Studiengangsdokumentation

Masterstudiengang *Transportation Systems*

Ingenieurfakultät Bau – Geo – Umwelt, Technische Universität München

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Preface to Language Usage

Pursuant to Article 3, Paragraph 2 of the German Constitution, women and men and their respective rights are considered equitable. Any and all masculine person references in the following charter apply equally to both, men and women.

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1. Aims and Strategic Importance

The Master of Science Program in Transportation Systems at the Department of Civil, Geo and Environmental Engineering of the Technical University of Munich provides an important value to the overall structure and targets of the department. Moreover, as a unique composition the study program Transportation Systems highly supports profiling of the Technical University of Munich.

1.1. Idea and Design of the Study Program

The transportation system is an important part of any economy and core element of daily human life. Mobility is not only a human basic need, it is the key factor of any modern society and economy. Nowadays, society and economy are both challenged by the growing demand for mobility as well as by the ecological and economic impacts of the increasing transportation demand. Traditionally in Germany, transportation science is only considered as academic section of civil engineering. However, phenomena like our globalizing world as well as pollution and climate change require new strategies in the area of transport planning, traffic control and infrastructure design. There is still a need for experts who know about rail and road design, algorithms of traffic management systems and the planning of public transport networks. But, at the same time, those specialists also require interdisciplinary skills to successfully deal with the defiance of modern mobility. The current professional environment and development show that transport engineers must also have skills in economics and project appraisal. Besides, they need knowledge about ecology and the concepts of sustainability, so that they can cope with current and future environmental challenges (e.g. noise emissions, air pollution or land-use and soil sealing). On the other hand, transport and mobility are connected with many social phenomena; they are influenced and also influence social structures and processes (e.g. social exclusion, changes in urban spatial structures. Hence, transport engineers have to know about transport sociology and psychology, so that they are able to consider the social aspects of transport (e.g. social impacts of transport investments, accessibility and reachability).

In general, the transportation system must be considered as part of a complex system if there shall be provided optimal transport conditions for people and goods as well as a good quality of living in urban areas. Therefore, transport planning strategies must consider and include the various interactions between transport, economy, land-use, and the natural environment.

Taking all these aspects into consideration, the Department of Civil, Geo and Environmental Engineering at TUM established a special and worldwide unique Master's program in transportation that reflects and critically examines the new challenges of modern and efficient transportation systems. The aim of this program is to provide students with the required expertise and skills, so that they are capable to understand, analyze, evaluate and operate existing transport systems. Students learn to develop and implement adequate strategies and methods to influence and improve these systems, while also considering economic, social and environmental aspects. For instance, they are taught how to design and operate modern transportation systems and integrated transport management systems. Moreover, they get familiar with the concepts of transport demand management, integrated land-use and traffic management as well as multimodal traffic management.

Apart from that, the demand for mobility and transport is a worldwide phenomenon. Therefore, the Master's Program in Transportation Systems additionally seeks to provide students with cross-cultural

competence and specific language skills to prepare them for the globalized transportation markets. Within courses and lectures modern transportation systems are considered by adopting a global and international approach. The Master's program is administrated in the English language and attracts students from all over the world. Due to this specific issue, the graduates of the study program will be experienced with cultural diversity and working together in multicultural teams.

In summary, the program is designed to enhance the classical training program for transport engineers towards an interdisciplinary and system-orientated education, including a shift in focus towards the basic and application research field. Taking all this into account, the program prepares highly qualified professionals for the dynamically growing market of transport and mobility.

1.2. Strategic Importance of the Study Program

In its basic philosophy, the Technical University of Munich (TUM) is committed to promoting innovation in all scientific fields that promise to improve the quality of life and cohabitation in the long term. The responsibility owed to future generations forms the basis for the interdisciplinary focal points of "Health & Nutrition", "Energy & Raw Materials", "Environment & Climate", "Information & Communication", and "Mobility & Infrastructure".

The Department of Civil, Geo and Environmental Engineering, including its central themes "Building" – "Infrastructure" – "Environment" – "Planet Earth", plays a leading role in covering interdisciplinary research fields and therefore contributes to the international appeal and reputation of the TUM. With its international orientation, the Master's Program in Transportation Systems strengthens worldwide positioning of the Technical University of Munich in one of the most relevant academic fields of our modern life, transport and mobility. Within the department, the Master's Program in Transportation Systems covers the central academic key factors (building – infrastructure – environment – planet Earth) in an interdisciplinary manner with a focus on transportation science. The program uses and combines methods and competences from other disciplines of the department, such as geodesy, civil engineering and environmental engineering. The central themes of the Master's Program in Transportation Systems "Mobility, Transport and Traffic" reflect the department's mission statement well and are suitable for cross-faculty networking offering opportunities to publically present this engineering profession as a modern and interdisciplinary field.

1.2.1. Building

According to the department's mission statement, civil engineering is of high relevance as building and living represent both: basic needs of human beings as well as an important industrial sector and considerable cultural good. The aim is to approach the ideal building scenario – that means a minimum consumption of resources and a minimum of emissions when producing building materials, building, operating, rebuilding, and demolishing constructions – by using sustainable building materials and constructions. Infrastructure design and construction is substantial and integral part of the Master's Program in Transportation Systems. The main focal points of education are the optimisation of construction principles, durability management, biogenic building substances and materials, reduction of emissions.

1.2.2. Infrastructure

In its overall concept the Department of Civil, Geo and Environmental Engineering considers construction of infrastructure as only one aspect of transportation. Today, efficient, environmentally friendly and safe operation of transportation systems is growing in importance. Transport planning is increasingly becoming a design and management task within an overall complex system that comprises passenger and freight transport as well as all other carriers. A functional high-performing transportation system is a prerequisite for economic development. If transportation is considered as an overall system, it becomes apparent that this sector is immensely important for the economy (e.g. the transportation budget is the largest of the state's individual budgets).

Within the Master's Program in Transportation Systems, transportation is considered with regards to the spectrum of urban fields of action: causes (e.g. land-use, urban structure, utilisation structure) and effects (e.g. exhaust and noise, congestion) as well as measures (e.g. integrated land-use and transport management, traffic control).

