Degree Program Documentation

Master's Program Earth Oriented Space Science and Technology (ESPACE)

TUM Department of Civil, Geo and Environmental Engineering

Name:	Earth Oriented Space Science and Technology (ESPACE)
Administrative Responsibility :	Department of Civil, Geo and Environmental Engineering
Degree:	Master of Science (M.Sc.)
Standard Duration of Study & Credits :	4 semesters / 120 credits
Form of Study:	Full-time
Admission:	Aptitude assessment procedure in accordance with current FPSO
Start:	WS 2005/06
Language(s) of Instruction:	English
Degree Program Coordinator:	Univ.-Prof. Dr.techn. Mag.rer.nat. Roland Pail (Program Director)
Additional Information for Special Degree Programs:	Double-Degree with Wuhan (China)
Contact for Further Questions:	Nikolas Pfaffenzeller +49 (0)89 289 23188
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Dean of Studies:	Prof. Dr. Ir. Walter Timo de Vries

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1 Degree Program Objectives

1.1 Purpose of the Degree Program

Earth observation satellites help us better understand and monitor our environment. Today, researchers within climatology, oceanography, meteorology as well as national agencies and logistics companies are all dependent on up-to-date satellite data. Design, development and data analysis of respective satellite missions require experts with knowledge not only in spacecraft design and orbit mechanics but also in satellite applications, as well as Earth system science, remote sensing and navigation. From an educational point of view, this diversity is a challenge. Classical university programs cover parts of this spectrum in different disciplines. These are aerospace engineering, electronic engineering or geodesy - just to mention a few - yet there is hardly any connection between these parts. Therefore several institutions in and around Munich decided to combine their expertise and set up a graduate program with the aim of educating **Satellite Application Engineers**. The result is the Earth Oriented Space Science and Technology (ESPACE) Master's program.

With the tremendous increase of satellites it turned out that there exists a knowledge gap between satellite technology and interpretation of acquired data for Earth observation applications. The degree program intends to train engineers who are able to bridge this gap. It meets the growing demand for globally available satellite data, e.g., GPS and its European equivalent Galileo, TerraSAR-X and TanDEM-X, Sentinels in the frame of EU/Copernicus, and Earth observation satellites like GOCE, GRACE, Cryosat, SMOS, Swarm, etc. For instance, this data is especially interesting for security-relevant applications (e.g., the EU program INSPIRE (INfrastructure for SPatial InfoRmation in Europe) to support in crisis situation response), for the fast growing international market in the field of satellite-supported positioning, navigation and logistics (from Google Maps to vehicle navigation systems for the purpose of routing and guidance), and for issues connected to the impact of global change on the environment and living conditions (e.g., sea level rise, melting ice mass, natural hazards, early warning systems). Graduates are able to make direct and important contributions to current topics of paramount importance to society, the economy and science. Accordingly, the need for qualified engineers is high.

The international English-based Master's degree program ESPACE was established in 2005. **ESPACE is an interdisciplinary Master's degree program positioned at the interface between space technology and the engineering and natural scientific use of satellite data**. It combines the technical aspects of the satellite and observation systems with scientific and commercial applications. This requires interdisciplinary knowledge beyond the borders of different engineering disciplines such as geodesy, mechanical and electrical engineering, as well as physics, informatics and geosciences.

Typically, tasks of space science and technology are handled in an international framework and **at the interface of science and industry** with major contributions by national and international space agencies (e.g., ESA, NASA, JAXA), which requires evidently globally interlinked expert knowledge, and which shall be decidedly linked to high-performance German scientific institutions and industry in this field. **Therefore, the ESPACE Master's program addresses international students with the goal to educate talented professionals for both the German and the international market.**

The goal of the ESPACE Master's degree program is to gain graduates who become experts in the use and development of satellites in the three areas of specialization: **(1) Earth System Science from Space, (2) Remote Sensing and (3) Navigation**. Students acquire fundamental knowledge and competencies in these three fields as a general basis, as well as the interfaces among them in order to be able to link technological know-how with practical application. They simultaneously learn the necessary basics of signal processing, sensor technology, orbital mechanics and space technology,

so that they are in a position to support planning and development of future missions for the above-mentioned areas. These fundamental competencies shall enable ESPACE graduates to discuss and interact with experts of all relevant fields of Earth-oriented space science in an interdisciplinary environment. Moreover, they acquire and deepen their specialist knowledge in one of the three subjects. Graduates of ESPACE are not only able to interpret, analyze and evaluate satellite data, they also make use of their knowledge to support designing all the phases of the development cycle of a satellite mission, be it the satellite design in terms of payload, instruments, orbit, rocket launch, signal processing or the ground segment. Graduates are therefore experts for satellite missions and their use in Earth observation.

Due to the complexity of the tasks in space and geosciences, which are usually performed in well-organized and functioning interdisciplinary teams consisting of people with different cultural backgrounds embedded in an international structure, students of the ESPACE Master's program develop intercultural and teamwork competencies through extensive project-oriented work.

The Munich region has a unique concentration of expertise in the fields of satellite technology, natural science, remote sensing and navigation as well in academic as in industry. The three universities, Technische Universität München (TUM), Ludwig-Maximilians-Universität München (LMU) and Universität der Bundeswehr München (UniBw) together with the research institute German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) bundle their expertise within the non-profit association *Munich Aerospace – Fakultät für Luft- und Raumfahrt e.V.* and industry. The international Master's degree program Earth Oriented Space Science and Technology (ESPACE) makes use of these favorable conditions to train engineers. Numerous reputed scientists at the above-mentioned institutes and external lecturers from industry and research are involved in the teaching process.

By including numerous scientific institutes and the space industry in the teaching concept, ESPACE makes full use of the potential of excellent scientists, offering also the opportunity of dedicated project work and Master's theses in close co-operation with, and in many cases even at the location of these institutions. Thus the students become involved in current projects, state-of-the-art technology and science, and daily practice.

1.2 Strategic Significance of the Program

Observing the Earth system is a successful research subject at the TUM**. The content of the subject matter covered by the ESPACE program is highly relevant to the interdisciplinary core themes environment & climate described in the TUM's mission statement**, because Earth observation with satellites significantly contributes to the monitoring and quantification of global change processes in all relevant sub-components of the Earth system, the determination and visualization of natural hazards as well as early warning systems. Also, the research work on the development of satellite procedures and the analysis of satellite information provide important stimuli for the focal areas of information & communication, as well as mobility & infrastructure.

The TUM specifically concentrates on forging international alliances with leading teaching and research institutes and networking in the fields of science and commerce. The international ESPACE Master's degree program, one of the first international degree programs instituted at the TUM, fulfils this mission goal and enjoys an excellent reputation both at home and abroad, thanks to the involvement of teaching staff from a large number of scientific institutes, international organizations and the global space industry, as well as guest lecturers from Germany, Europe and overseas. At the TUM, the cooperation afforded via the teaching concept stimulates numerous new, highly innovative research cooperation projects between the participating organizations from which the students also take substantial benefit.

TUM's mission goal of internationality is fostered, further extended and has been solidly established by the integration of a double Master's program for especially talented students in cooperation with a university in China - the first of its kind at the TUM. The **Double-Master's Agreement with the Wuhan**

University, one of the TUM's partner universities, was launched for the winter semester 2010/11. The positive acceptance by Chinese students, which have to pass a co-operative German-Chinese entrance selection process to ensure the high quality of candidates, demonstrates the demand for such an international agreement.

