilots flying from heavy helicopters all the way to supersonic fighting aircraft – are graduate students of the Faculty of Transport and Traffic Engineering, as well as the majority of employees of the helicopter fleet units of the Ministry of the Interior. In the recently founded company Air Adriatic almost all the newly employed aircraft captain assistants have graduated at the Faculty of Transport and Traffic Engineering. Out of some hundred trained military pilots, about 40 of them are flight instructors at their forces, and some of them are upgrading for the commanding duties and overtaking the obligations from the NATO program. Additional training of the mentioned students abroad (Europe and USA) leads to the verification of the quality of the study at the mentioned courses at the Faculty of Transport and Traffic Engineering.

For laboratory and practical training in flying the Faculty of Transport and Traffic Engineering has founded a special organizational unit entitled Croatian Aviation Training Centre which received on 10 May 2004 the Decision of the Air Traffic Authority, Class: UP/I-343-09/03-01/94, Reg. No.: 530-06-04-6) the European recognizable licence for the mentioned training. For further development of civil and military aviation it is necessary to continue education of such highly skilled professions in the field of aeronautics.

1.2. Partners outside higher education system

Outside the higher education system, the partners and employers of the graduated students of aeronautics include: Hrvatska kontrola zračne plovidbe (Croatia Control Ltd.), several air carriers including also the Croatian flag carrier Croatia Airlines, airports, Air Traffic Control Administration of the Croatian Ministry of the Sea, Tourism, Transport and Development, Ministry of Defence and the helicopter unit of the Ministry of the Interior. Cooperation agreements have been signed with some partners. Based on these agreements, part of the education related to practical training – laboratory work – is to be performed at the premises of the mentioned partners. For instance, laboratory work related to air traffic control is performed on the simulators at the Croatian Air Navigation Services and with the assistance of the experts from the respective company. Flying lessons are carried out at the training centre at the Air Military Academy in Zadar on military aircraft and simulators. This form of education is being carried out and planned to be carried out on the basis of the possibilities provided by the Act on Scientific Activities and Higher Education (Article 66/4).

Agreements on cooperation have been signed with individual partners. Based on these agreements, a part of education which refers to practical training – laboratory work – is carried out at the premises of the mentioned partners. For instance, laboratory work in air traffic control is performed at simulators of the Croatian Air Navigation Services Ltd. with the assistance of their professionals. Flight lessons are performed at the training centre at the Air Force Military Academy in Zadar on military aircraft and simulators. Such form of teaching is performed and is planned to be further performed based on the possibilities provided by the Act on Scientific Activities and Higher Education (Article 66/4).

1.3. Openness of the study toward the mobility of students

Throughout the aviation system, the English language is obligatory as the precondition of acquiring special licences and participation in everyday exploitation, that is, the possibility of joint global communication. This satisfies the primary precondition for the mobility of students. The harmonization of the curriculum with the globally accepted standards creates the basis for the students' mobility, i.e. the openness of the study. Several students (military pilots) have continued and successfully completed their study in the USA, at highly distinguished and very demanding Universities. Some students of the study of Aeronautics of the Faculty of Transport and Traffic Engineering, have successfully joined as equal associates the teams working on Eurocontrol projects, etc. The similarity of the programme not only allows but also requires the study to be open, with the only and principal barrier being the price and the unsolved issue of scholarships, accommodation, etc.

Starting with the next academic year several syllabuses in English are being planned. Since the Ministry of Science, Education, and Sport approved a TCR (Teleconference room) to the Faculty of Transport and Traffic Engineering, such lectures will be also available for distance learning.

A precondition to attend the graduate study programme of aeronautics is the completed undergraduate study programme of aeronautics at the Faculty of Transport and Traffic Engineering, and partly sufficient are also other study programmes at the Faculty, study of aeronautical engineering at Faculty of Mechanical Engineering and

Naval Architecture or similar studies (aeronautics and astronautics) at higher education institutions abroad, with the adequate difference in ECTS credits.