1.2.3. Environment

The topic "environment and energy" represents one of the central issues addressed by the Technical University of Munich as well as by the Department of Civil, Geo and Environmental Engineering; it is also one of the leading topics on the international agenda. Dealing with natural hazards and catastrophe prevention, i.e. the issue of "preparedness" (more generally referred to as disaster and risk management) based on complex information, prevention and intervention is extremely important for the built-up and natural environment. Therefore it is of social, ecological and economic priority. This subject represents a precautionary contribution to sustainable environmental protection and the management of ecological problems. Innovation results from the unique networking of the disciplines that previously merely existed alongside each other. In the foreseeable future the state, communes, the economy and society in general will greatly benefit from this. Inevitably, the socioeconomic aspects are pivotal for many essential research issues. The goal is to develop a continuous concept from one source for various risk areas such as flooding, food and water scarcity, landslides and mass movements etc. In this connection, the development of a dynamic system and handling concept in the shape of a complex expert system on the topic of environmental risk management is planned.

Due to its high relevance, the correlation between transport and the environment plays also an important role in the curriculum of the Master's Program in Transportation Systems.

1.2.4. Planet Earth

The Department of Civil, Geo and Environmental Engineering focuses also globally on our planet, as many environmental processes are global phenomena. Thus, earth system sciences should record dynamic changes and processes in and on the earth, the oceans and the atmosphere and model their mutual interactions.

At the Department of Civil, Geo and Environmental Engineering the Institute for Astronomical and Physical Geodesy and the Institute of Photogrammetry and Cartography are working on realising, analysing and using various satellite missions – not just for observing the Earth but also for interplanetary missions. This involves close cooperation to applied subjects such as geophysics or oceanogra-

phy, but also to engineering subjects such as mechanical engineering and electrical engineering that look at the orbit and position of the satellites, the sensors used or processing the collated raw data.
For the academic field of transportation systems, capture, analysis and manipulation of spatial or geographical data is of great importance. The curriculum of the Master's Program in Transportation Systems e.g. benefits from lectures and courses imported from the Chair of Cartography, the Chair of Land Management as well as from the Institute for Astronomical and Physical Geodesy.

1.2.5. Classification of the Study Program

Orientated on its mission statement, the Department of Civil, Geo and Environmental Engineering offers a wide range of study programs that cover the individual aspects and allow graduates to prepare in a targeted manner for their future work in science, research or commerce environments.
The Master's Program in Transportation Systems is embedded in the focus area "Mobility and Transportation Systems" where it plays a central role in interdisciplinary combining the knowledge of all chairs and professorships, applying it to an international perspective. Within this focus area the Master´s Program contributes to the development and transfer of knowledge and skills as well as to the development and transfer of methods, strategies and good practice examples for transportation. The structured approach of the study program is based on combining the network of teaching and research competence of the various departments at TUM to make use of the available resources, to serve the established professional study programs and research fields, and to open up new combined teaching and research fields by procuring additional resources. One central element of this concept is the development of a knowledge network as a public-private partnership with participants from industry, public offices and science fields.
The objective of the Master's Program in Transportation Systems is completely in line with the strategic targets of TUM. It is designed as international and multidisciplinary study program that contributes to the development of innovative solutions in the complex field of transportation. Through the engagement of outstanding experts and practitioners from different areas related to the field of transportation, the Master's program transfers knowledge and skills directly from practice into the courses and classes. Lectures, seminars and research conducted within this study program range from design of transportation networks to traffic management and transport planning. The topics are arranged multidimensionally and include local, regional and global aspects of transportation systems in rural, urban and megacity areas.

1.3. Requirements and Target Groups

Due to the conceptual design of the study program, it is of high importance that the applicants meet the standards set. There is a complex aptitude assessment to check the eligibility of every applicant for the Master's Program in Transportation Systems. This assessment includes criteria such as academic background knowledge in engineering science as well as in transport-related area (e.g. Bachelor's degree in civil engineering with specialization in transportation), an individual explanation of the motivation for studying this program, practical experience in the field of transportation systems, a presentation portfolio of previous academic works (e.g. Bachelor's thesis), and a proof of proficiency in the English language (e.g. IELTS, TOEFL). The competences shared with these criteria are essential

for meeting the overall target of a successful completion of the Master's degree in Transportation Systems.

2. Qualification Profile

After successful completion of the study program, graduates will receive the academic degree "Master of Science in Transportation Systems" that qualifies them for professional work or academic research in the field of transportation engineering. Graduates of this Master's program possess a wide portfolio of relevant competences, abilities and know-how in transport related areas, and they are capable to apply this knowledge and these skills when working in the dynamically growing market sector of transport systems.

2.1. General Competences and Abilities

On a general level, graduates from the Master's Program in Transportation Systems of TUM have the ability to develop and optimize solutions for a wide range of different tasks in transportation science and engineering. They are capable to systematically structure engineering tasks as well as to methodologically work out approaches to deal with different engineering and mathematical problems. Graduates know how to achieve knowledge and competence in special fields of engineering and they can use their theoretical-analytical skills on complex applications.

More specifically, TS graduates have the competence to analyze the complex system of contemporary mobility, including aspects of sustainability. They can identify the correlations between transportation infrastructure, transport control, means of transport as well as transportation of persons or goods. The graduates are able to discern the interrelation between land-use demand, transport supply, economic growth and natural environment. They know about the importance of accessibility and mobility and consider it in the planning and implementation process. Graduates have sound knowledge of the current methods of processing traffic data as well as of the standard applications and functions for visualization. They know and understand how to plan for an integrated transport system together with the skills to identify, analyze and solve problems related to this field.

TS graduates are all-round experts, competent in analysis methods, transport theories and modelling as well as project appraisal and planning instruments. Thus, they have the expertise to implement and apply different assessment methods and techniques in a relevant, issue-related way. In addition, they have know-how in traffic control and intelligent transportation systems applied in an urban or motorway context. Besides, they are able to use their knowledge and insights gained in the field of transportation to develop new solution strategies for problematic transportation systems as well as for efficient transport engineering and planning.

Thanks to interdisciplinary elements of the program, they are capable to overview and to give consideration to relevant economic, social and environmental aspects of transport for sound decision making. TS graduates are familiar with the important concept of sustainable development which requires new planning and management strategies. They know and understand significant sociological, ecological and economic concepts and theories. For instance, graduates can estimate and analyze benefits and costs of infrastructure measurements and modifications, they are also aware of the external costs

of transport operations and are able to plan and evaluate transport infrastructure investments. Furthermore, they are trained to consider ecological aspects like noise and vehicle emissions. In this way, they are able to contribute to more efficient and environmental-friendly mobility conditions.

Furthermore, graduates know how to find and absorb the required information and how to evaluate and edit it in a specific context. They are able to develop relevant research questions, to structure complex issues, and to present their findings in a logical and convincing way. Thus, they have profound competence in the use of scientific methods as well as in the development of solutions for practical problems based on scientific findings. TS graduates developed intellectual and social competence through abstract, analytical and networked thinking. They have the ability to familiarize with new, unknown fields of work quickly and methodically, as well as the ability to act interdisciplinary.

