



Establishment of the Space Engineering Program in Hungary

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Abstract

The Hungarian space age started in 1946 with the successful Lunar Radar experiment by Zoltán Bay. In the past 75 years, the Hungarian space sector evolved and grew dramatically, achieving international recognition in space communications, material science, picosatellites, dosimetry, and many more domains. However, there was no space engineering related higher education program in the country.

After hosting the 2nd Symposium on Space Educational Activities in 2018 in Budapest, there was an emerging need for starting a space program for engineering students. A summer workshop organized by the Hungarian Astronautical Society in 2018 fostered further the process, and the Budapest University of Technology and Economics (BME) officially initialized the establishment of the space engineering master curriculum in 2019. By the end of 2020, the relevant ministry approved the national space engineering master curriculum. This means that every Hungarian university, which has the necessary competences, can start a space engineering program for their students. In early 2021, the BME Faculty of Electrical Engineering and Informatics at BME requested approval for its space engineering master program. In October 2021, the relevant body approved the program, allowing the first class of space engineering students to arrive to the university in September 2022. The Hungarian space engineering master curriculum is a 2-year-long master program for 120 credits (in the European Credit Transfer and Accumulation System, ECTS). The master's program at the Budapest University of Technology and Economics has 26 subjects and a 4-week-long industrial training. We outline the establishment process of the national space engineering curriculum and introduce the curriculum of BME.

Keywords

university education; space engineering master program; curriculum establishment

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1. Introduction

The training of space engineers is now present worldwide in the higher education structure of individual countries. Space research, space science, and space technology are becoming more and more integrated into our daily lives today, so it is particularly important for educational institutions to provide training programs in this area as well. Every economy needs professionals who can navigate and be able to do real work in this area. In countries with a significant tradition of space exploration, technology and great economic potential, the space industry is of great importance. At the same time, smaller countries can also find areas where space industry opportunities, research and manufacturing potential exist. International organizations such as ESA or NASA provide many opportunities for almost anyone with the right knowledge to get involved in space-related developments.

There are several topics related to space. Basic scientific research aimed at getting to know space better is also well known to ordinary people. In such programs, mostly scientists and equipment development engineers work together. Many types of experiments in materials science, physiology, chemistry, pharmaceuticals, biology, and physics can also only be performed in outer space. Because today's equipment is basically built on an IT background, computing is also appearing in space equipment. Nor can we forget the international regulation of space radio communications, the legal issues of the use of outer space, which also requires appropriate expertise.

The education of all this, the training of professionals is primarily the task of higher education. In this wide-ranging topic, which is related to space, the Budapest University of Technology and Economics (BME) has set the goal of educating space industry professionals in the field of engineering.

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program for engineering students. A summer workshop organized by the Hungarian Astronautical Society in 2018 fostered further the process, and BME officially initialized the establishment of the space engineering master curriculum in 2019 [3].

Our university introduced this training program in Hungarian higher education, developed the training conditions, and based on these, launched a master's degree program that will train space engineers in two years from autumn 2022.

In this paper, we will describe the process of starting the space engineering program, and we will also present the structure of the training.

2. Expanding the Hungarian higher education structure

In the structure of higher education in Hungary, the launch of a new, previously non-existent program must be preceded by the definition of the training and output requirements of the program. This document contains the exact name of the new degree, the level of education (MSc in our case) to be obtained and the field of training, which in this case is the technical field. The preconditions for entering to the program, i.e. the type of higher education qualifications that can be applied for, must be defined. In our case, students with a basic degree in technical, informatics or natural sciences can choose the field of space engineering, and with a basic degree in electrical engineering and mechatronics engineering, it is not necessary to examine previously completed subjects. In the case of those coming from other bachelor programs, it may be necessary to examine the subjects taken during the preliminary studies, and in the case of a successful entrance examination, credit extension may be required.

During the training, students receive 120 credits, in which the ratio of theoretical and practical knowledge is defined as balanced.

In the training and output requirements, we defined the purpose of the training and the professional competencies to be achieved. Our intention is to train engineers who are able to perform design, development, production and operation tasks primarily related to space technology and space research. They have relevant knowledge of the specifics of the space environment, the structure of the equipment to be delivered to space and the processes of its creation, as well as the design, construction and operation of equipment and systems for the ground handling of space equipment. They are able to perform research and development

tasks at domestic and international space companies and institutes. They are also preparing to continue their studies in doctoral programs.

In line with the structure of the master's degree program in Hungary, the course also includes natural science knowledge, economics subjects and subjects providing space engineering professional knowledge. In the first part of the training period, the students work independently in the framework of a project laboratory, and then they prepare their diploma thesis.

The training and output requirements compiled based on the above are checked by the higher education supervisory authorities, after which the course is included in the list of courses on the basis of which a higher education institution with the appropriate educational and infrastructural competence can start the course.

The master's degree program in space engineering described in the training and output requirements is in line with the master's courses available in various European and other international institutions. Linked to other European curricula, the space engineering master program is primarily technology-oriented. It meets the national policy and industrial requirements related to the field of space engineering, as well as the requirements of the Ministry of Human Resources (our ministry responsible for education) and the national Accreditation Committee. However, during the master's studies, students acquire knowledge that is not available in other fields and is not or only to a limited extent available in other fields. The Hungarian space engineering program has been developed taking into account the international examples, which at the same time fits into the traditional four-semester, 120-credit structure of the Hungarian master's program and also offers the possibility to admit those from various technical undergraduate courses.