1.4. Miscellaneous

Due to the highly demanding and complex study of aeronautics, the equipment necessary to realize the curriculum (flight control simulators, aircraft simulators, training aircraft, laboratory and teaching equipment such as e.g. air-tunnel, etc.) the engagement of the government institutions is an imperative. The role and the engagement of the state is necessary also due to the fact that the basic partners outside the higher education institutions are actually in the majority ownership of the state (Air Traffic Control: 100%, airports: 55%, Croatia Airlines: 95%, etc.) or the government bodies (Ministry of Defence, Ministry of the Sea, Tourism, Transport and Development, Ministry of the Interior).

The proposed curriculum of AERONAUTICS at the Faculty of Transport and Traffic Engineering has been based on the advanced scientific experience and knowledge and it is considered suitable for the requirements of Croatia since it unifies civil and military aviation, rationally using scientific and material resources.

2. General Section

2.1. Name of programme

STUDY OF AERONAUTICS

As opposed to the study of aeronautical engineering at the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb, focusing on aircraft design, construction and maintenance, the study of aeronautics concentrates on air traffic, air transport, as well as aircraft operations and air space management.

Such a concept of aeronautics was accepted by the former College of Aeronautics in Velika Gorica near Zagreb. Depending on the respective courses of studies the students graduated from, they were awarded titles of: aeronautical engineer (pilot), air traffic engineer and aerotechnical engineer (aircraft maintenance).

There seems to be no universal common name for the study programme of this type. For example, the course of studies entitled *Aeronautics* at *Embry Riddle University* in USA, or at a Polish University, *Rzeszow University of Technology*, correspond to our study programme. A similar programme at *London City University* bears the name of *Air Transport Operations*, while yet another related study programme at the *Faculty of Transportation Sciences* in Prague has the name of *Transportation Technology and Communications*. Therefore we believe that the name of the proposed programme reflects the Croatian tradition, and the names of the corresponding programmes in other countries validate it as one of the viable options.

2.2. Institution

FACULTY OF TRANSPORT AND TRAFFIC SCIENCES, UNIVERSITY OF ZAGREB

2.3. Duration of programme

The undergraduate study takes 3 years, and the graduate study 2 years.

2.4. Entry requirements

All candidates who have completed the four-year secondary school education, met the classification requirements and satisfied the medical criteria according to the Air Traffic Act, have the right to enrol in the study of AERONAUTICS. The requirement for the students of aeronautics (military pilots) is the signed scholarship agreement with the Croatian Ministry of Defence (MORH).

2.5. Competences of students completing undergraduate study

By completing the study of AERONAUTICS the student acquires competences and the right to acquire special state licences of air traffic controller or civil pilot, i.e. fulfils the requirements needed to continue the specialist education for additional licences in the field of aviation. Also, the undergraduate study qualifies the student for the work in the area of air traffic control, technology of aircraft operations, and navigation flight planning that are described in Item 1a. The students who chose to work on the tasks of air traffic control or civil aviation (as pilots or operative managers) the undergraduate

study is the sufficient condition and the continuation of studying at the graduate study is considered unnecessary.

By continuing the study in order to acquire higher competences in the air traffic system the student can attend the graduate study of air traffic at the Faculty of Transport and Traffic Engineering or logistics at the same Faculty or other studies in the field of technical sciences at the University of Zagreb, with respective difference in ECTS credits. The students who selected to acquire the title of air force officer and have signed the scholarship agreement with MORH (Croatian Ministry of Defence) are obliged to continue the graduate study of aeronautics.

2.6. Competences of students completing graduate study

By completing the graduate study of AERONAUTICS the student acquires the competences for highly skilled jobs of the air force officer of the Croatian Air Force, pilot and commanding pilot tasks, planning and control of aircraft operations, design of the quality assurance system at airlines, performing the supervisory function, design and development of technical and technological documentation, strategic planning of development and management in the aviation system and the scientific-research work.