Working together on a project in a multicultural group as well as individually completing a Master's thesis generated and strengthened the graduates' skills in exploring scientific investigations and developing practical solutions, in cooperation with local companies and authorities. By working on "real-life" projects, graduates learned to process together a complex engineering task. Besides, they have the expertise to present and to discuss their findings on an academic level as well as to prepare a paper about their results and recommendations for scientific publishing. Considering methodological aspects, TS graduates are prepared for further academic projects (e.g. PhD thesis) or for challenges and tasks from the modern job market.

Thanks to the structure of the academic program that requires and promotes self-discipline as well as time management skills, graduates know how to obtain their goals, how to organize themselves and how to work in an independent and self-consistent way, e.g. by organizing and doing an internship in transportation related company or authority. In addition, graduates from the Master's Program in Transportation Systems have insight into the working world, especially into the daily activities of transport engineers. Several excursions to industries, construction sites, traffic control centers or public transport companies and discussions with experts in this field deepened the practical know-how of TS graduates. Therefore, TS graduates are well-prepared for working on a job after graduation. With this practical experience students also gained the ability to foster their individual study plans towards a genuine academic profile.

As the Master's program has a very international customization and the required internship is often done abroad, graduates are qualified to work for international enterprises in multicultural teams. Especially the academic training within a project seminar that requires working together in a multinational and interdisciplinary group generated cross-cultural competence and the ability to work efficiently in diverse teams. Thus, graduates are trained to be open-minded, pragmatic but thorough, analytical and structured, good communicators and quick thinking. Due to the diversity of the students coming from all over the world, graduates are able to act in a tolerant and responsible way. Thus, they have social and intercultural competence and strong communication skills, combined with the ability to handle conflicts in an adequate way. That means they are ideal employees for the international job market in a globalized world.

2.2. Specialization: Fields of Study

Graduates of the Master's Program in Transportation Systems have specialized knowledge and skills in one out of three specialization areas. Depending on that choice, graduates have specialized

knowledge and expertise either in transportation infrastructure, intelligent transportation systems (ITS), or transportation demand management. The knowledge in one of these fields can be deepened by the attendance of specific elective courses offered for the respective fields of studies.
Nonetheless, every TS graduates gained basic competences in all of these focus areas, as the principles are all taught within the obligatory modules of the program. However, with a specific focus on one so-called “field of study” graduates have the opportunity to develop an individual academic profile. In short summary: After graduation, students of the Master’s Program in Transportation Systems are transport engineers with a specialization either in infrastructure construction, traffic engineering and control or in urban structure and transportation planning.

2.2.1. Field of Study I: Transportation Infrastructure

The design and the construction procedures of roads and railways have an enormous impact on construction and life-cycle costs. Therefore, TS graduates with focus on transportation infrastructure acquired the skills they need to deal with these challenges. For instance, they know to design safe and sound pavements and railway tracks, which are additionally easy to maintain and of high availability. Besides, they have profound competence in the construction procedures for sustainable roads, airfields and railway tracks. With specialization in transport infrastructure TS graduates know how to design sustainable asphalt and concrete pavements, they are aware of load actions on and within those pavement structures and understand the respective road layout criteria, design tools and calculation methods. Apart from that graduates know how to deal with stations or any other types of turn-out configurations regarding the layout of railway lines, signaling and other safety installations. They are able to design railway tracks by considering load actions and reactions of the track superstructure and the respective substructure. They have the competence in designing and construction permanent ways and ballastless tracks covering also special track solutions like floating slab tracks dealing with vibrations and structure born noise problems.

2.2.2. Field of Study II: Intelligent Transportation systems (ITS)

Students of the Master’s Program in Transportation Systems who concentrated on design and application of traffic control methods, architecture of ITS projects and traffic control algorithms are able to improve traffic situations by designing signalized intersections and applying ITS related components. They have a sound understanding of traffic flow and its numerous facets, coherencies and interdependencies. Graduates are able to e.g. model delay and queuing processes and to consider kinematics and dynamics of driving as well as car-following-models. Besides, they are experts in signal control and can for instance design signal plans or progressive signal systems.
With focus on ITS, graduates have a deep insight into the various architectural components used in real-life ITS projects ranging from the roadside infrastructure via the communication networks to the central control systems in the fields of urban, highway, tunnel and regional traffic management systems. They have the skills to design, operate or manage traffic control systems and know about the importance of well-matching system architectures and traffic control algorithms. Furthermore, graduates have expertise in the technologies and capabilities of modern high-tech automobiles building a core element of advanced intelligent transport systems. They have competence in the use of microsimulation as a tool to assess traffic engineering and transport planning measures, including theoreti-

cal background of the methods implemented in the tools as well as practical exercises in using the software and some advice how real world simulation projects can be structured. In general, graduates with this field of study have detailed knowledge about the different system approaches and technologies which are used around the world for urban traffic control, motorway control, integrated traffic information and management and mobility and demand management.

2.2.3. Field of Study III: Transportation Demand Management

If specialized in transportation demand management (TDM), TS graduates know the theories and concepts of integrated land-use and transport modelling and are able to analyze and evaluate them in a systematic way. They are able to model integrated land-use and transport as well as to compose research surveys about e.g. urban mobility. They know the relevant feedback mechanisms and can analyze them. For instance, graduates are able to elaborate the limits of classical transport models with regard to implementing complex feedback mechanisms, especially concerning land-use interactions. Besides, they are able to discuss and to apply modelling approaches within classical transport models and beyond (activity-based modelling approaches, integrated land-use and transport models, system dynamics, and sensitivity model). Additionally, they have a complex understanding of transportation demand management measures, including an international approach. The graduates are aware of common obstacles in planning practice during the implementation of a TDM and can discuss relevant preconditions of TDM. In general, graduates with this specialization are experts in transportation demand and mobility management.

3. Target Groups

3.1. Target Audience

The Master's Program in Transportation Systems at the Technical University of Munich (TUM) focusses on applicants holding Bachelor's degrees in a transport-related area. Generally, application is open to candidates with a relevant Bachelor's degree in the areas of Transportation Engineering, Civil Engineering, Environmental Engineering, Electrical Engineering, Mechanical Engineering, Computer Sciences, Communications Engineering, Economics, Architecture or other scientific area related to transportation systems. As its courses are offered in the English language the program is addressed to national and international graduates and junior experts with a strong interest in planning, managing and optimizing transportation systems. With its international focus the program aims not only at attracting the best candidates worldwide, but also at providing knowledge transfer as well as at fostering the development of the transportation sector in emerging and developing countries. Last, but not least, the program is committed to contribute to the excellent worldwide reputation of "German engineering".

