HSB

Unterlagen

für das interne Akkreditierungsverfahren

des Studiengangs

Engineering and Management of Space Systems M.Sc. (EMSS)

Teil E

Module Handbook

Overall structure

The program "Engineering and Management of Space Systems M.Sc." is designed as a joint interdisciplinary international double degree. Cooperating institutions are the Hochschule Bremen (HSB) – City University of Applied Sciences, Germany, and Gdańsk University of Technology (GUT), Poland. The degree program will be carried out in English.

The first study semester consists of modules taught at the Gdańsk University of Technology (GDAŃSK TECH). The second study semester comprises modules taught at Hochschule Bremen City University of Applied Sciences (HSB). The third semester includes the master's thesis and can be performed at either of the two universities.

The curriculum comprises four different categories of modules:

1. **Mandatory modules:**
   3 modules per semester, which all students are required to complete.
2. **Special mandatory modules:**
   1 module per semester, the module to be selected is mandatory according to the desired specialization (see below).
3. **Elective modules:**
   1 module per semester, students can choose from a set of module options (choice is possibly restricted by specialization requirements, see below).
4. **Optional elective modules:**
   Additionally, and with respect to the international character of the program, the curriculum includes language courses at both universities (Polish language course for German students and German language course for Polish students).

Three different specializations

The program offers students to choose one out of three specialization options:

- **Computer Science – CS**
- **Electronics Engineering – EE**
- **Space Technologies – ST**

To complete the program with a specialization, students have to choose an appropriate set of modules within the catagories "Special Mandatory Modules" and "Elective Modules". For the Special Mandatory Modules, the module to select is defined according to the specialization (one option for each specialization). In the Elective Modules category, students can choose from a variety of module options, each of which is assigned to one (or more) specialization(s).

Additionally, for each specialization, the corresponding focus/subsystem within the project and the master thesis shall be covered.

If a specialization is chosen, the specialization will be included in the program certificate. However, it is also possible to complete the program without choosing a specialization.

Contents

1st Semester (GDAŃSK TECH): Mandatory Modules

1.1 Engineering Foundations of Satellite Systems (EFSS)

Module leader:	Prof. Dr. Zbigniew Łubniewski		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Mandatory module taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	90h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	90h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge on artificial satellite technology, including satellite subsystems and their roles and interdependencies.
- Student has knowledge on the main applications of artificial satellite systems: satellite navigation, satellite remote sensing.
- Student has knowledge of the typical steps and milestones in software and electrical engineering
- Student obtains in-depth mathematical knowledge useful for analysis and description of the operation of complex mechanical systems and technological processes
- Student obtains extended and in-depth knowledge of mechanics in the field of modeling and simulation of multifunctional mechanical systems

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student has the ability to plan GNSS measurements and to use GNSS receivers with correct interpretation of their indications and assessing the positioning accuracy.
- For a given remote sensing application, student is able to analyse and propose an appropriate solution, regarding the source and processing methodology of satellite Earth observation data, including the use of adequate software tools and their functions.
- Student can define steps and milestones for elementary software and electrical engineering project
- Student can solve simple software and electrical engineering work examples, process worksheets, analyze data sets, evaluate evidence, apply findings to a situation or problem and synthesize resolution(s), answer probing questions about a given research study.
- Student can design and create a computer code, contribute to the process related to research study considering group work and cooperation with other students while solving complex software electrical engineering problems
- Student while solving engineering problems in the field of machine design, he is able to evaluate and use typical methods and tools for calculating mechanics, and apply modern calculation methods as well as modify the existing methods

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- The student is able to analyze and implement tasks in the field of space mechanisms and structures, satellite technologies and electrical electrical engineering in a group, while maintaining high technical standards
- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Mechatronics and Mechanism Theory: Extension of the knowledge gained in the framework of general mechanics (statics, kinematics, dynamics). Familiarization with the description of the kinematics and dynamics of movement and any spherical body, the point of moving complex issues collisions, dynamic systems with variable mass and the basics of analytical mechanics (general equation of dynamics, the principle of virtual work, Lagrange equations I and type II); Theory of machines and mechanisms in the construction space. Method of vector and matrix to describe the geometry of mechanisms, known methods of kinematic analysis of planar mechanisms and Denavit-Hartenberg notation; Spacecraft structures; Finite Elements Method; Robotics, automatics, system control, manipulators kinematics, sensors and actuators, design robotic devices for use in space; Modeling methods in design: Broaden and consolidate knowledge in the field of machine design. Practical utilization FEM software.