2.7. Curriculum as a "one-cycle" programme

The given description obviously shows that the graduate study of aeronautics for the needs of the Croatian Air Force follows from the undergraduate study of aeronautics thus forming one unit. The curriculum has been harmonized with the Ministry of Defence of the Republic of Croatia, and the required syllabuses from the military sciences have been integrated into the curriculum. The proposed model is implemented in the countries that practice civil-military education, that is, where the military aviation does not rely only on classical Aviation Military Academies. A typical example is the course of *Military Pilot Speciality* at the *Embry-Riddle Aeronautical University*. The students of this course attend additional courses in military sciences such as e.g. military history, and a group of courses from the so-called ROTC program (*Reserve Officer Training Corps*) which includes the syllabuses of tactics, military geography, controlling and managing organizations, etc.

2.8. Academic title

The academic title acquired after completing the undergraduate study of AERONAUTICS is the Baccalaureus of Aeronautics (univ. bacc. ing. aeronaut.).

The academic title acquired after completing the graduate study of AERONAUTICS is the Master of Aeronautics (univ. mag. ing. aeronaut.).

3. Programme Description

3.1. List of compulsory and elective modules and courses

3.1.1. Design of studies

In the process of conceiving the study of aeronautics, the specific professional requirements, Croatian and foreign experiences, as well as the prospect of an optimal number of students, which amounts from 40 to 50 per year, have been taken into account. As shown in the schematic presentation below, the undergraduate study programme comprises of the following modules:

- compulsory courses common to all study programmes of the Faculty of Transport and Traffic Engineering
- Study of Aeronautics compulsory courses
- Study of Aeronautics elective courses: "for pilots" and "for Air Traffic Controllers".

The structure of the curriculum of the Study of Aeronautics is presented in the following table:

UNDERGRADUATE STUDY

Compulsory common core courses of the study programmes of the Faculty of Transport and Traffic Engineering (semesters I-IV)	
Compulsory common core courses of the Study of Aeronautics (semesters I-VI)	
Group of elective courses – "controller module" (semesters III-VI)	Group of elective courses – "pilot module" (semesters III-VI)

GRADUATE STUDY

Compulsory aeronautical courses of the Study of Aeronautics	Elective aeronautical courses	Elective courses in Military science	Elective theoretical/practical flight courses
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Students acquire the fundamental knowledge of Mathematics, Physics, Mechanical engineering, Electrical engineering, Engineering drawing and documentation, Computing etc., in the compulsory core courses common to all study programmes at the Faculty of Transport and Traffic Engineering. The common core curriculum includes a course in Fundamentals of transportation technology in which the students gain the knowledge essential to understanding technological processes in various branches of transport and traffic, as well as the ability to evaluate their quality.

In the framework of the common aeronautical module, students receive the basic knowledge in Theory of flight, Navigation, Theory of air traffic control etc. The students of Aeronautics attend Aviation English as a compulsory course from the first semester onwards in order to achieve the necessary proficiency in aeronautical communication in accordance with the recommendations issued by ICAO (*International Civil Aviation Organization*).

The compulsory common core curriculum provides the fundamental knowledge and skills enabling the students to study independently and acquire specific professional expertise in any given segment of their future profession. At the same time it establishes a sound basis for their further professional development by continuing their studies at the graduate level and guarantees the necessary competence to keep up with the technological advances and carry on with their professional duties throughout their careers.

The study of aeronautics has two elective modules: “pilot module” and “air traffic controller module”. The academic programmes of the common aeronautical module as well as the elective modules are conceived in such a way as to include the subject matter required by the relevant international civil aviation organizations. For the “pilot module” these are the JAA (*Joint Aviation Authority*) requirements, and for the “air traffic controller module” the EUROCONTROL (*European Organization for the Safety of Air Navigation*) requirements, respectively. This allows the student to subsequently take the state exams for the corresponding professional licenses. The students sponsored by the Croatian Ministry of Defense (MORH), who intend to become Air Force officers – military pilots, choose the course “Flight Performance and Planning I” from the undergraduate “pilot module”, while the students who intend to meet the requirements for the civil pilot license choose “Flight Performance and Planning”

As already mentioned, for the purpose of laboratory and practical flight training the Faculty of Transport and Traffic Engineering has founded a special organizational unit entitled Croatian Aeronautical Training Centre for civil pilot education.