3.2. Previous Knowledge

During an elaborate aptitude assessment, there will be examined if the single applicant has the required engineering skills related to transportation systems (e.g. algorithmic, informatics, programming, computer-aided simulation, drive engineering, communications engineering, sensor technology; geoinformatics, surveying, mathematics and statistics, bridge construction or engineering mechanics).

Applicants should be able to demonstrate that they are open-minded and able to work scientifically respectively principle-based and method-oriented. They should have a scientifically oriented interest in engineering problems from the field of transportation and in the solution of those problems.

As applicants and students of this Master's program come from all over the world and graduated from different education systems, we require at least some basic knowledge in transportation science (e.g. urban development and planning, transportation planning, traffic engineering and control, transportation infrastructure). Thus, we assure that the students with their heterogeneous academic backgrounds share at least some basic previous knowledge, where we can build upon with our study program. Besides, this pre-requisite of academic skills in transportation engineering also helps to filter out those students who are really scientifically interested in the field of transportation systems – as there are many applicants who seem to be rather interested in any English taught Master's program at TUM. To study this international program, every student has to proof adequate knowledge of the English language. This is usually done by submission of a language test certificate (e.g. TOEFL, IELTS).

3.3. Target Numbers

The Transportation Systems study program is designed for a limited number of students in order to provide an optimal individual learning atmosphere. Lectures, labs and exercises are laid out for approximately 40 students per intake and thus strengthen the ability of students to exchange and interact with lecturers and classmates. However, the increasing number of applicants and students represent a success story, but also a challenge: They are currently challenging TUM room capacities (esp. CIP pools) as well as administration and lecturers of the Master's program.

3.4. Quantitative Figures

The Master's Program in Transportation Systems started in the year 2007 with only 21 students. In the following years the study program gained national and international reputation and therefore continuously receives a rising number of applications from countries all over the world.

Year	Number of Applications	Countries of the Applicants
2007	31	Bangladesh, China, Eritrea, Ghana, Greece, Germany, Malaysia, Mexico, Nepal, Pakistan, South Korea, Turkey, Ukraine
2008	68	Bangladesh, Bolivia, Colombia, Chile, China, Czech Republic, Ethiopia, Ghana, Greece, Indonesia, Mexico, The Netherlands, Pakistan, Panama, Russia, Syria, Taiwan, Turkey
2009	95	Australia, Austria, Canada, Chile, China, Estonia, Ethiopia, Germany, Greece, Hungary, India, Indonesia, Israel, Malaysia, Mexico, Nigeria, Pakistan, Panama, Philippines, Turkey, Ukraine, USA, Vietnam, Yemen
2010	129	Australia, Azerbaijan, Bangladesh, Canada, China, Columbia, Costa Rica, Ethiopia, France, Germany, Ghana, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Italy, Jordanian, Kazakhstan, Latvia, Lebanon, Lithuania, Mexico, Nepal, Netherlands, Nigeria, Pakistan, Panama, Russia, Singapore, Turkey, Venezuela, Uganda, USA
2011	209	Armenia, Australia, Azerbaijan, Bangladesh, Bulgaria, Canada, China, Columbia, Costa Rica, Egypt, Estonia, Ethiopia, France, Germany, Ghana, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Italy, Jordan, Kazakhstan, Latvia, Lithuania, Lebanon, Malaysia, Mexico, Morocco, Nepal, The Netherlands, Nigeria, Panama, Pakistan, Russia, Sierra Leone, Singapore, Spain, Syria, Turkey, Uganda, United Kingdom, Ukraine, Uzbekistan, USA, Venezuela, Vietnam
2012	267	Austria, Bangladesh, Bhutan, Brazil, Bulgaria, Cameroon, China, Columbia, Egypt, Ethiopia, Germany, Finland, France, Ghana, Greece, Hungary, India, Indonesia, Iran, Ireland, Italy, Jordan, Korea, Latvia, Lebanon, Libya, Malaysia, Mexico, Mongolia, Morocco, Myanmar, Nepal, Nigeria, Pakistan, Poland,

		Romania, Ruanda, Russia, South Sudan, Spain, Sudan, Syria, Thailand, Turkey, Uganda, Ukraine, United Kingdom, USA
2013	299	Afghanistan, Albania, Australia, Azerbaijan, Bangladesh, Belgium, Bhutan, Brazil, Bulgaria, Cameroon, China, Columbia, Costa Rica, Croatia, Ecuador, Egypt, Ethiopia, Germany, France, Ghana, Greece, Iceland, India, Indonesia, Irak, Iran, Italy, Jordan, Kenya, Korea, Lebanon, Lithuania, Malaysia, Mexico, Morocco, Nepal, Nigeria, Pakistan, Palestine, Poland, Portugal, Ruanda, Russia, Serbia, Slovenia, Spain, Syria, Taiwan, Thailand, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, USA, Venezuela, Vietnam
2014	308	Afghanistan, Albania, Australia, Austria, Azerbaijan, Bangladesh, Brazil, Bulgaria, Cameroon, Canada, China, Columbia, Ecuador, Egypt, Ethiopia, Germany, Ghana, Greece, Guatemala, Hungary, India, Indonesia, Irak, Iran, Israel, Italy, Jordan, Lebanon, Macedonia (FYROM), Malaysia, Mexico, Morocco, Nepal, Nigeria, Pakistan, Palestine, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Serbia, Simbabwe, Spain, Sudan, Sweden, Syria, Thailand, Turkey, Uganda, Ukraine, United Kingdom, USA, Uzbekistan, Venezuela
2015	361	Afghanistan, Albania, Armenia, Austria, Bangladesh, Belgium, Bosnia and Herzegovina, Brazil, Bulgaria, Cambodia, Cameroon, Canada, Chile, China, Columbia, Croatia, Ecuador, Egypt, Ethiopia, El Salvador, Finland, France, Gambia, Germany, Ghana, Greece, Guatemala, Hongkong, Iceland, India, Indonesia, Irak, Iran, Ireland, Israel, Italy, Jordan, Kazakhstan, Kenia, Korea, Latvia, Lebanon, Malaysia, Mexico, Morocco, Nepal, New Zealand, Nigeria, Pakistan, Palestine, Philippines, Romania, Russia, Sambia, Sweden, Serbia, Sierra Leone, Spain, Sudan, Sweden, Syria, Taiwan, Thailand, Turkey, Uganda, Ukraine, United Kingdom, USA, Uzbekistan, Venezuela
2016	418	Afghanistan, Albania, Austria, Bangladesh, Brazil, Bulgaria, Cameroon, Canada, China, Colombia, Costa Rica, Ecuador, Egypt, France, Germany, Ghana, Greece, Hongkong, Hungary India, Indonesia, Irak, Iran, Israel, Italy, Jemen, Jordan, Kasachstan, Kenya, Kongo, Korea, Kosovo, Lebanon, Macedonia (FYROM), Malaysia, Mexico, Morocco, Myanmar, Nepal, Netherlands, Nigeria, Norway, Pakistan, Palestine, Peru, Poland, Portugal, Russia, Sambia, Serbia, Simbabwe, Spain, Sri Lanka, Sudan, Syria, Taiwan, Tansania, Thailand, Togo, Turkey, Uganda, Ukraine, United Kingdom, USA, Uzbekistan, Vietnam
2017	517	Afghanistan, Albania, Argentina, Azerbaijan, Austria, Bangladesh, Bolivia, Brazil, Bulgaria, Cameroon, Canada, China, Chile, Colombia, Ecuador, Egypt, Ethiopia, Finland, France, Georgia, Germany, Ghana, Greece, Honduras, Hongkong, Iceland, India, Indonesia, Irak, Iran, Italy, Jordan, Kasachstan, Kenya, Kongo, Korea, Kyrgyzstan, Lebanon, Libya, Malawi, Mexico, Morocco, Myanmar, Namibia, Nepal, Nigeria, Norway, Pakistan, Palestine, Paraguay, Peru, Philippines, Poland, Romania, Russia, Sambia, Serbia, Singapore, Spain, Sri Lanka, Sudan, Syria, Taiwan, Tansania, Thailand, Togo, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, USA, Uzbekistan, Venezuela, Vietnam