- Satellite Technologies: Artificial Earth satellite as a system. Satellite subsystems and their roles and interdependencies: mechanical subsystem, power supply subsystem, avionics subsystem, orbit control and stabilization subsystem, thermal control subsystem, telecommunication subsystem, software and data handling subsystem, other subsystems. Satellite ground segment. Main applications of satellite technology. Satellite telecommunications. Satellite navigation: architecture, elements, functions and services of global navigation satellite system (GNSS); the essence of determining position coordinates in GNSS code measurements; pseudo range measurement, pseudo range measurement errors: tropospheric and ionospheric refractions, ephemeris data errors, clock errors, mutli-path, errors introduced by the receiver, other errors; DOP coefficients and their influence on positioning accuracy; operational characteristics of navigation positioning systems. Satellite remote sensing: Earth observation satellites (EOS) and their instrumentation components; electromagnetic waves and their use in satellite imaging; technical features of satellite EO system; sample applications of satellite remote sensing in land, sea and atmosphere observation; short review of present EO systems and programs.
- Electrical and Software Systems Engineering: Basic concepts of systems engineering; Principles of electrical systems engineering; Principles of software systems engineering for electrical systems.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	E.g. link to Aulis, if applicable

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Mechatronics and Mechanism Theory	Edmund Wittbrodt Wiktor Sieklicki Krzysztof Lipiński	2	Lectures, excercises	Portfolio (PF)
Satellite Technologies	Zbigniew Łubniewski Tomasz Berezowski	2	Lectures, laboratory, project	
Electrical and Software Systems Engineering	Tomasz Zubowicz, Bartosz Puchalski	2	Lectures, laboratory, project	

1.2 Space System Management (SSM)

Module leader:	Prof. Dr. Małgorzata Zięba		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Mandatory module taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	105h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	75h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- The student knows the basics of space law.
- The student knows and understands the idea of information society and the fundamental dilemmas of modern civilization relating to cyber security.
- The student knows and understands the principles of protection of information with a special legal status in terms of cyber security of users of cyberspace
- The student is familiar with the current opportunities for the development of applications that integrate the activities of people and systems in the virtual space, the mechanisms of decision-making under risk, and models for the organization of an open management system.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- The student knows how to cite legal acts concerning space.
- The student is able to perform a risk analysis of the project
- Student knows how to manage a team in a virtual space

Communication and cooperation

- The student is able to select and apply appropriate methods protecting against risks
- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Understanding safety and reliability as part of scientific ethics
- Reflect on one's own learning and work goals and those set by others
- Reflecting on non-material values in space projects.

Course content:

- Space Law: International public law – basic features; Sources of international law; Relationship between international law and domestic law; Space law – basic definitions; Sociological sources of space law; Formal sources of international space law; Formal sources of domestic space law; International space organizations; Fundamental features of the status of outer space; Delimitation of outer space; Responsibility of states for damages caused by space objects; Registration of artificial space objects; Status of the Moon and other celestials bodies; extra-conventional issues of the outer space
- Cybersecurity: Brief introduction to cybersecurity; IT Security risk management practices; Threat modelling; Multilayered approach to information security management; Introduction to DevOpsSec approach
- Risk management in space: Become familiar with methods of hedging against different types of risks and acquire the ability to risk calculation
- Virtual work and virtual team management: The course is needed for contemporary workers, especially in high-tech, developed environments. How to lead virtual teams and work in them?
  This course will present to the students content on diversity and working in virtual teams. Several topics will be discussed in detail, together with practical examples.
  Building trust in virtual teams; Communication in virtual teams; Choosing the appropriate technology for communication processes and using it in practice; Understanding diversity in virtual teams (language, cultures, professional background); Team canvas; Development of the competencies needed in virtual teams; Team development stages (the Lewis model and other approaches).