Military pilot students undergo their practical training in an air force base in Zadar. The practical training is being carried out in accordance with the Law on Scholarly Activities and Higher Education /article 66(4)/: “Institutions of higher education can, in accordance with their statute and accreditation, and based on an agreement with an appropriate organization (hospital, community health centre, law firm, engineering bureau, commercial firm, specialized institution, government body etc.) organize part of their teaching activities in the respective organization under the guidance of their own teachers, and with the proper cooperation of experts from that organization.”

The practical training in question is being provided by the head of the Section for Military Aviation of the Department of Aeronautics.

The students who have opted for the “Air traffic Control module” attend their practical classes (Simulation of Aerodrome/Approach/Area control) in the Croatia control (Croatian Air Navigation Services) based on the Agreement on scholarly, educational and technical cooperation. Instead of the above mentioned practical classes, a student of aeronautics (in case he/she does not meet the required medical criteria or due to his/her own choice) has the opportunity to choose other elective courses offered either within the same or in some other university study programme, and gain the corresponding number of ECTS credits.

The students who have chosen to pursue a career in air traffic control or civil aviation (as pilots, controllers or operation managers) gain sufficient competencies upon the completion of the undergraduate studies and are not obliged to continue their studies at the graduate level.

The university study programme of aeronautics – pilot module – has integrated all the theoretical knowledge requirements for the acquisition of the so called „frozen ATPL“ (Airline Transport Pilot Licence). The students who successfully complete the „pilot module“ of the Study of aeronautics, including the elective laboratory classes and practical training for civil pilots („Flight Performance and Planning“), are entitled – in accordance with the requirements of their pre-diploma practical training - to carry on their practical flight training at the certified Croatian Aeronautical Training Centre of the Faculty of Transport and Traffic Engineering or at any other recognized and accredited school. Students do not earn any ECTS credits for their practical flight training. Similarly to the practice of the above mentioned comparable European universities, this part of their education is considered as additional specialization for private needs.

Before the official beginning of the 1st semester, the students to be sponsored by The Ministry of Defence are offered 12 hours of flight training at the Zadar Air Force Base aimed at the timely selection for the military pilot career. The students who have chosen to pursue the career of military aviation officer and Croatian Air Force pilot (25-30% of all students enrolled), based on the grant contract signed with the Ministry of Defence, are obliged to continue the graduate study of aeronautics. In case they do not successfully complete the pilot module, including the elective laboratory and practical classes (cf. the course in Flight Performance and Planning), either for medical or some other reasons, they are free to continue their studies at the same study programme, but will be obliged to choose other courses in order to earn the equivalent number of ECTS credits.

3.1.2. The Curriculum of Aeronautical Studies

Table 3.1. presents “common core courses taught at the Faculty of Transport and Traffic Engineering”, attended by students of all courses of study. This group of courses accounts for 33% of ECTS credits at the undergraduate study level. The same table shows the “common core courses of the Study of Aeronautics”, which account for additional 28% ECTS credits, so that all common core courses equal 61% ECTS credits.

The curriculum allows the students to successively meet the requirements for the continuation of their studies. At the same time, it reflects the dynamics and gradual sequence of introducing and expanding the knowledge of aeronautical disciplines, depending on the particular module chosen and the freedom to choose courses according to particular students’ interests.

In order to present the study scheme in a transparent way, it is given in the following table by courses grouped according to semesters. The tables show that the undergraduate study lasts three years and the student has to earn a minimum of 180 ECTS credits, 17 % of which can be electives. In the graduate studies the student has to earn a minimum of 120 ECTS credits, 41 % of which can be elective courses. At the end of the table of undergraduate and graduate studies, we show the student workload semester by semester, and the cumulative total of ECTS credits.