The Master's Program in Transportation Systems works with a complex and elaborated aptitude assessment; every single application is evaluated individually. The significant difference between the number of applicants and the number of admitted students results from the fact that only applicants meeting the stipulated aptitude criteria are admitted to the study program.

4. Demand Analysis

This Master's degree qualifies graduates to apply for admission to doctoral studies/ PhD-course (postgraduate research program). Graduates have the option of undertaking further research or studies in many different research institutions and organizations all over the world. In addition, as a professional in transportation engineering with the Master's Program in Transportation Systems, graduates are able to start a career in many different areas of the transportation sector (e.g. governmental and non-governmental agencies, public transport authorities, urban and regional planning departments, transportation companies, transportation engineering consultants, freight and logistic enterprises, automotive and infrastructure industry, infrastructure-maintaining companies). With a Master's Degree in Transportation Systems graduates can e.g. design roads and railways, simulate traffic, apply and de-

sign intelligent transport systems, analyze transport data and statistics or consult municipalities in questions regarding transport planning strategies of today and for future demand.
The experience of staff at the Department of Civil, Geo and Environmental Engineering and from outside TUM (public and private sector) as well as the feedback obtained by students and alumni show a high demand for highly qualified professionals in the field of transportation engineering all over the world.

4.1. Demands of the Labor Market

The Master's Program in Transportation Systems is a unique feature offering a broad and highly professional education in transport issues. As the program is as much as possible based on real-life experience and also includes seminar projects, excursions and internships, graduates are best qualified for the modern transportation market. Feedback from alumni has emphasized the high demand for transportation professionals at the labor market and stressed the importance of the integrated design of this study program regarding all different aspects of transportation. This "generalist, but specified" education has allowed our graduates to easily start their career as transport professionals in German, but also in international companies and authorities. The feedback from alumni as well as from companies and authorities cooperating with the program has supported the general layout of the program as meeting the labor market requests.

4.2. Demands of Potential Students

The Master's Program in Transportation Systems at the Technical University of Munich is completely conducted in the English language and designed for both, national and international students. Thus, students come from all different continents and many of them from developing or threshold countries. This aspect also reflects the high relevance of an efficient transport system for a country's economy and society. Applicants differ in age, motivation, and background, i.e. some have years of work experience, others have just finished their Bachelor's degree. Most of them have an academic background in civil or environmental engineering or urban planning.

5. Competitive Analysis

Before the Master's Program in Transportation Systems was set up, a severe and intensive analysis of competitive study programs in the transportation sector in Germany and worldwide was carried out by the Chair of Traffic Engineering and Control. The results of this non-published analysis proofed the necessity to initiate and design and implement a new Master´s Program specifically designed for today´s need of organizing transportation systems globally. It was found that there was no study program for obtaining Bachelor´s or Master´s degree in Germany offering an interdisciplinary and internationally designed approach to the transportation. The Master's Program in Transportation Systems at the Technical University of Munich is a unique feature. Since its first implementation in the winter semester 2007 it has achieved high reputation in the international transport society.

5.1. External Competitive Analysis

The international Master of Science Program in Transportation Systems at the Technical University of Munich is a unique study program. The raising awareness of this program on an international basis is reflected in the continuously rising numbers of applicants. Moreover, another Master's program of the Technical University of Munich was created in Singapore taking the TS program as example of good practice. It is carried out at GIST – the German Institute of Science and Technology, a subsidiary of Technical University of Munich in Singapore (TUM Asia). This new Master's program launched in August 2009 and is called "Transport and Logistics". It is suited to management-oriented students without engineering background.

With regard to other German universities, the Master's Program in Transportation Systems at TUM has no relevant competitor. There are only a few Master's programs in Germany dealing with transportation and they are usually focused either on the economic perspective with major in logistics and supply chain management or on the mechanical perspective with focus on automotive engineering.

The closest comparable programs represent the Master's program in "Verkehrswesen" ("Traffic and Transport") offered by the Technical University of Darmstadt and the Master's program in "Mobilität und Verkehr" ("Mobility and Transport") at the RWTH Aachen University (Rheinisch-Westfälische Technische Hochschule Aachen); both programs are taught in the German language.

5.2. Internal Competitive Analysis

Within the Master's Program in Civil Engineering as well the Master's Program in Environmental Engineering, students have also the opportunity to focus on transportation as a field of specialization. That means that some modules of the TS program are also open to students of these study programs. However, the specialization areas in civil and environmental engineering represent only some limited aspects of the Master's Program in Transportation Systems. Hence, the TS program at the Technical University of Munich is a stand-alone study program without comparable study programs at the department or university.