Language of teaching:	English

Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Space Law	Krzysztof Drzewicki	2	Lectures, project	Written exam (KL)
Risk management in space	Alicja Żukowska	1		
Cybersecurity	Jakub Syta	2		
Virtual work and virtual team management	Małgorzata Zięba	2		

1.3 Interdisciplinary One Year Project Part 1 (IOYP 1)

Module leader:	Prof. Dr. Marek Moszyński		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Mandatory module taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

Knowledge and understanding (broadening of knowledge, deepening knowledge, understanding of knowledge)

- Gain a practical understanding of the organization and implementation of interdisciplinary space projects
- Gaining and deepening knowledge of specific space systems engineering methodologies, tools and frameworks

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Elaborate stakeholder and mission requirements
- Define the concept of operation (CONOPS) for the given mission
- Define system requirement based on stakeholder and mission requirements
- Plan and carry out projects considering the scientific and technical status of the respective field of application
- Design, develop and implement space systems including all necessary subsystems and facilities
- Perform verification and validation of the defined systems
- Organize project management using current methodologies and tools
- Cost calculation
- Critically evaluate project goals and revise them if necessary

Communication and cooperation

- Plan, discuss and prioritize project goals
- Introduce, discuss and evaluate system technical solutions
- Support each other in understanding the mission and the system
- Evaluate and approve the subsystem and system solutions of others
- Reporting and Lessons Learned
- Reflect on one's own learning and work goals and those set by others and take responsibility, as well as draw conclusions for the work processes in the team
- Addressing conflicts and come to solutions

Reflection of academic and professional identity

- Research complex tasks on project-related topics from science and practice
- Present complex technical problems and solutions to experts
- Publish project results scientifically

Course content:

Students deal with the realistic systems in the space domain in the context of teamwork and customer requirements based on the research activities of the university institutes or business partners.
The contents are e.g.

- Use the methods and principles of Space Systems Engineering
- Work according to Systems Engineering processes
- Define Systems Engineering roles
- Use relevant norms and standards (especially ECSS Space Standards)
- Perform all necessary phases (Requirements Engineering, System Architecture and Component Design, Development, Verification & Validation) using classical and/or agile methods
- Define necessary operational concepts (Operations, Maintenance, Evolution, Quality management, Reuse, Disposal)
- Use project management methods and tools (both classical and agile according to the context)

Language of teaching:	English

Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Interdisciplinary One Year Project Part 1	Marek Moszyński	4	Project	Project work (PA)

1.4 Special Mandatory Module 1 (Placeholder)

Module leader:	Prof. Dr. Jasminka Matevksa (HSB)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Placeholder for Special Mandatory Module taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	56h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module is a placeholder for the Special Mandatory Module to be selected in the 1. semester at GDAŃSK TECH. With a defined selection of special mandatory modules and electives, the program can be completed with a specialization in either Computer Science, Electronics Engineering, or Space Technologies. For each specialization, the module to be selected for the Special Mandatory Module placeholder in the 1. semester is defined as follows:

- SPECIALIZATION SPACE TECHNOLOGIES: Module 1.6 Mechanical Engineering and Aviation (MEA)
- SPECIALIZATION COMPUTER SCIENCE: Module 1.7 Software Engineering and Management (SEM)
- SPECIALIZATION ELECTRONICS ENGINEERING: Module 1.8 Electrical Control System (ECS)

Students can also complete the program without choosing a specialization.

By completing the respective module, students acquire theoretical and practical competencies in either Space Technologies, Computer Science or Electronics Engineering relevant for the engineering and management of space systems. These competencies can be applied to solve practice-related problems in management and engineering of space systems. A detailed description of the respective learning outcomes is given within the module descriptions of the modules 1.6, 1.7 and 1.8.