Table 3.1. Faculty of Transport and Traffic Sciences undergraduate study programme: aeronautics

CODE	COURSE	Final Exam	ECTS Credits	Hours of Lectures + Practical cl. weekly /SEMESTER						
				I L+E	II L+E	III L+E	IV L+E	V L+E	VI L+E	
Compulsory Common Core Courses at the Faculty of Transport and Traffic Engineering:										
1020	Physical Education	0	0	0+2	0+2	0+2	0+2	0+2	0+2	
1001	Mathematics I	1	8	3+3						
1002	Mathematics II	1	8		3+3					
1003	Probability and Statistics	1	8				3+3			
1004	Physics	1	5	2+2						
1005	Mechanics I	1	7			3+2				
1007	Electrical engineering	1	6	3+2						
1008	Computing	1	5	2+2						
1009	Engineering drawing and documentation	1	5	2+2						
1013	Fundamentals of transport technology	1	8		3+3					
Compulsory Common Core Courses of the Study of Aeronautics:										
3001	Aviation English I	0	1	1+1						
3002	Aviation English II	1	1		1+1					
3003	Aviation English III	0	1			1+1				
3004	Aviation English IV	1	1				1+1			
3005	Theory of Flight I	1	8		3+2					
3006	Aviation Meteorology	1	5				3+1			
3007	Theory of Flight II	1	8			3+3				
3008	Theory of Air Traffic Control I	1	5			3+2				
3009	Air Navigation I	1	6				3+3			
3010	Aerodromes	1	3						2+1	
3011	Radiotelephony Communications I	0	2				1+1			
3012	Radiotelephony Communications II	1	3					1+1		
3013	Human Performance and Limitations	1	4					3+1		
3014	Air Law	1	2					2+0'		
Elective Courses in the Common Core Part of the Study of Aeronautics:										
1031	Engineering Materials	1	5			2+2				
	Elective Course A **									
Subtotal Load: L+E Hours Weekly					25	19	22	20	8	3
Subtotal Exams		21			5	4	4	4	3	1
Subtotal ECTS Credits			115		30	25	26	22	9	3

Table 3.2. Pilot module of the study of aeronautics

CODE	COURSE	Final Exam	ECTS Credits	Hours of Lectures + Practical cl. weekly /SEMESTER					
				I L+E	II L+E	III L+E	IV L+E	V L+E	VI L+E
Common Core Courses of Pilot Module of the Study of Aeronautics									
3015	Aircraft Instruments and Electrical Systems	1	5					3+1	
3016	Aircraft Structures and Systems I	0	3			2+1			
3017	Aircraft Structures and Systems II	1	4				2+1		
3018	Air Navigation II	1	6					3+3	
3019	Aircraft Performance and Planning I	0	5					2+2	
3020	Aircraft Performance and Planning II	1	6						2+2
3021	Aircraft Powerplants I	0	3					2+1	
3022	Aircraft Powerplants II	1	5						3+1
3023	Operational Procedures	1	3						1+1
Elective Courses of Pilot Module of the Study of Aeronautics									
1021	Mechanical Engineering	1	7		3+2				
1033	Traffic Geography	1	3						2+1
3050	Flight Training *	1	8						0+4
3051	Flight Training I*	1	8						0+4
	Elective Courses B **		18						
3100	Final Paper***	0	7*						*
Subtotal Load: L+E Hours Weekly				0	5	3	3	17	17
Subtotal Exams		9		0	1	0	1	2	4
Subtotal ECTS Credits			65	0	7	3	4	19	25+7

Table 3.3. Air Traffic Controller module of the study of aeronautics

CODE	COURSE	Final Exam	ECTS Credits	Hours of Lectures + Practical cl. weekly /SEMESTER					
				I L+E	II L+E	III L+E	IV L+E	V L+E	VI L+E
Common Core Courses of ATC Module of the Study of Aeronautics									
3024	Air Traffic Control Equipment and Systems	1	5			2+1			
3025	Radio and Radar Systems	1	7					3+2	
3026	Theory of Air Traffic Control II	1	5				2+1		
3027	Air Transportation Vehicles	1	5						3+1
3028	Aeronautical Information System	1	4		2+1				
3029	Air Traffic Flow Management	1	6						3+2
3030	Aviation English V	1	2					1+2	
3031	Radiotelephony Communications III	1	4						1+2
Elective Courses of ATC Module of the Study of Aeronautics									
3032	Simulation of Aerodrome Control*	1	6				0+3		
3033	Simulation of Approach Control*	1	7					0+4	
3034	Simulation of Area Control*	1	7						0+4
	Elective Courses C **		20						
3100	Final Paper***	0	7*						*
Subtotal Load: L+E Hours Weekly				0	3	3	6	12	16
Subtotal Exams		11		0	1	1	1	2	3
Subtotal ECTS Credits			65	0	4	5	11	16	22+7