6. Design of the Study Program

The Master's Program consists of four semesters and takes 24 months overall. It is based on lectures combined with exercises and excursions, grounded as much as possible on real life studies. The language of instruction is English. Generally, the program is orientated towards an international perspective. Lectures and the exercises provide students with a deep theoretical understanding of the transportation system on local, national and global level. The Master's Program in Transportation Systems is a unique feature and fully conducted at TUM. The study program is designed to provide students with the necessary knowledge and skills in the studies of transportation engineering/ planning, transportation demand management, integrated land-use and traffic management, transportation network design and intermodal traffic management. Upon completion of this program, graduates are able to apply these knowledge and skills when working in the dynamically growing market sector of transportation. Graduates from this Master's Program have knowledge and a sound understanding of how to plan integrated transportation systems. They have the skills to identify, analyze and solve problems related to this field. Besides, graduates know and understand the interrelation between land-use de-

mand, transportation supply, economic growth and natural environment. They are aware of the importance of accessibility and mobility in the planning and implementation process. Apart from that, graduates understand the important concept of sustainability and the requirement of new planning and management strategies.
In addition, after completion of the Master's Program in Transportation Systems graduates have specialized knowledge in one of the following three fields of study, Transportation Infrastructure, Intelligent Transportation Systems, or Transportation Demand Management. The specialization comprises one required elective module as well as several dedicated elective subjects for each focus area.

The overall program can be split into four main stages:

Stage 1 (Theoretical Studies):
In the first stage of the Master's program the students acquire the general, sound and broad-based background and deepen the theoretical knowledge of the overall concepts of transportation systems. All of the subjects offered in stage 1 are mandatory for every student. At the end of stage 1, students choose their specific study focus.

Stage 2 (Field of Study/ Specialization):
Students select one out of three specialization areas, the so-called "fields of study". Hence, the students can focus on one specific field of the transportation sector: infrastructure, traffic control or transport planning. Each area of specialization contains one core module. Besides, students can choose additional subjects from the elective module catalogue to strengthen their individual profile. The specialization modules as well as the elective courses are offered during the second and third semester.

Stage 3 (Practical Application):
The program includes a project seminar dealing with real-life problems in transportation project planning and application. Within this project work the students explore scientific research and practical solutions in an experimental environment. In multinational and interdisciplinary groups, graduates work out a survey concept and realize field work. Besides, they analyze and discuss their findings with lecturers, research staff and authorities involved in the respective project.
Another practical application of the theoretical studies is the compulsory internship. Students experience real-life working environment and challenges when they complete an internship in companies or authorities related to transportation, supervised by TUM researchers of the Master's Program in Transportation Systems. The internship is also meant to assist the students with regard to further scientific specialization for the Master's Thesis as well as career options after graduation.

Stage 4 (Master's Thesis):
At the end of the program, students have to write a Master´s thesis on a transportation related subject. Frequently, the thesis is done in cooperation with a company or authority, but supervised and evaluat-

ed by academic TUM professors. The students have six months to complete the thesis. They can conduct the thesis either in Germany or abroad.

Concerning mobility of students, one of the core elements of the Bologna Process, the Master's Program in Transportation Systems offers plenty of opportunities. First of all, students can participate in one of the three double degree programs with French and Swedish top ranked universities: the École Nationale des Ponts et Chaussées (ENPC), the École Polytechnique, and the Royal Institute of Technology (Kungliga Tekniska Högskolan). Apart from that, the clear majority of the TS students already come from all over the world; only approximately five percent of all TS students have German origin. Hence, the Master's program significantly contributes to the internationalization strategy of the TUM and the general research location Germany. TS students have the opportunity to participate in exchange programs of the Department of Civil, Geo and Environmental Engineering and TUM. Thanks to the European Credits Transfer System (ECTS), academic records achieved at European universities can be easily recognized at TUM. But also with non-European partner universities recognition of academic achievements is ensured within the cooperation contracts. The Master's program is designed for only four semesters, therefore the second and/or third semester suit best for a stay abroad. However, most of the students did their semester exchange already during their Bachelor's program. Therefore, many TS students go abroad for their required internship and/or write their Master's thesis at partner universities. For instance, there are close ties with the TUM CREATE Research Center at Singapore, namely the research team "Transportation and Traffic Engineering", where TS students regularly do their internship and/or Master's thesis.

An overview of the study program structure is given in the following tables:

Transportation Systems: Curriculum FPSO 2016

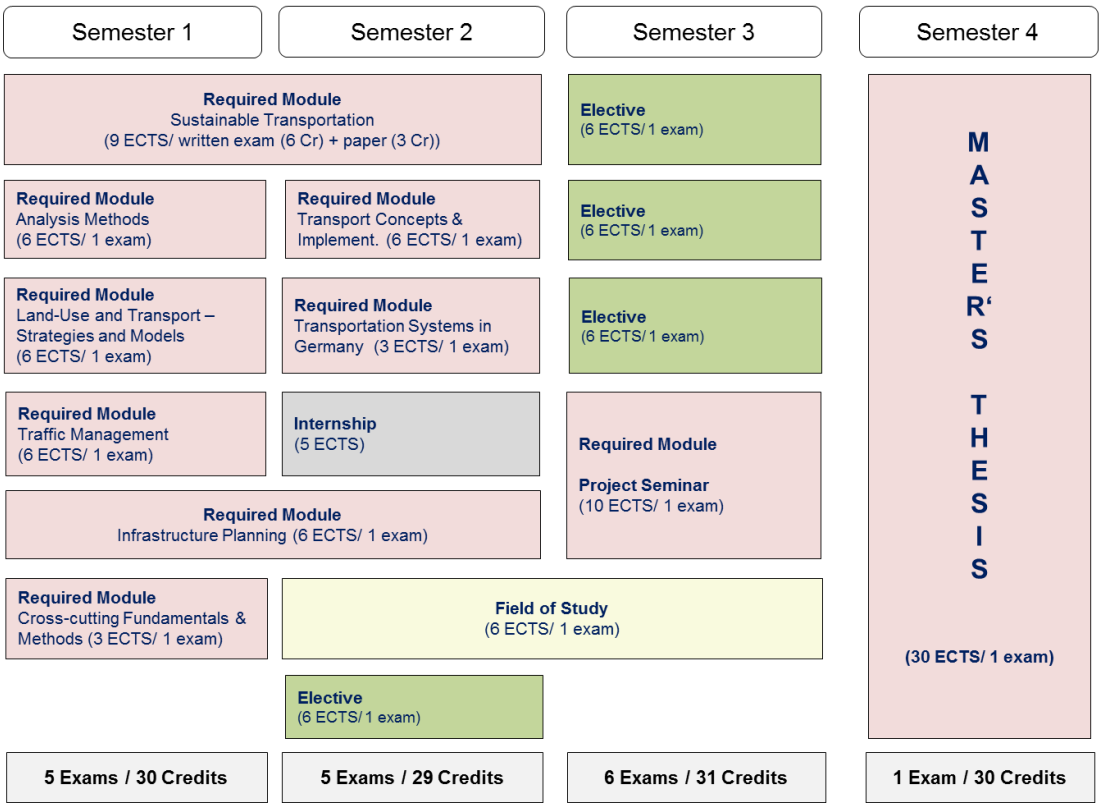

Table: Overview - Curriculum of the Master's Program in Transportation Systems

Transportation Systems: Curriculum FPSO 2016 – Field of Study I

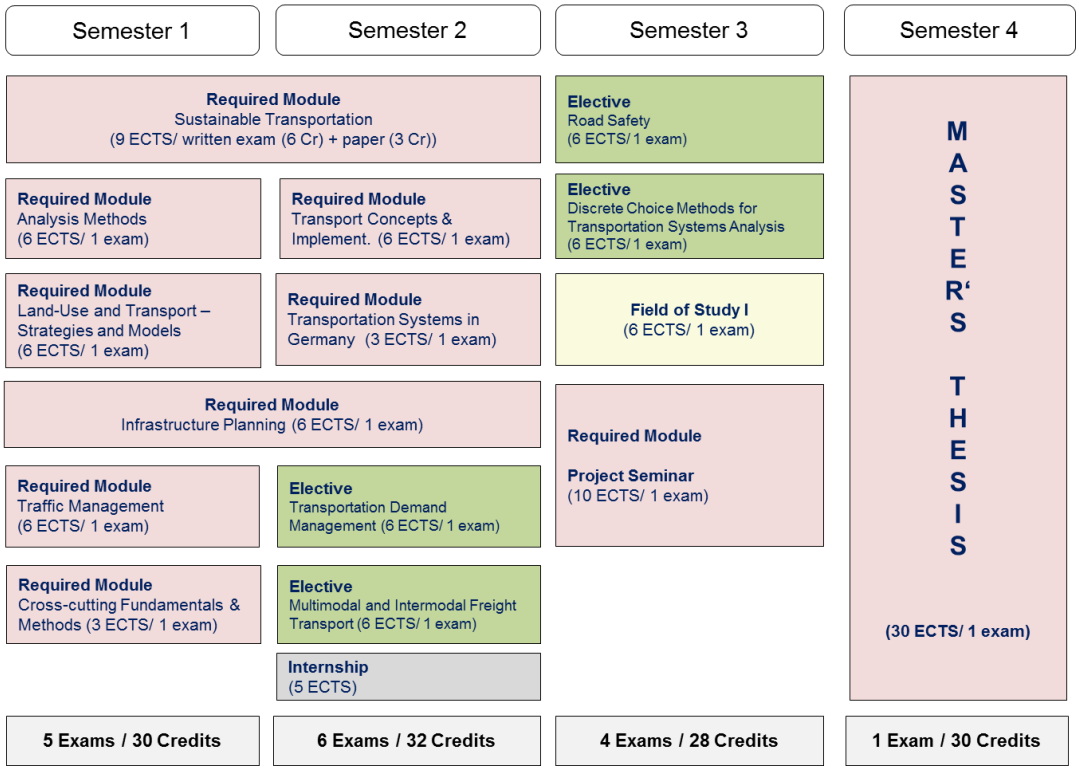

Table: Overview – Curriculum with specialization in "Transportation Infrastructure" (FPSO 2016)

Transportation Systems: Curriculum FPSO 2016 – Field of Study II

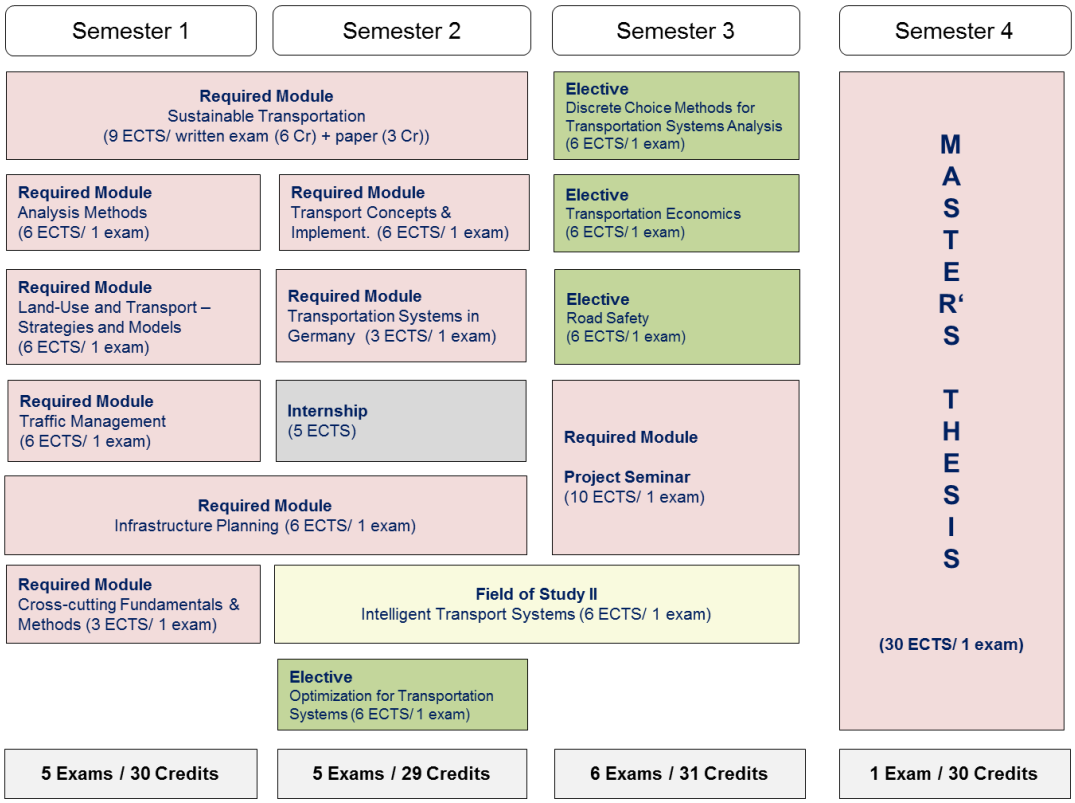

Table: Overview – Curriculum with specialization in "Intelligent Transport Systems (ITS)" (FPSO 2016)