Course content:

A detailed description of the respective course contents is given within the module descriptions of the modules 1.6, 1.7 and 1.8.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	See module description of the modules 1.6, 1.7 and 1.8.
Further information:	See module description of the modules 1.6, 1.7 and 1.8.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
See module descriptions 1.6, 1.7 and 1.8	See module descriptions 1.6, 1.7 and 1.8	2	See module descriptions 1.6, 1.7 and 1.8	Portfolio (PF) or Exam (KL) and Project work (PA)

1.5 Elective Module 1 (Placeholder)

Module leader:	Prof. Dr. Jasminka Matevksa (HSB)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Placeholder for Elective Module taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	56h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module is a placeholder for the Elective module to be selected in the 1. semester at GDAŃSK TECH. With a defined selection of special mandatory modules and electives, the program can be completed with a specialization in either Computer Science, Electronics Engineering, or Space Technologies. For the Elective Module placeholder, students are required to choose one of the elective modules listed below. Please note the assignment of the modules to the specializations:

- 1.9 Management and Production Engineering (MPE) – SPECIALIZATION SPACE TECHNOLOGIES
- 1.10 Contemporary Construction Materials (CCM) – SPECIALIZATION SPACE TECHNOLOGIES
- 1.11 Rocket Science (RS) – SPECIALIZATION SPACE TECHNOLOGIES
- 1.12 Objective Programming and Spatial Data Processing (OPSDP) – SPECIALIZATION COMPUTER SCIENCE
- 1.13 Optimization Algorithms (OA) – SPECIALIZATION ELECTRONICS ENGINEERING
- 1.14 Systems Modeling and Simulation (SMS) – SPECIALIZATIONS COMPUTER SCIENCE and ELECTRONICS ENGINEERING
- 1.15 Antenna Technique and GNSS Applications Programming – SPECIALIZATIONS COMPUTER SCIENCE and ELECTRONICS ENGINEERING
- 1.16 Robotics for Human Health and Performance (RHHP) – ALL SPECIALIZATIONS
- 1.17 Current Topics of Systems Engineering 1 (CURSE 1) – SPECIALIZATION DEPENDING ON THE TOPIC

By completing the respective module, students acquire theoretical and practical competencies relevant for the engineering and management of space systems. These competencies can be applied to solve practice-related problems in management and engineering of space systems. A detailed description of the respective learning outcomes of each elective is given within the module descriptions of the modules 1.9 – 1.18.

Course content:

A detailed description of the course contents is given within the module descriptions of the modules 1.9 – 1.18.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	See module description of the modules 1.9 – 1.18.
Further information:	See module description of the modules 11.9 – 1.18.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
See module descriptions 1.9 – 1.18	See module descriptions 1.9 – 1.18	2	See module descriptions 1.9 – 1.18	See module descriptions 1.9 – 1.18
See module descriptions 1.9 – 1.18	See module descriptions 1.9 – 1.18	2	See module descriptions 1.9 – 1.18	

1st Semester (GDAŃSK TECH): Special Mandatory Modules

1.6 Mechanical Engineering and Aviation (MEA)

Module leader:	Dr Paweł Szymański		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Mandatory module for ST specialization taught in the 1. Semester at GDAŃSK TECH	**Contact hours (h):**	105h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	75h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has a well-established knowledge of the maintenance and life cycle of technical equipment, facilities and systems
- Student is able to use and develop technical documatation
- The student has knowledge related to heat transfer devices in the absence of gravity
- Student knows the basics of avionics
- Student knows the basics of CAD design
- Student knows Finite Element Method

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student calculate heat transfer by conduction, convection and thermal radiation in no gravity environment
- Student knows the on-board instruments on aircraft
- Student knows and applies the rules of creating calculation models in machine design

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- The student is able to use the available literature found in international databases: Elsevier, Springer, Taylor Francis and use the obtained information in the calculation methodology of practical issues related with heat transfer in energy systems
- Student understands the human impact on the development of aviation
- Student knows technical English in the field of machine design

Course content:

- Space technologies as the development of aviation including avionics factor: Introduction to aviation and space; Space technology as a branch derived from aviation; The development of on-board instruments and avionics from pioneering times of aviation to the conquest of space; Basics of the human factor in aviation and space technology; Genesis and development of the spacecraft; Basics of the space architecture; Basics oft he space policy; Space agencies and forces of the world; Basic knowledge of the Earth's atmosphere and near outer space.
- Modelling methods in design (CAD, FEM):
- Heat & Mass transfer in no gravity environment: Introduction – importance of passive methods of heat transfer; Principles of Heat Transfer; Heat Transfer Mechanisms; Fins and Heat Sinks; Thermal Resistance Network; Thermal Specification of Microelectronic Packages; Fundamentals of Convection Heat Transfer; Natural Convection Heat Transfer; Radiation Heat Transfer; Advanced Cooling Technologies (Heat Pipes, Thermosyphons, Loop Heat Pipes, Vapor Chambers, Thermoelectric Coolers, Phase-change materials, e.g. graphene)
- Basics of finite difference method, finite volume method and finite element method. Problem of properly defined boundary conditions and basics of turbulence modeling. Basic features of computational fluid dynamics solvers, mesh generators, convergence criteria and results analysis Students run the simulations for 3D flows by means of available CFD code. Students generate the mesh for selected geometry, select model and solver settings, run the simulations for steady and unsteady case, analyse the convergence and visualize results.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Space technologies as the development of aviation including avionics factor	Jakub Marszałkiewicz	2		Portfolio (PF)
Modelling methods in design (CAD, FEM)	Grzegorz Rotta	2		
Heat & Mass transfer in no gravity environment	Paweł Szymański, Krzysztof Tesch	3		

1.7 Software Engineering and Management (SEM)

Module leader:	Prof. Dr. Bogdan Wiszniewski		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Mandatory module for CS specialization taught in the 1. Semester at GDAŃSK TECH	**Contact hours (h):**	90h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	90h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge on implementation and management of software development project, including project life-cycle, typical steps and milestones, and methods and frameworks for project organisation and management.
- Student has knowledge on critical software development with special emphasis on testing and quality assurance.
- Student has knowledge on embedded systems architecture, design and applications.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student is able to perform critical analysis of the requirements and restrictions with respect to the designed software system.
- Student runs the software project according to the selected agile or disciplined methodology.
- Student has skills for managing software project using a given methodology.
- Student is able to design the critical software testing procedure along with verification of the results.
- Student is able to design an embedded system on the basis of a given specification.

Communication and cooperation

- Within the scheme of group work, students obtain skills needed to plan, discuss and prioritize software project goals.
- Students are able to support each other in understanding the requirements of the software system as well as to evaluate and approve the work completed by others during project implementation.

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Software project implementation and management: project life-cycle, methods and frameworks for project organisation (disciplined, agile, hybrid); systems engineering management (risk management, configuration management, change management), project management and operations management
- Critical systems software testing and quality assurance: Environment, program and error models; Functional testing strategies; Structural testing strategies; Parallel and distributed systems software testing; Organization and planning of testing process; Product lifecycle vs. testing cycle; Software validation, verification and testing; Static analysis techniques; Documentation standards (IEEE, ESA); Quality assurance vs. product assurance
- Embedded systems architecture: Construction of an embedded system; Basic concepts related to the construction of embedded systems (architecture, interfaces, computing modules); Embedded system model (layers: hardware, system, application); Hardware platforms in embedded systems, microcontrollers in embedded systems; Signal processors in embedded systems; PC class computers in embedded systems; Industrial PC standards; DAC and ADC converters; Systems with PWM output, voltage-frequency converters; Prototyping: single board computers, Multiprocessor systems architecture; Buses of multiprocessor systems; Consequences of the existence of shared resources; Operating systems for embedded systems; POSIX standard; Linux operating system; Real-time operating systems; Kernel and its environment in RT operating systems / embedded systems; Process manager, namespace management, memory management; Threads and processes, thread scheduling algorithms, thread synchronization methods, inter-process communication; Hardware interrupt handling concepts; File systems; Bootloaders; GNU Toolchain; Drivers programming; Techniques of efficient use of hardware resources; MISRA C programming standard.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Software project implementation and management		2		Portfolio (PF)
Critical systems software testing and QA	Bogdan Wiszniewski	2		
Embedded systems architecture	Iwona Kochańska	2		

1.8 Electrical Control Systems (ECS)

Module leader:	Dr Tomasz Zubowicz		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Mandatory module for EE specialization taught in the 1. Semester at GDAŃSK TECH	**Contact hours (h):**	90h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	90h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge of the typical steps and milestones in software and electrical engineering
- Students will learn how the newest power electronic converters in autonomous systems are built and how they operate, what are the requirements for selecting power systems for specific applications, especially for working with batteries and photovoltaic panels. Moreover, they will learn how the use of converters influences the quality of energy and the environment.
- Students will learn how to apply a circuit computer simulation to analyze the operation of power electronic converters, which will allow to build a model of a selected converter.
- Student has knowledge of the typical steps and milestones in adaptive filter design