The main objectives of the ESPACE program are also in full agreement with the long-term guiding principle of the Department for Civil, Geo and Environmental Engineering "Construction – Infrastructure – Environment – Planet Earth" (cf. Fig. 2.1), specifically contributing to the areas "Planet Earth" and "Environment". **ESPACE represents the department's only international Master's program in the field "Planet Earth".** In its mission statement, the BGU department emphasizes the growing impact of global processes in the Earth system on political decisions and also economic, social and technological development. Therefore the central elements of the core theme 'Planet Earth' are the global observation of the Earth as a system from space, allowing changes and processes in and on the Earth to be recorded and their mutual interaction demonstrated in models. **ESPACE combines the various aspects of the development and analysis of national and international Earth science satellite technologies in a unique manner by linking the expertise available at the department (in particular a number of chairs of the Focus Area "Geodesy") in terms of the realization, analysis and use of various satellite missions with application subjects (e.g. geophysics, climatology) and complementary engineering subjects (e.g. mechanical engineering, electrical and computer engineering).**

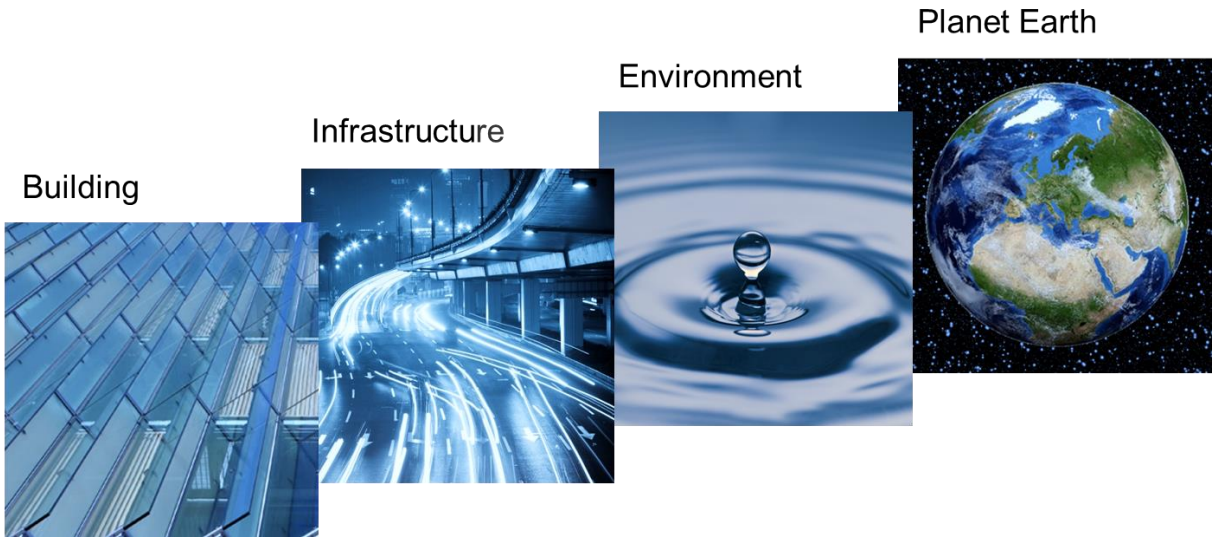


Fig. 2.1: Guiding principle of the Department of Civil, Geo and Environmental Engineering

2 Qualification Profile

Graduates of the international Master's program Earth Oriented Space Science and Technology (ESPACE) have **solid thematic and methodological competencies in the topics of Earth-oriented space science and technology**, they are able to perform a quality conscious, responsible and creative approach and have a solid and comprehensive fundament of expert knowledge. Basic competencies are acquired by all graduates in three core areas *satellite and remote sensing data analysis* | *space engineering* | *satellite applications*, in order to establish fundamental knowledge of all relevant subjects enabling the graduates to work in a wide range of space sciences.

The focus of the core area ***satellite and remote sensing data analysis*** lies on the development and application of processing methods to satellite-derived data and models. With this core subject, graduates acquire the methodological competence to apply different processing methods and approaches to practical problems of satellite and space engineering, they are able to select the optimal method for certain practical problems in the field of satellite and remote sensing data analysis. The graduates work with data and process models, to assess the results quantitatively and are able to interpret the results in the context of space science and technology.

In the core area ***space engineering***, students acquire thematic and methodological competencies in the field of spacecraft technology (spacecraft design, spacecraft subsystems, launcher systems, rocket design), orbit mechanics and dynamics, ground segment design, and robotics. Graduates have the basic know-how and competencies required to review state-of-the-art knowledge of space engineering, to systematically expand existing specialized know-how by developing, upgrading and implementing new methods and technologies in the field of space engineering; they are able to realize and to analyze the interplay among the subdomains of space engineering. They are able to understand and to apply the control principles for orbital, spacecraft attitude and robotic operations, and to reproduce the behavior of these systems on ground for verification purposes.

The focus of the core area ***satellite applications*** lies on the analysis, modelling and interpretation of satellite and remote sensing data related to the key satellite applications. Graduates have a thorough understanding of the basic components of system Earth and its main geodynamic processes in the Earth's interior, at the surface, and the global energy budget, and they are able to develop, upgrade and implement mathematical and physical concepts and to apply them for the solution of practical problems in the field of satellite applications, to interpret geophysical, geodetic and geodynamical results, and to put them into the scope of geoscientific concepts. They are able to understand the basic principles and concepts of photogrammetry, remote sensing, geoinformation systems, and satellite navigation, and they are able to apply related methods, to assess and to interpret the results. Graduates have the competence to view processes in their entirety, to connect the expertise acquired in a particular discipline with a more general scope and to derive consequences and guidelines for action on this basis.

These core competencies in the three areas enable ESPACE graduates to have knowledge of the most important fundamentals in the field of Earth-oriented space science and technology, to build interfaces and to develop overarching concepts and technologies among them. This interdisciplinary expertise qualifies ESPACE graduates for a wide range of professional profiles both in science and industry. Graduates are able to determine the appropriate theories, to develop methodological approaches and to apply them either in an industrial or in a scientific environment. Going deeper, they are able to design actual research questions, to select and justify concrete ways of implementing their research, to select adequate research methods, to justify this selection and to explain research results and interpret them critically.

Beyond their competencies in the three core areas as described above, the main criteria of the qualification are further focused by three selected areas of specialization: (1) Earth System Science from Space, (2) Remote Sensing, and (3) Navigation. Here, students acquire specialized expert

knowledge in one thematic field and are trained to acquire in-depth knowledge, to apply related methods, to assess and to evaluate results and to create new methods and technologies in this field.

Graduates selecting the specialization in ***Earth System Science from Space*** acquire a profound scientific knowledge of the Earth's system and its sub-components (ocean, atmosphere, hydrosphere, solid Earth). They are able to link data from Earth observing satellites and geophysical models describing Earth system dynamics, to apply them to record, present and evaluate processes and mass transport in the system Earth, and to evaluate their impact for global change. Graduates specializing in ***Remote Sensing*** are able to apply in-depth methods to record, analyses and visualize sensor data of various wavelengths and scales. They are able to evaluate the suitability of ground-based, airborne and space-assisted optical, infrared and microwave sensors for task-specific problems in the field of remote sensing. They have the competence to combine data analysis methods for creating digital city and terrain models, change analysis, and monitoring/forecasting natural hazards. Graduates specializing in ***Navigation*** are able to apply and evaluate methods for precise navigation and global surveying using geodetic space procedures and calculate precise orbits using data from GNSS and terrestrial navigation systems. They are able to analyze and solve problems of sensor fusion and integrated navigation systems and related practical applications such as car navigation, aeronautical and space applications.

The graduates' social skills are enhanced, and they acquire different abilities in the areas of specialization, social and personal skills independently. The graduates learn to work in teams and to act effectively in accordance with the needs of parties in communication and interaction situations. Besides participants of the ESPACE Master's Program develop the capacity for teamwork and cooperation skills as well as constructive, scientific and conceptual decision-making competence. As an example, each participant of the project group is with his acquired technical and professional competence an expert in his remit. A goal-oriented and situation-specific interaction of these experts conducts to a successful project completion. Furthermore, the graduates are able to positively solve conflicts in group dynamics. It is to be mentioned in particular the interdisciplinarity and its positive impact of the ESPACE Master Program: the graduates are able to use their different qualifications and expertise from their bachelor studies for resource-oriented work (wide range of bachelor graduates like among others electrical and mechanical engineers, natural scientists or geoscientists). The graduates are able to present results and methods in accordance with the scientific practice.

The graduates have enhanced their self-competence. Graduates are able to work independently and autonomously, they are able to accept criticism, and are self-confided into the performed work, reliability, responsibility and the sense of duty. Furthermore, the graduates acquired the ability to act problem-oriented on a respective task and beyond to integrate this task into a wider context. This is complemented by the ability for professional and self-reflective action in the core areas and in the selected specialization area. Summarized this can be understood as the development of a professional self-image which is especially important for the possible work fields of the graduates in science and industry. They enter into dialog with both academics and non-academics from various disciplines and fields about viable alternatives to solving discipline-specific, subject-related problems.

In the framework of ESPACE intercultural sensibility is promoted and thus there is the basis for a better intercultural understanding. The graduates know different communication behaviors and Modes of Thought as well as they know how to overcome distances.