Table 3.4. Workload and ECTS Credits for the study of aeronautics

Load and ECTS Credits Study of Aeronautics	ECTS	Hours of Lectures + Practical cl. weekly /SEMESTER					
		I L+E	II L+E	III L+E	IV L+E	V L+E	VI L+E
Compulsory Courses of the Study of Aeronautics:							
Weekly load: L+E Hours		25	19	18	20	8	3
Number of Exams		5	4	3	4	3	1
ECTS Credits	110	30	25	21	22	9	3
Elective Courses of the Study of Aeronautics:							
Weekly load: L+E Hours				4			
Number of Exams				1			
ECTS Credits	5			5			
SUBTOTAL OF COMMON CORE PART OF THE STUDY OF AERONAUTICS:							
Subtotal Load: L+E Hours Weekly		25	19	22	20	8	3
Subtotal Exams		5	4	4	4	3	1
Subtotal ECTS Credits	115	30	25	26	22	9	3

Pilot Module of the Study of Aeronautics

Pilot Module of the Study of Aeronautics							
Weekly load: L+E Hours				3	3	17	10
Number of Exams				0	1	2	3
ECTS Credits	47			3	4	19	14
Elective Courses of Pilot Module							
Weekly load: L+E Hours				5			7
Number of Exams				1			1
ECTS Credits	18			7			18
SUBTOTAL PILOT MODULE OF THE STUDY OF AERONAUTICS							
Subtotal Load: L+E Hours Weekly			5	3	3	17	17
Subtotal Exams			1		1	2	4
Subtotal ECTS Credits	65		7	3	4	19	25+7
TOTAL PILOT MODULE OF THE STUDY OF AERONAUTICS							
Total Load: L+E Hours Weekly		25	24	25	23	25	20
Total Number of Exams		5	5	4	5	5	5
Total ECTS Credits	180	30	32	29	26	28	35

ATC Module of the Study of Aeronautics

ATC Module of the Study of Aeronautics							
Weekly load: L+E Hours			3	3	3	8	12
Number of Exams			1	1	1	2	3
ECTS Credits	38		4	5	5	9	15
Elective Courses of ATC Module							
Weekly load: L+E Hours					3	4	4
Number of Exams							
ECTS Credits	27				6	7	14
SUBTOTAL ATC MODULE OF THE STUDY OF AERONAUTICS							
Subtotal Load: L+E Hours Weekly			3	3	6	12	16
Subtotal Exams			1	1	1	2	3
Subtotal ECTS Credits	65		4	5	11	16	29
TOTAL ATC MODULE OF THE STUDY OF AERONAUTICS							
Total Load: L+E Hours Weekly		25	22	25	26	20	19
Total Number of Exams		5	5	5	5	5	4
Total ECTS Credits	180	30	29	31	33	25	32