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student can define steps and milestones for elementary software and electrical engineering project
- Student can solve simple software and electrical engineering work examples, process worksheets, analyze data sets, evaluate evidence, apply findings to a situation or problem and synthesize resolution(s), answer probing questions about a given research study.
- Student can design and create a computer code, contribute to the process related to research study considering group work and cooperation with other students while solving complex software electrical engineering problems.
- Student can solve simple filtering problems and work examples
- Student can design and create an adaptive filtering algorithms, contribute to the process related to research study considering group work and cooperation with other students while solving complex software electrical engineering problems.

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Control design: Basic concepts of systems engineering; Principles of electrical systems engineering
- Adaptive Filter Design: Basic concepts of adaptive filter design and implementation; Principles of adaptive filtering and signal processing
- Power conversion in autonomous systems: Introduction of autonomous systems. Modern semiconductor devices (GaN, SiC), consolidation. DC / DC topologies (unidirectional - bidirectional). Operation and control of: resonant converter LLC, dual active bridge converter and three-phase + multi-level inverter. Control systems of power electronic systems. Battery charging / discharging systems; Introduction of simulation software. The simulation of coveter DC/DC/AC. Sensitive study. Optimal components selection. Analysis of normal and fault operation.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching methods**	**Examination method(s), scope and duration**
Control Design	Tomasz Zubowicz, Bartosz Puchalski	3	Lectures, Laboratory, Project	Portfolio (PF)
Adaptive Filter Design	Tomasz Zubowicz, Bartosz Puchalski	2		
Power conversion in autonomous systems	Piotr Musznicki, Marek Turzyński	1		

1st Semester (GDAŃSK TECH): Elective Modules

1.9 Management and Production Engineering (MPE)

Module leader:	Dr Aleksandra Wiśniewska		
ECTS points:	3 ECTS	**Workload (h):**	90h
Type of module and position in the course of study:	Elective module for ST specialization taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	45h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	45h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- The student knows the principles of work management, standards and norms related to the organization of work and the principles of teamwork
- The student achieves a structured in-depth knowledge necessary to design and optimise complex discrete production processes, modelling their sequences and performing the calculations associated with their productivity and flexibility using numerical techniques.
- He has knowledge of the operation of automated manufacturing systems and methods of selection of means of implementation of tasks and components of the process and planning its course in the conditions of systematic integration of production

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Demonstrates the ability to quantify the performance of production systems and to perform a preliminary economic analysis of planned engineering activities in the field of automation of production systems and the operation of machinery and technical equipment.

Communication and cooperation

- The student is able to use source materials in a foreign language: understands the content, uses correct terms
- The student is able to assess the suitability of methods and tools for solving an engineering task in the field of construction and operation of facilities and equipment, recognizing their limitations, and to select and apply the appropriate method and tools to solve a complex project task related to economic analysis and financial control of project implementation
- Professional technical communication with other scientists

Reflection of academic and professional identity

- The student uses the knowledge gained from various modules to assess the non-technical consequences of engineering activities and adopts responsible attitudes.
- The student identifies basic problems related to production processes and systems

Course content:

Elements of a manufacturing process (definitions and terms). The structure and functions of a production system. Integration forms of process components: machining (manufacturing), material flow (transportation), information flow and process control. Classification of machine tool control technologies. Numerical control and automatic regulation. Automation components for machine tools and their systems. Automation versus flexibility and production scale. Productivity and the degree of system autonomy. Flexibly automated CNC machine tools, machining centers and autonomous machining stations in integrated manufacturing systems (IMS). Flexible manufacturing systems (FMS). Factors and measures for FMS integration: transportation and material (part/tooling) handling subsystems using manipulators and industrial robots. Integration of process flow functions. Surveillance and diagnosis in FMS. FMS operation and process flow control. Typologies of production facility organisation. The stationary system layout. Cellular and linear forms of layout organisation. The means for hybrid manufacturing technology realisation.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.