3 Target Groups

3.1 Target Groups

Admission requirements for national and international applicants are a Bachelor's degree or diploma in a natural or engineering science subject. Generally, the target group is composed of highly motivated candidates with affinity and interest in technical and geoscientific subjects and engineering talent from all over the world, who intend to work in the field of satellite technologies in conjunction with Earth observation.

3.2 Program Prerequisites

The qualification of candidates for the ESPACE program is ensured by means of an aptitude assessment process which examines the specific competence and the ability to work in a methodological, principle-based, interdisciplinary and scientific manner, details are provided in the Degree Program and Examination Regulations (FPSO). The aptitude assessment process is based on the submitted documents. In addition to the content of the degree held (natural or engineering science subject), one particular point of focus is to check whether the competencies gained in the fields of mathematics, physics and informatics are equivalent to those skills gained in a natural or engineering science Bachelor's degree taken at the TUM. Students must submit proof of competence in English (e.g. IELTS, TOEFL) with a minimum score of 6.5 (IELTS) or 88 (TOEFL Internet based testing) before they can be admitted to the program. A letter of motivation, and an essay on a scientific subject relevant to the general scope of the degree program need to be submitted together with the application documents. The aptitude assessment process is governed by the FPSO of the degree program and is carried out by an aptitude assessment commission. If there is any doubt about the candidate's fulfilment of the above-mentioned qualification requirements, the applicant is invited to a video interview. The aptitude assessment process ensures that only qualified candidates are admitted, as is reflected in the very low drop-out figures. Over 90% of those who have taken part in the ESPACE program since it was launched have completed it successfully.

Fast processing of the applications is essential especially in the case of international degree programs, which all compete globally for the most talented students. Most of these students apply for several degree programs at different universities. Experience has shown that many of these applicants decide in favor of the degree program that offered them a position first, allowing them much more time to take care of their funding, visas and accommodation. This is why ESPACE endeavors to carry out aptitude testing promptly and to inform the applicants of their results as soon as possible. ESPACE aptitude assessment commission recommends applicants from non-EU countries to apply before15th of March for the following winter semester intake.

3.3 Target Numbers

The target number of number of enrolled students per year is in the order of 30 students a year, because of the size of the available lecture halls, seminar and computer rooms, as well as supervision capacities of the program's current staff (cf. also Section 7 and 8).

Since the program was launched in the winter semester 2005/06, over 1200 applications have been received (incl. applications for the winter semester 2018/19). After the aptitude assessment process, 456 students were admitted (incl. applications for the winter semester 2018/19) and 301 students were enrolled (incl. those admitted for the winter semester 2018/19; Fig. 3.1).

By the end of the summer semester 2018, more than 180 students had successfully completed the ESPACE Master's program.

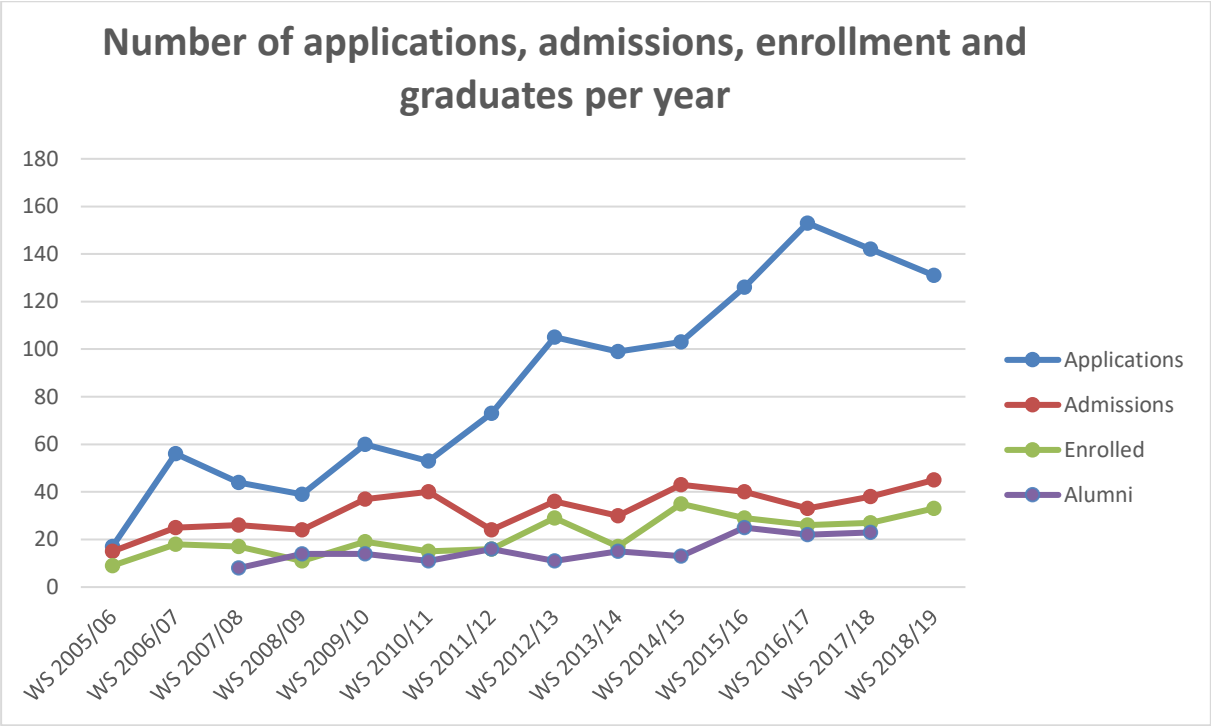


Fig. 3.1: Number of applications, admissions, enrolment figures and graduates of the respective program year since the Master's degree program started in WS 2005/06.

The ESPACE degree program was approved in May 2005 so that there was little time to advertise it for the upcoming winter semester 2005/06; nevertheless, 9 students enrolled. Since then, advertising both at home and abroad has intensified. In particular, a new website was created and the information material revised. The application figures have also increased thanks to the attendance of ESPACE staff at numerous student information events (e.g. Masterbeurs, Space Technology Education Conference (STEC), Open Day at DLR) and the inclusion of the ESPACE program in the DAAD information brochure. The successful definition and establishment of a professional profile (Satellite Applications Engineering) also led to an increase in the number of applications for the program (Fig. 3.1). The number of applications for the program was razing continuously over the years, and during the last three intakes has been oscillating around 140. The number of admitted students of about 40 per year, shows the intention of ESPACE to select only the top students. Since winter semester 2012/13 the number of admitted students includes also 5-10 candidates involved in the Double Degree program with Wuhan.

The academic background held by enrolled ESPACE students vary greatly. Exemplary, Fig. 3.2 and Fig. 3.3 shows the variety of subjects students have studied before attending the ESPACE program so far. Most common background are Electrical Engineering, Geodesy and Geosciences (about 15% each), but also many ESPACE students held Aerospace Engineering as their previous degree (12%).