Table 3.5: Graduate study programme: aeronautics

CODE	COURSE	Final Exam	ECTS Credits	Lectures + Practical classes per Semester			
				VII L+E	VIII L+E	IX L+E	X L+E
Compulsory Courses of the Graduate Study Programme of Aeronautics							
3043	Air Traffic Technology	1	5	2+1			
3035	The Helicopter Theory of Flight	1	4	2+1			
3036	Radiotelephony Communications IV	0	2	1+1			
3058	Radiotelephony Communications V	1	3		1+1		
3037	Aircraft Ballistics	1	6		3+2		
3038	Aircraft Maintenance	1	5		2+1		
3039	Air Navigation III	0	3		1+1		
3040	Air Navigation IV	1	7			3+2	
3041	Theory of Flight III	1	5			2+1	
3500	Diploma Thesis	1	30				0+10
Subtotal Load: L+E Hours Weekly				8	12	8	10
Subtotal Exams		8		2	3	2	1
Subtotal ECTS Credits			70	11	17	12	30
Elective Courses Group of the Study of Aeronautics D**:							
3042	Avionics and IFR Flying	1	5	2+1			
1412	Operational Research	1	6		2+2		
3045	Elements of Aviation Safety	1	5		2+1		
1413	Dynamics of Transport Vehicle	1	5			2+1	
2016	Geographic Information Systems	1	4			2+1	
1416	Transport Optimization	1	5			2+1	
Elective Courses Group of Laboratory and Practical Flight Exercises L*:							
3052	Flight Training – Aircraft II*	1	8	0+5			
3053	Flight Training – Aircraft III*	1	8		0+5		
3054	Flight Training – Aircraft IV*	1	8			0+5	
3055	Flight Training – Helicopter II*	1	8	0+5			
3056	Flight Training – Helicopter III*	1	8		0+5		
3057	Flight Training – Helicopter IV*	1	8			0+5	
Elective Courses Group of „Military Sciences“ M**:							
3046	General Tactics	1	5	2+1			
3047	Military History	1	5			2+1	
3048	System of Defence	1	5			2+1	
3049	Command and Leadership in a Military Organisation	1	5		2+1		

4. Students' competences within Croatian and European Qualification Framework

The study programme of aeronautics includes the study and application of laws, principles and methods of flight management and control of aircraft in the airspace. A continuous increase in air traffic is the result of high demands for highly educated professionals, who, in addition to knowledge and skills in aircraft management and guidance, will have high-skilled engineering knowledge and knowledge applicable to solving problems related to the implementation and use of new technologies, with an emphasis on process management in organizations and companies directly and indirectly related to air travel. At the university graduate studies of aeronautics students acquire specific knowledge and skills for an effective use of air transport, as well as for the organization and control that is necessary to manage processes in air traffic.

The study programme consists of two groups of subjects: compulsory subjects common to all students of aeronautics and elective subjects. In the group of compulsory subjects, students gain theoretical knowledge and practical skills in the technology of air transport, aircraft maintenance, helicopter flight theory and the theory of flight and aerodynamics at high speeds. Through the optional group of subjects, students can direct and guide themselves to the area of self-interest. Elective courses are modelled by a completed appropriate module at the undergraduate level (pilot and air traffic control module) and on this basis they represent a logical extension of study and upgrade of knowledge acquired at the undergraduate level. With this strategy of continuing the study from the undergraduate level, definition of required subjects and selection of elective courses, students can round out specific and concrete knowledge and skills in the field of aeronautics.

The profile of students who have completed undergraduate study of aeronautics, pilot module, through elective subjects, have the opportunity to acquire a higher level of knowledge and competences through subjects which elaborate the topics from avionics and instrument flying, air reconnaissance and surveillance, and the dynamics and aging of aircraft structures, by which there is a possibility to expand knowledge of the subject which are based primarily on the air traffic control undergraduate module, such as the optimization of the transportation process, human factors in aviation, management of capacities and air traffic flow and quality in aviation. On the other hand, the graduate students of aeronautics, air traffic control module, through the graduate study, are enabled to expand and upgrade the spectrum of knowledge in the areas that are not focused solely on the professional competence of air traffic controllers from the operator's perspective. This way, it is possible to acquire interdisciplinary engineering knowledge and skills that are not strictly related to the particular profile of completed undergraduate study, and to provide students with the knowledge and understanding of the processes and phenomena required for the management, guidance and organizing of research projects and other highly complex work in organizations and companies working in the area of aviation and aeronautics. Within the university graduate studies in aeronautics, there is a special elective group of subjects in the field of military science, which are complementary to the level of knowledge and skills required of senior officers in the Air Force. With this group of elective subjects, students can choose a group of laboratory and practical

flight exercises that are modelled by sequentially increasing acquisition of practical skills required for flight activity.

These elective subjects are conducted in coordination with the Ministry of Defence and are available only to students who study with the support of Ministry of Defence. In the fourth semester of the graduate study, students verify their knowledge by completing the final thesis and taking a final exam. The graduate study of aeronautics has precisely defined learning outcomes at the level of each individual subjects and at the level of study programmes, which are an integral part of the teaching quality assurance system. The resultant competences of Master aeronautical engineers arise from them.