Further information:				
Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching methods**	**Examination method(s), scope and duration**
Management and Production Engineering Course 2	Prof. Mariusz Deja Dr inż. Mieczysław Siemiątkowski Dr inż. Aleksandra Wiśniewska	3	Lectures Laboratory Project	Portfolio (PF)

1.10 Contemporary Construction Materials (CCM)

Module leader:	Krzysztof Krzysztofowicz		
ECTS points:	3 ECTS	**Workload (h):**	90h
Type of module and position in the course of study:	Elective module for ST specialization taught in the 1. Semester at GDAŃSK TECH	**Contact hours (h):**	45h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	45h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge about design, structure, properties and testing of structural materials used in space industry

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student is able to design a procedural equipment or device compliant with the specifications using a design aid system in the form of a design documentation, selecting the appropriate model, performing critical analysis with the proper selection of tools and technologies
- Student is able to acquire information from specialist literary sources and other sources regarding the construction and operation of machines and related disciplines in polish and in a foreign language.

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

……

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Contemporary Construction Materials	Krzysztof Krzysztofowicz	3	Lectures Laboratory	Exam (KL), Lab excercises (EX)

1.11 Rocket Science (RS)

Module leader:	Dr. Marek Chodnicki		
ECTS points:	3 ECTS	**Workload (h):**	90h
Type of module and position in the course of study:	Elective module for ST specialization taught in the 1. Semester at GDAŃSK TECH	**Contact hours (h):**	45h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	45h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- The student knows the construction of rockets
- The student has knowledge of mechanics, in particular, the knowledge necessary to understand the basic phenomena physical phenomena occurring in external ballistics objects related to rocket technology.
- The student has knowledge of how to take measurements on rockets and estimate the obtained results.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Students can consciously use computer software in the area of rocket research
- Student is able to use analytical, numerical, simulation methods to formulate and solve rocket research tasks, and able to interpret and use experimental results appropriately.

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Understands the need for further education to improve professional, personal and social competencies.
- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Rocket Science – Fundamentals
- Nozzle
- Rocket equation
- Propulsive
- Rocket engines
- Orbits
- Rocket dynamic and motions
- Payload

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Rocket science	Dr. Marek Chodnicki	3	Lectures, Project	Exam (KL)

1.12 Objective Programming and Spatial Data Processing (OPSDP)

Module leader:	Prof. Dr. Zbigniew Łubniewski		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Elective module for CS specialization taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	90h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	90h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge of object-oriented programming on the example of four object-oriented programming languages: C++, Java, C#, Python.
- Student knows models and formats of spatial data and their applications as well as the architecture and functionality of modern GIS.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- The student acquires practical skills on writing object-oriented software by performing laboratory tasks in specific programming languages.
- Student is able to use and to implement various methods of processing and analysis of spatial data, including 3D data and their visualization.

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Objective programming: Software programming paradigms including object oriented approach; Encapsulation, inheritance, abstraction and polymorphism in C++ language; Specific features of C++ object-orientation; Java language and its comparison to C++ language; C# language as successor of C++ and Java languages; Python as a scripting object oriented language
- Spatial data processing technologies: Introduction to GIS, definitions, basic functionality, data types and sources; Popular GIS software (Quantum GIS, GRASS, ArcGIS, other); Standards for spatial data representation: shapefile, GML, KML, WMS, WFS, WCS, CSW; GIS data sources: satellite Earth observation data, laser 3D scanning data; Review of open technologies for spatial data processing (GeoTools, Geoserver, OpenLayers, GeoEXT, Nominatim, Routino, Google Maps API, Cesium); Raster and vector databases, SQL spatial extensions, vector data processing in geodatabases
- 3D visualisation of space data: basics of 3-dimensional computer graphics, 3D data visualization methods, coordinate systems for space and spatial data, 3D data formats, programming technologies and libraries, 3D graphics in WWW

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Objective programming	Emilia Lubecka	2		Exam (KL), Lab exercises (EX)
Spatial data processing technologies	Zbigniew Łubniewski, Marcin Kulawiak	2		