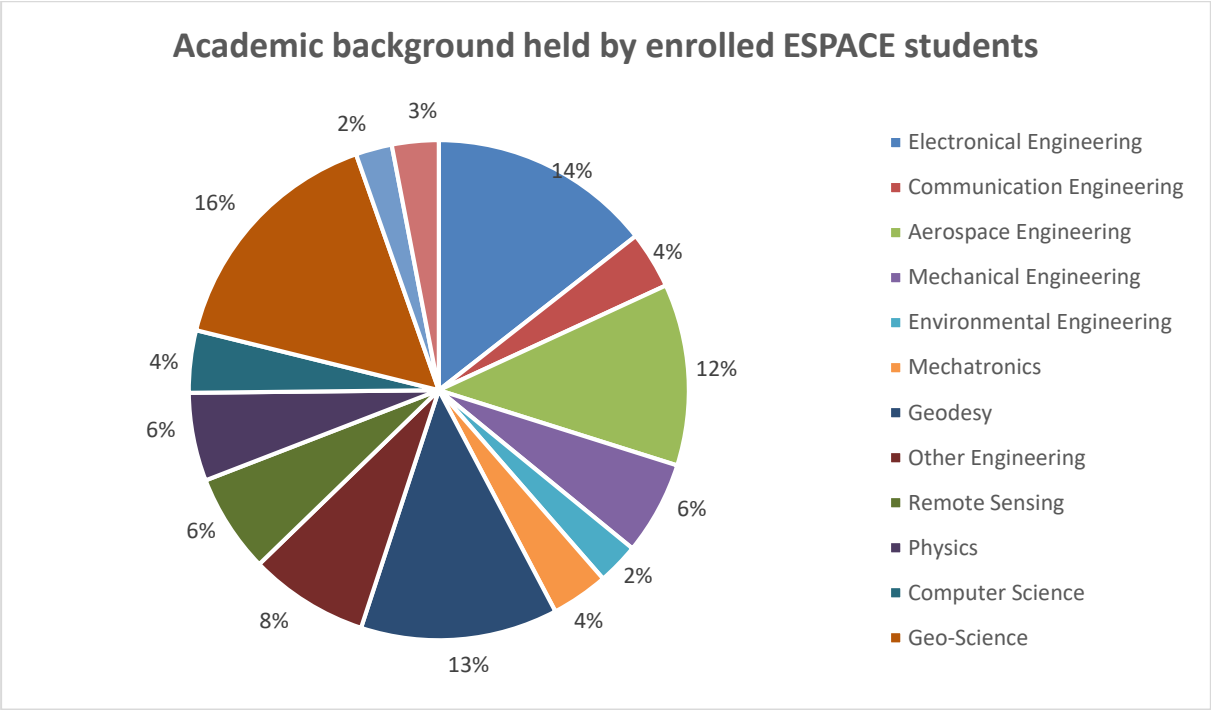


Fig. 3.2: Distribution of engineering and scientific subjects studied by enrolled students before attending the ESPACE Master's program (WS 2005/06 – WS 2018/19).

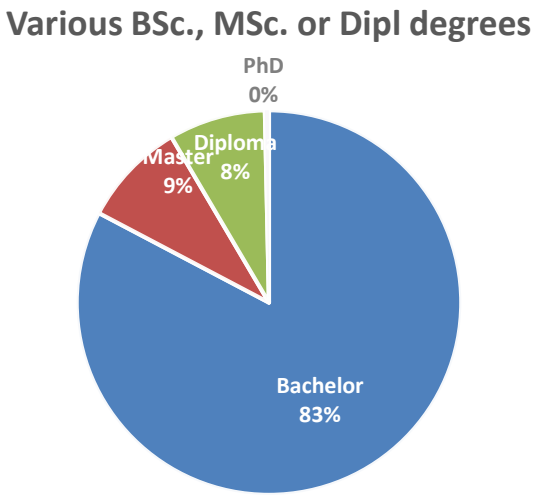
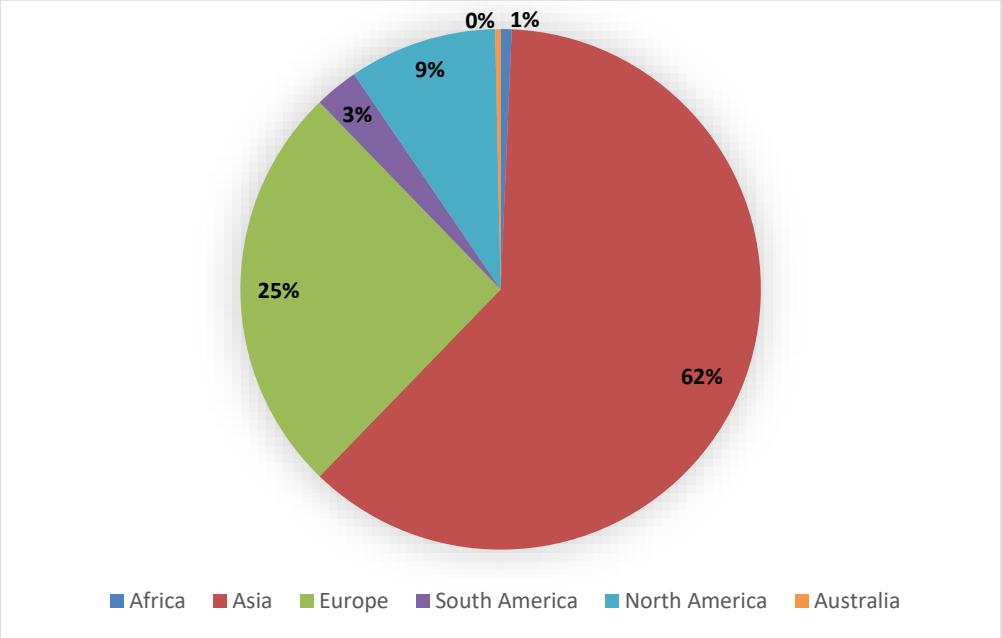


Fig. 3.3: Distribution of highest academic degree held by enrolled ESPACE students (WS 2005/06 – WS 2018/19).

The students who enrol in the program come from a wide range of countries (Fig. 3.4 and Table 3.1). The largest percentages of students come from China (34 %), Germany (9 %) and India respectively Greece (8 %). Consequently, with 91% the rate of participation by international students is very high. The most common reasons why 35 % of the admitted students do not actually take up their space in the program are difficulties relating to finding funding for the course and accommodation, refused visa applications and the decision to take up a different Master's degree program. It is therefore difficult to estimate in advance how many admitted applicants will actually commence their studies. Early notification of admission to the program may be one way to counter this.



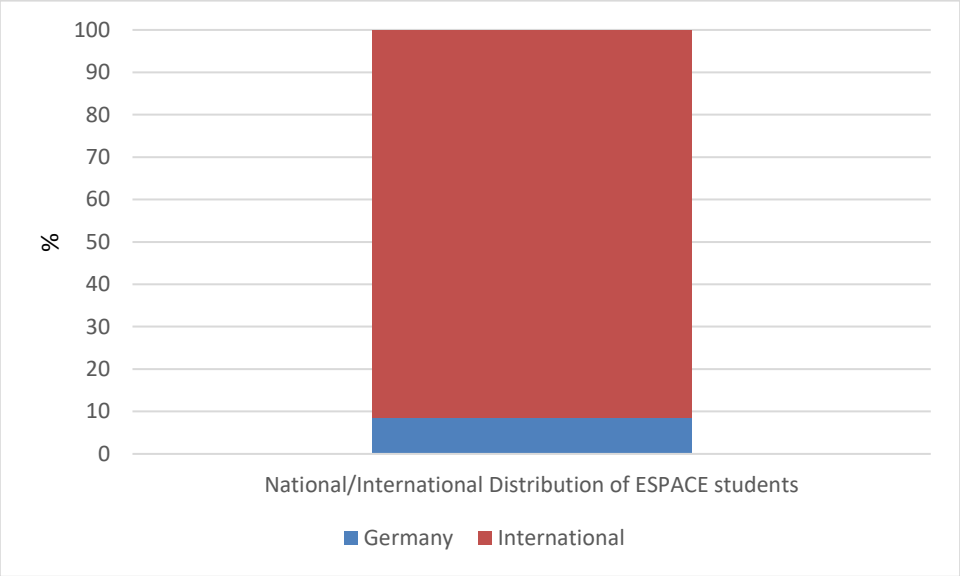


Figure 3.4: Home continents of ESPACE students

Table 3.1: Home countries of the ESPACE students (WS 2005/06 - WS 2018/19)

Africa		Asia		Australia	Europe		North America		South America	
Egypt	5	Bangladesh	3	1	Austria	4	Canada	4	Colombia	4
Nigeria	1	China	101		Belarus	1	Mexico	13	Costa Rica	1
Sudan	1	India	23		Bulgaria	2	United States	10	Ecuador	1
		Indonesia	2		Czech Republic	1			Panama	1
		Iran	5		Finland	2			Venezuela	1
		Israel	1		France	1				
		Japan	2		Germany	26				
		Kazakhstan	4		Greece	10				
		Lebanon	2		Ireland	1				
		Malaysia	1		Italy	11				
		Nepal	6		Lithuania	1				
		Pakistan	5		Macedonia	1				
		Philippines	1		Portugal	1				
		Russia	10		Romania	2				
		South Korea	1		Spain	7				
		Taiwan	5		Ukraine	3				
		Thailand	2		United Kingdom	1				
		Turkey	6							
		Uzbekistan	1							