Transportation Systems: Curriculum FPSO 2016 – Field of Study III

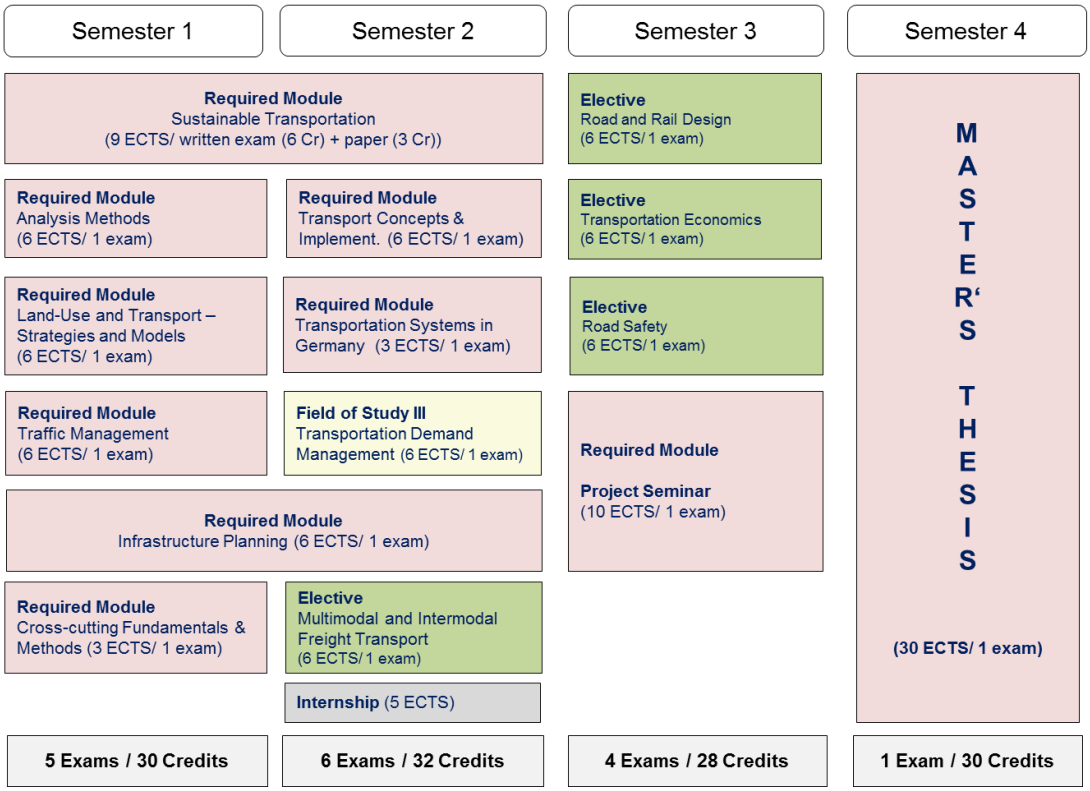

Table: Overview – Curriculum with specialization in "Transportation Demand Management" (FPSO 2016)

The grading scale ranges from 1 to 5: 1.0 to 4.0 are passing grades and 4.3 to 5.0 are failing grades. The following table provides you with a guide to awarded points in an exam.

Grade Description	Very good		Good			Satisfactory			Sufficient		Failed		
Grade	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0

The study program has a modular structure including required modules, required elective modules as well as several elective modules. The standard module size is 6 ECTS credits for required and 6 or 3 ECTS credits for elective modules. Each semester, the elective modules catalogue is updated to meet the changing demand within the transportation sector. Students are informed about the update prior to semester start.

Every student of the Master's Program in Transportation Systems has to achieve a minimum of 120 ECTS credits. The student has a maximum of 6 semesters to complete his or her Master's program, as long as he or she meets the study progress criteria prescribed in § 10 (4) of the General Academic and Examination Regulations (APSO) at TUM. The study progress of every student is monitored each semester, and students who are at risk of falling below the required amount of credits will get a warning. In general, the students are free to take as many retake examinations as necessary. There is offered one retake exam per module and semester. Credits are awarded when the student passes the examination (with a result of at least 4.0).

7. Organizational Link and Responsibilities

The Master's Program in Transportation Systems is embedded into the Chair of Traffic Engineering and Control at the Department of Civil, Geo and Environmental Engineering of the Technical University of Munich. As it is an interdisciplinary study program, several other chairs and departments of the TUM are involved.

Examination board of the study program:
Prof. Dr. Constantinos Antoniou (chairman)
Prof. Dr. Gebhard Wulfhorst (vice-chairman)
Prof. Dr. Fritz Busch
Dr. Bernhard Lechner
Dr. Birgit Vierling
Secretary: Christine Göppel

8. Resources

The Master's Program in Transportation Systems is grounded on solid resources regarding personnel as well as material. Lecturers, rooms and CIP pools are of high standard. According to the growing demand and the steadily increasing numbers of applications and students, rooms and especially CIP pools are no longer available in a sufficient number.

8.1. Personal Resources

The Master's Program in Transportation Systems has a sufficient number of research and administrative staff guaranteeing good study conditions. As the study program is completely integrated into the department, professors and PhD researches from various backgrounds are working for this program. Moreover, guest lecturers are invited to share their knowledge and experience with the students of transportation system applications worldwide.

Lecturers from TUM-BGU

- Professors and post-docs of the Department of Civil, Geo and Environmental Engineering
- Different PhD researchers of the Department of Civil, Geo and Environmental Engineering

Lecturers from other TUM Departments

- Geodetic Observatory Wettzell
- Department of Architecture
- Munich Center for Technology in Society

Guest Lecturers

- Lecturers from other universities
- Lecturers from companies, authorities, organizations, and research institutes

8.2. Facilities

Tutorials, Tutorial Systems

Due to the diverse scientific and technical background of the international students, there are offered tutorials during the first semester.

Conduction of Courses

Courses are conducted mainly by TUM professors and academic researchers holding a PhD. In many lectures it is possible to include visiting professors and practitioners from outside TUM for guest lectures. This option is highly appreciated by students and TUM staff. A continuous conduction of all electives and required elective modules can be guaranteed with the staff working at the Institute for Transportation and for the study program in Transportation Systems.

Teaching Material

Whiteboard, laptop, projector, etc.

Machines, Laboratories, Equipment

For several lectures and project seminars of the study program access to CIP pools and various computer programs and software packages are essential. These are available at the different chairs where the lectures are conducted, e.g. the Chair of Cartography, or in CIP pools of the department. Special computer programs are provided in a limited number, e.g. MatLab, ArcGIS.

Rooms for Lectures, Self-Study or Group Work

The Master's Program uses capacities of the chairs integrated into the program as well as rooms administered by the department. Most rooms have a capacity for a maximum of 35 students. They have been available in sufficient numbers, so far. Due to the steadily increasing number of applicants there will be a need for larger rooms. The focus area "Mobility and Transportation Systems" holds two seminar rooms for about 30 people which can be used by the students for seminar and group work upon prior appointment. Rooms and workstations for student work are available in a limited number.