3. The space engineering program at Budapest University of Technology and Economics

Following the successful accreditation of the training and output requirements, BME has developed the documents required for the start of the course, which have been accepted by the organizations supervising higher education. This made it possible for the first master's degree program in space engineering in the history of Hungary to start.

The curriculum for both the spring and fall semesters is detailed in the introductory document. It contains the detailed topics of all the subjects of the training and the names, positions and academic degrees of the participants in the education.

The training will be attended by 64 instructors, of whom 51 have PhD degree. The students will study a total of 26 subjects. In addition, one is free to choose from six science subjects and two from 12 professional subjects. Independent project work, internships and diploma thesis tasks are also part of the program.

The literature about space technology [4] has provided a great deal of help in developing the main concepts of the start-up.

Admission to the master's degree program in space engineering is possible from the undergraduate courses in the fields of engineering, informatics and natural sciences. Since students from different backgrounds come to the training, four compulsory elective subjects in the training program help students to deepen their professional knowledge in accordance with their undergraduate education and interests. However, whatever subjects students choose, the totality of the subjects they study ensures that they acquire all the competencies listed in the training requirements.

Given that all students have already received mathematics training, in the case of the space engineering program, the optional subject of advanced mathematics in the science group provides students with the opportunity to expand their knowledge in the most necessary field. Students choose one of four compulsory subjects: stochastics, analysis, advanced linear algebra, and combinatorial optimization. The admission committee of the department provides support in the selection of the appropriate subject based on a written entrance examination for mathematics.

In the case of the elective natural science subject of the group of natural sciences, the students must choose one of six subjects, the choice of the subject depends on the student's orientation.

In the space engineering professional knowledge block, students must choose two of a total of 12 subjects within the framework of Compulsory Elective 1 and Compulsory Elective 2. This option is based on the diverse experience of the BME staff in various fields of space engineering training and provides students with the opportunity to deepen their

knowledge according to their interests through two compulsory elective courses during the 120 credits. At the same time, the transfer of the professional knowledge required by the training requirements to all students takes place during the completion of the other subjects of the training. Technically, out of the 12 subjects in the compulsory elective block, some of the subjects will be announced in the autumn semester and some in the spring semester.

Table 1. Groups of subjects in BME's space engineering program

Scientific knowledge
mathematics, physics, materials science, space environment, and profession-specific core subjects;
Professional knowledge
comprehensive theoretical knowledge of the development, design, construction, manufacture and quality control of tools and equipment related to space technology and complex units, and of the complex services created by them, required in the field of space engineering;
Compulsory courses
special knowledge of materials, devices, apparatus, equipment, systems, technology and design required to practice one of the fields of specialization represented in the field of space engineering: digital signal processing in communications, on-board data processing systems, fine mechanical design, photonic devices and optical communication, Earth observation/ remote sensing, the role of small satellites in space technology, special spacecraft and space security, nonlinear finite element analysis, optical remote sensing, rockets, rocket propulsion, design and power supply of space equipment, thermal dynamics of spacecraft;
project laboratory;
diploma thesis;
Economic and human knowledge
economic, leadership and management skills, coordination of the development of complex space equipment, domestic space activities and the international environment
Free elective subjects from the entire university offer

We plan to announce the master program in space engineering in the spring and autumn semesters as well, offering students the opportunity to be admitted to the training both in the beginning of September and in the beginning of February. Therefore, the training program is provided with both a spring semester start, and a fall semester start. The professional content of the training program is unchanged, but for educational reasons, the subjects are announced in a different order in the beginning of spring and autumn. When developing the topics of the subjects, we tried to avoid overlapping. Therefore, we did not define any pre-study conditions in the subject topics (except for the Project Laboratory 1-2 and the Diploma Design 1-2 subjects, which are built on each other). Even the subjects of the Space Technology Laboratory 1 and the Space Technology Laboratory 2 are not built on each other. Therefore – like other subjects – it is possible to listen to them in a different order in the courses starting in the spring and autumn semesters.

4. Admission to the space engineering program

The aim of the BME master's program in space engineering is to enable the widest possible range of students with basic technical, natural science and IT qualifications to be admitted to the training. Therefore, the entry conditions have been set so that a certain amount of credit points obtained during the pre-studies is already sufficient to apply. At the same time, we organize a written entrance exam for the program. For those with an undergraduate degree in engineering, science, or computer science to be successfully admitted, they are free to choose three of a total of six subjects in their written entrance exam. These subjects are mathematics, physics, computer science, electronics, digital engineering and control engineering. In the case of successful admission, we make suggestions for students regarding the subjects that may be required to expand their knowledge.

The space engineering program provides a high degree of interdisciplinary knowledge, so we are confident that each student will find the knowledge that best suits them during their study. Flexibility is provided by the optional subjects offered in the program.

5. Results

BME announced the program in the Hungarian admission system for applicants starting in September 2022. The application deadline was February 15. Recruitment applications are

currently being processed, so we do not yet have information on the exact number of applicants. Based on the preliminary briefings and forums, the interest is very high, so we hope to reach the limit of 40 people set for this semester.

The first year of graduation will receive its degree in 2024, which will also be a significant milestone for the national space industry, which has significant expectations for graduates.

6. Conclusions

In our paper, we presented the milestones leading to the establishment of a master's degree in space engineering in Hungary. We have described the considerations leading to the development of the training and output requirements of the program, which will serve as a basis for the institutions undertaking to start the program. After the successful accreditation of the training and output requirements, BME developed the start-up document in detail. We have presented the structure of this document, the structure of the training and the subject, teaching and institutional background it contains.

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