4 Analysis of Need

ESPACE Alumni can be best described as **satellite application engineers** who are working in space agencies, space industry, research institutions, or universities. In space agencies they manage the complete lifecycle of an Earth observation satellite mission from mission planning, via development and implementation, satellite operations and data analysis to applications. In space industry they take over tasks in the design of Earth observation missions, specifically matching overall mission requirements and industrial Hardware and Software development. In research institutions and universities they perform PhD studies in actual research questions related to Earth observation with satellites. As satellite application engineers they analyze interactions between satellite sensors, processing algorithms and science applications in order to obtain the optimal results. The aerospace technology industry and the fields of Earth system sciences, remote sensing and navigation are employment sectors that will grow in importance in the future. For example, natural catastrophes such as the Sumatra Earthquake (2004), the floods in Pakistan (2010) and the Tohoku Earthquake (2011) are impressive reminders that there is a great need for Earth system sciences research; the primary information sources here are the observations made from space. There is also a great need for globally available data in connection with security-related applications (e.g. for civil defense and humanitarian aid). Likewise, there is a growing international market in the field of satellite-supported positioning, navigation and logistics, all of which indicates that ESPACE graduates have excellent professional prospects. Graduates' excellent competencies and skills makes the young scientists enrolled in the ESPACE program very sought-after employees. Based on all graduates (about 90) whose employment situation is known to the ESPACE program office, 59% of the graduates are working as researchers after completion of the program, either in ESPACE cooperating institutions (36%) or in other research institutions worldwide (23%). About 45% of the graduates go on to complete a PhD. About 41% of graduates continue their professional carrier in industry primarily in the aerospace, energy or automation sectors (e.g. Airbus Defense and Space, RapidEye, OHB-System, SpaceTech, Sagem Defense, Mitsubishi Power Systems, General Motors, etc.). About two thirds of the ESPACE graduates start their professional career in Germany.

5 Competition Analysis

5.1 External Competition Analysis

ESPACE is an international interdisciplinary consecutive Master's degree program. **There is no degree program with comparable portfolio in Germany.**

The degree program is positioned within the scope of the field that examines the observation of the Earth system from space at the TUM. It occupies a strategically important future position at the interface between engineering science and the natural sciences. Also, thanks to its inclusion in numerous external scientific institutions and the space industry, ESPACE is a prototype of a degree program within the Munich aerospace industry (see Section 1).

ESPACE builds an interdisciplinary bridge between space technology and the engineering and Earth science-related use of satellite data, allowing technical aspects to be linked with applications. In contrast to the conventionally separate degree programs in these fields, such as geodesy, geophysics, mechanical and electrical engineering, aerospace engineering, as well as physics, informatics and geosciences, ESPACE combines this knowledge into one unique degree program. Better suited than students who study these separate fields, ESPACE graduates are able to take a more comprehensive look at decisive positions in the scientific and commercial fields and to mediate between the disciplines. The integration of technology knowledge and application know-how into a single program is particular to the ESPACE program, making it unique in Germany. Moreover, English is the official language of instruction of the ESPACE program, making it attractive to students from around the world. In Europe, there exist a few related Master's degree programs on other space-related topics with different focal points. For example, at TU Delft master programs in Aerospace Engineering or Applied Earth Sciences are offered, which address either technology or satellite data applications. At University of Toulouse a variety of master courses in Aeronautics and Space are offered, which are focused on space technology rather than Earth observation. At DTU Copenhagen there is offered a Master program in Earth and Space Physics and Engineering, which has a special focus on technologies for monitoring and mapping the Earth and exploring the universe, but less on spacecraft technologies. In contrast ESPACE intends to cover the complete spectrum from satellites to applications, which makes the program also unique in Europe. But, in case ESPACE students want to get a deeper knowledge in one of these areas, these universities could be a possibility for studying abroad.

By virtue of the high concentration of scientific institutions in the fields of satellite technology, Earth sciences, remote sensing and navigation, and the various companies working in the space industry, there is a high level of interest in the Munich region for the junior scientists trained in the ESPACE program. Therefore the degree program is ideally positioned at the TUM.

5.2 Internal Competition Analysis

The ESPACE degree program is primarily run by the TUM Chair of Astronomical and Physical Geodesy (APG), supported by 5 further Chairs of the Focus Area Geodesy: Satellite Geodesy, Geodetic Geodynamics, Photogrammetry and Remote Sensing, Remote Sensing Technology, Signal Processing in Earth Observation. The profile of ESPACE is different from all other Master's degree programs run at the TUM.

The degree programs interdisciplinary concept supplements the portfolio of rather more specialized TUM degree programs in these disciplines. In terms of content, there is no competition. The related Master's programs Geodesy and Geoinformation, run by the Department of Civil, Geo and Environmental Engineering, and Aerospace Engineering, run by the Department of Mechanical Engineering, are much more specialized and consequently have a different focus and pursue other degree program objectives. Geodesy and Geoinformation, for example, is a consecutive master program building on Bachelor programs in geodesy, geomatics or similar. As the qualification profile

for ESPACE is much broader there is hardly any competition in terms of applicants. Aerospace Engineering currently is offered in German language, therefore it is not suited for most international applicants.

In some subjects there are correlations between ESPACE and other degree programs from different departments at the TUM and LMU. ESPACE lecturers also teach the English-language Master's degree programs Geodesy and Geoinformation (BGU), Environmental Engineering (BGU), Transportation Systems (BGU), Cartography (BGU), Communications Engineering (EI), Geophysics (LMU and TUM) and the German-language Master's degree programs Electrical Engineering and Information Technology (EI) and Aerospace (MW). Numerous teaching events from the ESPACE program can also be selected as elective subjects for the Geodesy and Geoinformation degree program.

6 Structure of the Degree Program

ESPACE is a method- and application-oriented degree program. Important elements are technical key components (as required e.g. to plan, design or execute a satellite mission) and special engineering and scientific methods required to evaluate, analyze and interpret satellite data.

The program is comprised of 4 semesters (Fig. 6.1). The degree program is taught in English only.

The detail structure of the degree program is as follows:

Semester 1 and 2: Basics and fundamentals - core areas

In the first two semesters all modules are obligatory, because the students must acquire basic skills in mathematical and physics-based subjects (numerical modelling, signal processing and microwave remote sensing and estimation theory and machine learning) as well as modules in the fields of ***satellite and remote sensing data analysis,*** satellite technology and ***space engineering,*** orbital mechanics (spacecraft technology, orbit mechanics and on-orbit dynamics and robotics) and ***satellite applications*** as well as applied satellite usage (applied earth observation). Several modules have the goal to bring the students coming from a wide range of different Bachelor's programs to the same level of knowledge. Furthermore throughout all these modules the students gain overall basic skills in each one of the later areas of specialization Earth system science, remote sensing and navigation. After these two semesters, students have acquired the competencies concerning the basics of the above mentioned subjects, to identify the links and interfaces among different subjects of Earth and space science, to apply basic methodologies and to assess and interpret scientific and technological results. This is a pre-requisite to fulfil one of the program's main goals, i.e. that ESPACE graduates are able to work in an interdisciplinary environment and with experts from all relevant fields of Earth-oriented space science and technology.

Semester 3: areas of Specialization

In addition to the remaining required module "Spacecraft technology 2" (5 Credits) and the broad spectrum of competencies acquired during the first two semesters, in the third semester the students select one of the three areas of specialization, namely (1) Earth System Science from Space, (2) Remote Sensing, or (3) Navigation (Fig.6.2).

1. Semester	2. Semester	3. Semester	4. Semester
Introduction to Earth System Science Type of Module: required Klausur 120 min, 5 Credits	**Scientific Working in Earth Oriented Space Science and Technology** Type of Module: required research paper, 5 Credits		
Numerical Modeling Type of Module: required Klausur 120 min, 5 Credits	**Applied Earth Observation** Type of Module: required parcours, 5 Credits	**Specialization** Type of Module: required 15 Credits	
Introduction to Photogrammetry. Remote Sensing and Digital Image Processing Type of Module: required Klausur 120 min, 5 Credits	**Satellite Navigation and Advanced Orbit Mechanics** Type of Module: required Klausur 120 min, 5 Credits		**Master's thesis** **Master's Colloquium** Type of Module: required 30 Credits
Signal Processing and Microwave Remote Sensing Type of Module: required Klausur 75 min, 5 Credits	**Estimation Theory and Machine Learning** Type of Module: required Klausur 60 min, 5 Credits	**Electives** Type of Module: elective 10 Credits	
Introduction to Satellite Navigation and Orbit Mechanics Type of Module: required Klausur 120 min, 5 Credits	**Ground and Space Segment Control** Type of Module: required Klausur 120 min, 5 Credits		
Applied Computer Science Type of Module: required Klausur 90 min, 5 Credits	**Spacecraft Technology 1** Type of Module: required Klausur 90 min, 5 Credits	**Spacecraft Technology 2** Type of Module: required Klausur 90 min, 5 Credits	
30 Credits **6 exams**	**30 Credits** **6 exams**	**30 Credits** **≥ 6 exams**	**30 Credits** **1 exam**

Fig. 6.1: Overview of the current ESPACE degree chart: the table shows the individual modules including the module type and the credits.