Students' competences at the university graduate programme of aeronautics:

(a) KNOWLEDGE AND UNDERSTANDING

- Knowledge and understanding of engineering methods needed to solve complex problems related to the analysis and optimization of processes
- Knowledge and understanding of basic scientific and engineering principles and methods
- Deep knowledge and understanding of the theoretical principles within the field of aeronautics and the wider context of engineering
- Ability to critically review and distinguish problems
- Knowledge and understanding of social, commercial, legal and ethical context of engineering

(b) ENGINEERING ANALYSIS

- Solving medium-complex problems at the level of minor project in accordance with the level of knowledge and understanding
- The ability to analyze large amounts of raw data in order to interpret results
- The ability to define and solve partly defined problems in an interdisciplinary environment
- Ability to apply knowledge and understanding of the engineering design models, systems and processes
- Ability to apply innovative methods to solve problems using analytical methods and methods of simulation and modelling

(c) ENGINEERING DESIGN

- Creativity in the application of existing and development of new, original ideas and methods
- The possibility of generation, analysis and implementation of suggestions to technological problems
- The ability to apply engineering and statistical methods and application of management tools and techniques to improve work processes and organizational processes

(d) RESEARCH

- Identification, location, and ways of organizing and carrying out measurements in order to obtain the original data
- The ability to design and implement experimental investigations
- The ability to critically evaluate, assess and draw conclusions
- The possibility of experimental research through the process of planning and organization of an experiment

(e) ENGINEERING PRACTICE

- The ability to connect knowledge from different fields and master complex systems
- Ability of engineering approach to work in complex and technically undefined conditions with incomplete information, using quantitative methods of engineering practice
- Detailed knowledge of the applied techniques and methods, and, in particular, their limitations
- Selective collection and disposal of information and data
- The ability to present research results

(f) COMPLEMENTARY SKILLS

- The ability to work efficiently and independently in a team and to lead a team efficiently
- Ability to effectively use a variety of methods to communicate with the engineering community at a national and international level
- Conscience on all aspects of engineering practice, and on professional ethics and responsibilities
- The ability to use methods of business practices and methods of project management
- Recognize the need for lifelong learning

In all the syllabuses the system of continuous student assessment is applied. The number of credits in the system of continuous supervision depends on the required activities within each subject. The structure of credits for each subject has been determined and published in advance. Regular attendance at lectures is compulsory. The student achievement for a certain subject is verified by entering the grade in the student document. Depending on the results achieved by the student in continuous assessment and/or examinations, the grades may be: excellent (5), very good (4), good (3) and sufficient (2). In some subjects the student achievements are not graded, but the completed requirements are confirmed in grade entry by symbol "+".

After completion of the graduate study programme of aeronautics, students gain a prerequisite for admission to postgraduate specialist programmes in order to obtain a university degree of a university specialist as well as in postgraduate doctoral studies at the Faculty of Transport and Traffic Sciences in Zagreb for acquiring the doctor's degree. Requirements for admission to graduate studies at other higher education institutions are determined and prescribed by those institutions.

Study programme of aeronautics is aimed at educating and training students to perform highly complex jobs in economics, government, public and private sectors and science, as well as development and application of scientific and professional achievements. Basic orientation of the study is focused on air travel, transportation and flight activity, exploitation of aircraft and airspace. Specificity of the study is implemented upgrading of the undergraduate study (modules) with the aim of training pilots and air traffic controllers according to certified training programmes by Croatian and European aviation authorities. In this way, students have the option to acquire conditions for obtaining appropriate authorizations and working permissions, either as pilots, or air traffic controllers. This segment is not a requirement for the study, so there is a possibility for students to complete their graduate programme of aeronautics without special requirements that they previously completed undergraduate study of aeronautics, and that they don't have the conditions for obtaining professional authorizations. Irrespective of their choice of studying through the study of aeronautics, students completing the studies also acquire internationally defined level of knowledge and skills that allow them to perform these highly skilled occupations. The holder of this qualification is authorized, according to the Law, to use the university degree: Master in Aeronautical Engineering.