Areas of Specialization		
Earth System Science from Space	**Remote Sensing**	**Navigation**
Atmosphere and Ocean Type of Module: required elective 5 Credits Klausur 90 min	**Photogrammetry** Type of Module: required elective 5 Credits Presentation	**Precise GNSS** Type of Module: required elective 5 Credits Klausur 120 min
Geokinematics and Continental Hydrology Type of Module: required elective 5 Credits Klausur 120 min	**Remote Sensing** Type of Module: required elective 5 Credits parcours	**Advanced Aspects of Navigation Technology** Type of Module: required elective 5 Credits Klausur 120 min
Earth Observation Satellites Type of Module: required elective 5 Credits Klausur 90 min	**Geoinformation** Type of Module: required elective 5 Credits Klausur 60 min	**Navigation Labs** Type of Module: required elective 5 Credits laboratory assignments

Fig. 6.2: Specialization options in the third semester: An overview of the three areas of specialization with their respective modules. The modules are required modules within the respective area of specialization.

Thus, they deepen their methodological competencies, they are able to develop, upgrade and apply dedicated methods and gain advanced expertise in one of these areas. The chosen area of specialization serves as the thematic context for practicing and sharpening methodical competencies in a particular field. The students take three required modules (within each specialization). The areas of specialization and the composition of the corresponding two elective modules ensures the comprehensiveness of students' profiles. Figs. 6.3 to 6.5 show the complete degree program for the three fields of specialization with exemplary elective modules.

1. Semester	2. Semester	3. Semester	4. Semester
Introduction to Earth System Science Type of Module: required 5 Credits	**Scientific Working in Earth Oriented Space Science and Technology** Type of Module: required 5 Credits	**Earth System Science from Space** **Atmosphere and Ocean** Type of Module: required Klausur 90 min, 5 Credits	
Numerical Modeling Type of Module: required 5 Credits	**Applied Earth Observation** Type of Module: required 5 Credits	**Geokinematics and Continental Hydrology** Type of Module: required Klausur 120 min, 5 Credits	
Introduction to Photogrammetry. Remote Sensing and Digital Image Processing Type of Module: required 5 Credits	**Satellite Navigation and Advanced Orbit Mechanics** Type of Module: required 5 Credits	**Earth Observation Satellites** Type of Module: required Klausur 90 min, 5 Credits	**Master's thesis** **Master's Colloquium** Type of Module: required 30 Credits
Signal Processing and Microwave Remote Sensing Type of Module: required 5 Credits	**Estimation Theory and Machine Learning** Type of Module: required 5 Credits	**Exemplary: Geoinformation** Type of Module: elective Klausur 60 min, 5 Credits	
Introduction to Satellite Navigation and Orbit Mechanics Type of Module: required 5 Credits	**Ground and Space Segment Control** Type of Module: required 5 Credits	**Exemplary: Advanced Aspects of Navigation Technology** Type of Module: elective Klausur 120 min, 5 Credits	
Applied Computer Science Type of Module: required 5 Credits	**Spacecraft Technology 1** Type of Module: required 5 Credits	**Spacecraft Technology 2** Type of Module: required Klausur 90 min, 5 Credits	
30 Credits **6 exams**	**30 Credits** **6 exams**	**30 Credits** **≥ 6 exams**	**30 Credits** **1 exam**

Fig. 6.3: ESPACE degree chart for specialization "Earth System Science from Space" with exemplary elective modules.

1. Semester	2. Semester	3. Semester	4. Semester
Introduction to Earth System Science Type of Module: required 5 Credits	**Scientific Working in Earth Oriented Space Science and Technology** Type of Module: required 5 Credits	**Remote Sensing** **Photogrammetry** Type of Module: required Presentation, 5 Credits	
Numerical Modeling Type of Module: required 5 Credits	**Applied Earth Observation** Type of Module: required 5 Credits	**Remote Sensing** Type of Module: required Parcours, 5 Credits	
Introduction to Photogrammetry. Remote Sensing and Digital Image Processing Type of Module: required 5 Credits	**Satellite Navigation and Advanced Orbit Mechanics** Type of Module: required 5 Credits	**Geoinformation** Type of Module: required Klausur 60 min, 5 Credits	**Master's thesis** **Master's Colloquium** Type of Module: required 30 Credits
Signal Processing and Microwave Remote Sensing Type of Module: required 5 Credits	**Estimation Theory and Machine Learning** Type of Module: required 5 Credits	**Exemplary: Atmosphere and Ocean** Type of Module: elective Klausur 90 min, 5 Credits	
Introduction to Satellite Navigation and Orbit Mechanics Type of Module: required 5 Credits	**Ground and Space Segment Control** Type of Module: required 5 Credits	**Exemplary: Advanced Aspects of Navigation Technology** Type of Module: required Klausur 120 min, 5 Credits	
Applied Computer Science Type of Module: required 5 Credits	**Spacecraft Technology 1** Type of Module: required 5 Credits	**Spacecraft Technology 2** Type of Module: required Klausur 90 min, 5 Credits	
30 Credits **6 exams**	**30 Credits** **6 exams**	**30 Credits** **≥ 6 exams**	**30 Credits** **1 exam**

Fig. 6.4: ESPACE degree chart for specialization "Remote Sensing" with exemplary elective modules.

1. Semester	2. Semester	3. Semester	4. Semester
Introduction to Earth System Science Type of Module: required 5 Credits	**Scientific Working in Earth Oriented Space Science and Technology** Type of Module: required 5 Credits	**Navigation** **Precise GNSS** Type of Module: required Klausur 120 min, 5 Credits	
Numerical Modeling Type of Module: required 5 Credits	**Applied Earth Observation** Type of Module: required 5 Credits	**Advanced Aspects of Navigation Technology** Type of Module: required Klausur 120 min, 5 Credits	
Introduction to Photogrammetry. Remote Sensing and Digital Image Processing Type of Module: required 5 Credits	**Satellite Navigation and Advanced Orbit Mechanics** Type of Module: required 5 Credits	**Navigation Labs** Type of Module: required laboratory assignments, 5 Credits	**Master's thesis** **Master's Colloquium** Type of Module: required 30 Credits
Signal Processing and Microwave Remote Sensing Type of Module: required 5 Credits	**Estimation Theory and Machine Learning** Type of Module: required 5 Credits	**Exemplary: Earth Observation Satellites** Type of Module: elective Klausur 90 min, 5 Credits	
Introduction to Satellite Navigation and Orbit Mechanics Type of Module: required 5 Credits	**Ground and Space Segment Control** Type of Module: required 5 Credits	**Exemplary: Remote Sensing** Type of Module: elective parcours, 5 Credits	
Applied Computer Science Type of Module: required 5 Credits	**Spacecraft Technology 1** Type of Module: required 5 Credits	**Spacecraft Technology 2** Type of Module: required Klausur 90 min, 5 Credits	
30 Credits **6 exams**	**30 Credits** **6 exams**	**30 Credits** **≥ 6 exams**	**30 Credits** **1 exam**

Fig. 6.5: ESPACE degree chart for specialization "Navigation" with exemplary elective modules.

Semester 4: Master's thesis

The fourth and last semester is used to write the Master's thesis (30 credits). With the Master's thesis the competence to perform scientific work independently and to properly document and present the results are verified. The Master's thesis has to be completed within 6 months and has to be submitted in form of a research paper as a written and bounded document. Typically the number of pages of the thesis is between 50 and 150, but this strongly depends on the thesis' topic.

In addition to regular lectures and accompanying exercises, the curriculum also includes excursions, projects and seminars. These team-building activities serve to promote cohesion within the group, thereby allowing interdisciplinary skills and social competencies to be acquired (e.g. intercultural communication, team work in given projects). At the beginning of the 1st semester, students go on a two-day excursion to the Geodetic Observatory in Wettzell that is run jointly by the Federal Office for Cartography and Geodesy (BKG) and the TUM. This excursion offers an introduction to the degree program and also allows the students to get to know each other. Teamwork is also encouraged by means of several projects that are part of the required and elective program. In particular, this includes the module Scientific Working in Earth Oriented Space Science and Technology in the 2nd semester that consists of a broad software project on the topics of analysis and validation of satellite data (for example sea level observation). A series of seminars in the 2nd semester, during which every student needs to hold a presentation about a given current scientific topic from within the ESPACE environment, not only serves specialization purposes, but it also helps to develop soft skills (presentation techniques, rhetoric, structured style of preparation and work) and thus to strengthen their individual competencies. Also, numerous presentations as part of the specialization modules in the 3rd semester help teach the students how to make presentations, hold lectures and defend their own work. Beyond the curriculum, there are also seminars on the topics of intercultural awareness and culture in a university context (1st semester) and writing techniques for the Master's thesis (prior to the 4th semester). Students are encouraged in a wide range of courses to critically assess the technological developments versus ethic aspects and impact on the Earth as our home planet. For example, space debris nowadays is a threat to Earth observation satellites and more general for all human activities in space. Therefore a sustained management of space resources and the related technology need to be secured. This topic is addressed in some courses, where students shall identify countermeasures with respect to this problem in order to enable future space activities.

All modules of the degree program are organized in a way so that they do not overlap within the respective semester and that they logically build on each other. For example the 2nd semester module "Satellite navigation and advanced orbit mechanics" is based on competences acquired in the 1st semester module "Introduction to satellite navigation and orbit mechanics". This holds for most other modules in the curriculum. The students can easily attend all required and elective modules. The rooms that are used on the main grounds of the TUM are just a few minutes' walk from each other. All events that take place at the TUM Campus Garching are scheduled for the same day. This means that students do not need to commute between two locations on one day. There is enough time between the events for preparation and follow-up. Depending on the selected area of specialization, there are some days that are completely free of events from the 3rd semester onwards. These days are available for independent study or also for other activities e.g. work as a student assistant. In the Appendix, the schedule of courses for the first three semesters are provided.

Mobility

ESPACE is an international degree program. Most of the participants therefore come from abroad. Because the program is taught in English, ESPACE events are highly interesting for many students that come to the TUM as part of the ERASMUS program.

To encourage mobility among the ESPACE students, the program offers students the opportunity to write their Master's thesis abroad under the joint supervision of a foreign and TUM academic teaching

staff. This is highly popular among the students. In the past, Master's theses have been accomplished at the following foreign institutes: European Space Agency, University of Leeds, Ecole Polytechnique (Canada), California Institute of Technology (Caltech)/NASA Jet Propulsion Laboratory (JPL), Universidad Politecnica de Madrid, University of Hawaii. Additionally, also the 3rd semester might be used as a mobility "window", because it contains only one single required module "Spacecraft Technology 2", which can be acquired in equivalent form at many foreign universities. Also the contents of the three required modules of the three specializations in 3rd semester are offered in a similar way at several target universities. Therefore, it is possible to study one or even two semesters of the Master's program at another university without impairing the study progress (see e.g. section 5.1).

Regarding national and international exchange programs, the Department of Civil, Geo and Environmental Engineering offers extensive consulting services. Since many years the department employs a Delegate for International Affairs, who provides consulting and supervision of students who are potentially interested to participate these programs. Detail information on relevant exchange programs can be found at the BGU website https://www.bgu.tum.de/en/stay-abroad/outgoing/exchange-programmes/.

As of the winter semester 2010/11, there is a Double-Master's Agreement with Wuhan University (WHU), China, one of the TUM's partner universities. The agreement, which has been extended in 2015 for another five years, governs the TUM's first Double-Master's program with a Chinese university. The WHU is the most important university in China in the fields of geodesy and geoinformation. Students who want to take part in the Double-Master's program need to extend their study for an extra year (three instead of two years). During this three years at least one whole year needs to be spent at the WHU and one whole year at the TUM. The specialization option in the third year of the program is available at both the TUM (areas of specialization: see above) and the WHU (areas of specialization: Navigation, Remote Sensing, Geodesy or Geoinformation allowing the students free choice of where to study their specialized subjects. The Master's thesis (six months) is supervised jointly by professors of both universities. This also strengthens the research cooperation between both universities. Graduates of the Double-Master's program receive two Master's certificates, one from the TUM and one from the WHU. The Double-Master's agreement between both universities that was signed in 2010 governs the process and the curriculum of the Double-Master's program. The first ten students from WHU started their studies at TUM in the winter semester 2012/13. Since then, every year continuously 6 to 10 new Double Degree students had been coming to TUM. In addition, a number of students at TUM decided to purchase the Double Degree and went to Wuhan University.

7 Organization and Coordination

The degree program is run by the Department of Civil, Geo and Environmental Engineering at TUM. This department is responsible for the degree program. Six out of ten Chairs of the Focus Area Geodesy of the Department of Civil, Geo and Environmental Engineering are responsible for the main student teaching load. The Department of Mechanical Engineering (in particular the Chair for Astronautics (LRT)) and the Department of Electrical and Computer Engineering (in particular the Chair of Communication and Navigation) make important teaching contributions. Related the letters of intent by the Department of Mechanical Engineering is included in the Appendix.

By including numerous scientists from the TUM, LMU, UniBW, DLR, and industry (e.g. ESA) in the teaching concept, ESPACE makes benefit of the concentrated potential of the Munich region in the fields of satellite technology, Earth sciences, remote sensing and navigation (Fig. 7.1), as it is described in Chapter 1 and 2.

The degree program is managed by a Directing Board comprising the six professors of the Focus Area Geodesy that directly contribute to ESPACE (Prof. Bamler, Prof. Hugentobler, Prof. Meng, Prof. Pail, Prof. Seitz, Prof. Stilla). Prof. Pail is the Program Director. Strategic questions of the ESPACE degree program are regularly discussed in an Extended Directing Board, which is comprised of representatives of all contributing institutions. There is also an ESPACE program office in which a program coordinator and academic counsellor and a team assistant take care of all student affairs and the administration.

As part of the Double-Master's Agreement, Wuhan University (WHU), China, is also involved in training the students that choose this program (see Section 6). Furthermore, the teaching activities for the ESPACE program are linked to numerous research projects at the participating institutions.

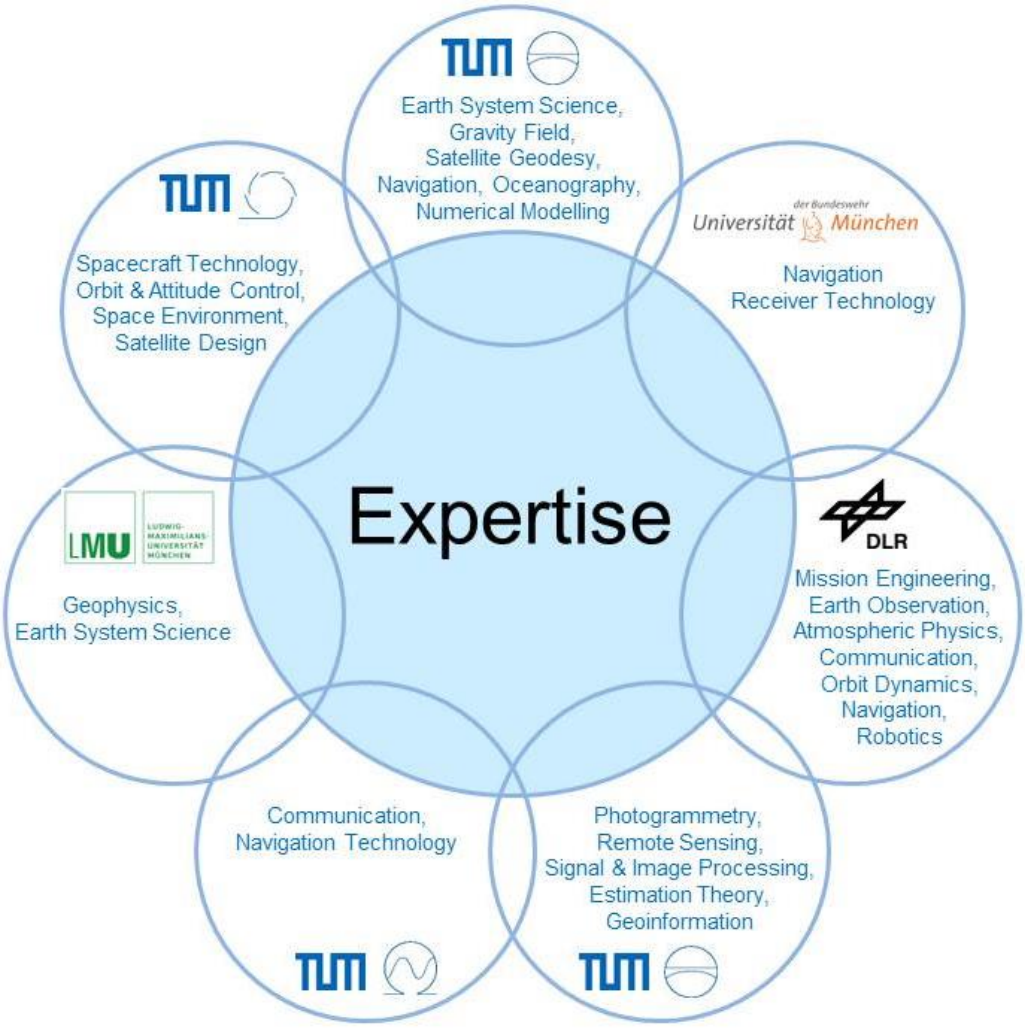


Fig. 7.1: Overview of the participation by various organizations in the ESPACE degree program

Links to the websites of the organizational units:

www.espace-tum.de
www.bgu.tum.de/iapg
www.pf.bgu.tum.de
www.lfk.bgu.tum.de
www.dgfi.tum.de
www.lrt.mw.tum.de
www.nav.ei.tum.de
http://www.dlr.de/caf
www.dlr.de/kn
www.dlr.de/rm
www.unibw.de/lrt9
http://www.geophysik.lmu.de

ESPACE students are enrolled at the TUM. The admissions procedure is maintained by the Student Service Center (SSZ), division *Student Admission*, including applying to study at TUM, enrolment, StudentCard, Leave of Absence, re-enrolment, recognition of academic and study qualifications, withdrawal from TUM, etc. The aptitude assessment is carried out by an aptitude assessment

commission, managed by the program director. Another academic teaching staff and the program coordinator are also on the commission. A student representative assumes an advisory role.

General student advising is performed by the SSZ division *General Student Advising* (also Service Desk or Hotline), who supports prospective students in determining the course of study best suited to their needs and wishes. In addition, they support current students in dealing with the various challenges of their study. Furthermore the SSZ holds an Office for Disabled and Chronically Ill Students to ensure barrier-free education. This office offers support and advice on a wide range of matters such as examination procedures, disability accommodations, applying for electronic learning aids and much more.

The degree program management and the management of the ESPACE Committee for Student Affairs is the responsibility of the program director, Prof. Dr. Roland Pail. The positive development of the ESPACE program is largely due to the installation of its own degree program office, which coordinates and manages the program, and also offers academic counselling services - the Student Advisory Office of the degree program ESPACE - is hold by M.Sc. Nikolas Pfaffenzeller. The degree program office is closely involved in developing the degree program (modularization, FPSO, ensuring the admission requirements are satisfied, evaluating lectures and the degree program as well performing quality management), advertising (flyers, website, participation in international information events and exhibitions) and various student affairs (counselling, examinations, study handbook). The ESPACE quality circle is part of the quality circle of the degree program Geodesy and Geoinformation. Besides the ESPACE Master's program and the Bachelor's and Master's program Geodesy and Geoinformation, the Master program Cartography and Land Management and Land Tenure as well as the Bachelor program BoLE are part of the common quality circle. The members of the quality circle are the dean of Geodesy and Geoinformation, who forms the head of the quality circle, the degree program coordinators, degree program directors and student representatives of the involved degree programs.

ESPACE is attached to the Geodesy Departmental Committee for Student Affairs, which is responsible for all 5 study programs hosted at the Focus Area Geodesy. The presence of student representatives also from the ESPACE degree program guarantees that the interest of students and needs of the students are adequately considered and treated. The Departmental Committee for Student Affairs is chaired by Prof. Thomas Kolbe.

The Central Examinations Office of SSZ is responsible for notification of examination results, grade reports, graduation documents, certificates, etc. The ESPACE examination board is headed by Prof. Hugentobler (FESG, BGU). Other members of the examination board are the program director (Prof. Pail), two additional professor from the BGU department (Prof. Stilla, Prof. Seitz), and one representative from the mechanical engineering department (Dr. Rott, LRT), a representative of the examination office and the secretary of the examination board. Course schedule as well as room management for courses is under the responsibility of the Student Advisory Office. Exam schedules and exam locations are organized by the secretary of the examination board.

8 Resources

8.1 Staffing Resources

The largest contribution to the students' training is made by six chairs of the Focus Area Geodesy (BGU). Many of the teaching events for the ESPACE program are also offered by the Chair for Astronautics (LRT).

One special feature of the degree program is the involvement of many excellent scientists from the institutes in and around the TUM. In the greater Munich district, there is a unique concentration of expertise in the fields of satellite technology, Earth sciences, remote sensing and navigation spread among the three universities (TUM, LMU, UniBw), research institutes (e.g., DLR) and industry. ESPACE taps this potential by involving numerous scientists from the TUM (departments BGU, MW, EI), LMU, UniBW, DLR, DGFI and industry (Airbus, OHB) in the degree program coordinated by the BGU department (Fig. 7.1).

DLR's commitment to the ESPACE teaching concept should be highlighted. The holder of the TUM Chair for Remote Sensing Methods (Prof. Bamler) and the TUM Chair for Communication and Navigation (Prof. Günther) are also the heads of the respective institutes at the DLR and are very closely involved in the ESPACE program. The DLR expressly supports the degree program via its scientific staff and allows the students to take an active part in projects e.g. as part of their Master's thesis or as student assistants.

The close involvement of experts from various fields of expertise from non-university organizations is one of the outstanding features of the degree program. The degree program profits greatly from this commitment, however it does not depend upon it for teaching. If there was a drop in the participation of speakers from outside, the modules could still be held by competent staff from the TUM.

There is a detailed list of the human resources available for teaching in the enclosed resources spreadsheet (Appendix).

There are two members of staff in the program office responsible for the organization and coordination of the degree program, student affairs and administrative tasks.

8.2 Material Resources/Rooms

The main lecturing room used by the ESPACE degree program is the seminar room HS 2609. Some modules also take place in the lecture halls HS 0120 and HS 0714. The students of the degree program can also use the APG's computer room. The CIP pool of the BGU department is also available.

There is a library containing many relevant books for the ESPACE program office that have been procured especially for the degree program. There are enough resources available to complete the degree program successfully.

9 Advancements

As part of the TUM-wide program *innovaTUM*, in the early 2000s the Department of Civil, Geo and Environmental Engineering (BGU) has striven to take new strategic direction. The most important goal of this new strategy was to hone the profile of the department in terms of research and teaching within the scope of its mission statement “Construction – Infrastructure – Environment – Planet Earth” formulated in 2003. At the same time, the department aimed to further consolidate cooperation with neighboring departements or schools and research institutes external to the university.

Against this background, a profile-forming initiative was selected as part of a competition that took place within the department of each of the four core themes named in the mission statement (as well as for an overriding interface topic). As an initiative for the core theme “Planet Earth”, ESPACE was described in an external assessment process within the scope of the *innovaTUM* program of TUM as “expressly worthy of promotion with few concessions” (Endbericht der Fakultät für Bauingenieur-und Vermessungswesen zu innovaTUM-2008, TU München). The human resources and funding required to carry out the program resulted from this process.

In the near future the Master’s program ESPACE is foreseen to be shifted to the new host department **Aerospace and Geodesy**. The new department will bundle academic research activity in the aerospace and aeronautics sectors and will handle new transport systems through communications and satellite technology and observe and measure planet Earth with unprecedented precision. With it specific unique profile at the interface of satellite technology and applications in Earth Observation and contributions of Geodesy as part of BGU, Mechanical Engineering and Electrical and Computer Engineering, the ESPACE programme will fit excellently in the research and education strategy of the new department.

With these updated regulations the module structure is more logical with respect to the curriculum. In addition there is offered more freedom for elective modules and more flexibility. Finally, with this rearrangement of courses the third semester is better suited for studying abroad.