3D visualisation of space data	Marcin Kulawiak	2		

1.13 Optimization Algorithms (OA)

Module leader:	Dr. Tomasz Zubowicz		
ECTS points:	3 ECTS	**Workload (h):**	90h
Type of module and position in the course of study:	Elective module for EE specialization taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	60h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	30h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge of the typical steps and milestones in optimization problem formulation and solving

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student can solve simple engineering optimization problems and work examples, analyze data sets, evaluate evidence, apply findings to a situation or problem and synthesize resolution(s), answer probing questions about a given research study
- Student can design and create a computer code, contribute to the process related to research study considering group work and cooperation with other students while solving complex software electrical engineering problems
- Student can efficiently utilize open-source libraries and tools dedicated for optimization problems to solve and illustrate the results

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Principles of gradient and non-gradient optimization algorithms
- Metaheuristic optimization utilizing population-based optimization models
- Solving real-life engineering problems related to space system design
- Working with open-source (Python) optimization libraries

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Optimization Algorithms	Tomasz Zubowicz Bartosz Puchalski	4	Lectures, Laboratory	Written exam (KL)

1.14 Systems Modeling and Simulation (SMS)

Module leader:	Dr. Bartosz Puchalski		
ECTS points:	3 ECTS	**Workload (h):**	90h
Type of module and position in the course of study:	Elective module for CS and EE specialization taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	60h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	30h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge of the typical steps and milestones in system modelling and simulation

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student can solve simple engineering modelling problems and work examples, analyze data sets, evaluate evidence, apply findings to a situation or problem and synthesize resolution(s), answer probing questions about a given research study
- Student can design and create a computer model, contribute to the process related to research study considering group work and cooperation with other students while solving complex software electrical engineering problems
- Student can construct simulation environment independently by utilizing open-source libraries and packages
- Student can analyze, illustrate, and formulate conclusions related to obtained results

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Modelling and identification of space systems and components
- System structural identification techniques
- System parameter identification
- Neural and fuzzy modelling

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Systems Modeling and Simulation	Tomasz Zubowicz Bartosz Puchalski	4	Lectures, Laboratory	Written exam (KL)

1.15 Antenna Technique and GNSS Applications Programming (AT_GNSSP)

Module leader:	Prof. Włodzimierz Zieniutycz		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Elective module for CS and EE specialization taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	90h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	90h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge on the specificity of the wireless channel used in space applications.
- Student has knowledge on selected GNSS systems and tools for processing data derived from them.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student is able to measure the electric parameters of selected antennas and arrays used in space applications, as well as to use numeric tools for simulation of these parameters and for design of classical microstrip antenna.
- Student is able to properly collect, process and export GNSS data for further analysis purposes using external tools and software.
- Student is able to design a mobile application utilising GNSS data for several applications.

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Antenna technique in space applications: Introduction: electromagnetic frequency bands, basics of radiation theory and electromagnetic wave guiding, quantitative description of field phenomena; Antenna parameters: radiation pattern, gain, effective antenna aperture, Friss transmission equation, polarization parameters, noise parameters; Theory of antenna array, the concept of array factor, homogeneous and nonhomogeneous linear arrays, planar array, beam forming systems; Overview of selected types of antennas: dipoles and their power supply systems, biconical, helical, spiral antennas, tubes, microstrip antennas, slot, reflector antennas. Earthly space and space as a specific working environments for telecommunication systems and antennas - factors determining the choice of materials and the processes for the designing and construction of antennas; Antenna measurement: environmental measurements, antenna parameters measurement: radiation pattern, gain, ellipticity, reflection
- Programming of GNSS applications: Positioning and navigation algorithms; Satellite navigation receivers; Structure and formats of GNSS data (at various levels of processing); Methods and algorithms for GNSS data processing; Mobile systems and platforms; Selected evaluation platforms and its programming; Selected graph-based algorithms related to navigation; Numerical libraries to solve navigational equations; GNSS signal processing algorithms

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration

<table>
<tr><td>Antenna technique in space application</td><td>Włodzimierz Zieniutycz</td><td>3</td><td rowspan="2">Lecture, Project</td><td rowspan="2">Written exam (KL)</td></tr>
<tr><td>Programming of GNSS applications</td><td>Przemysław Falkowski-Gilski</td><td>3</td></tr>
</table>

1.16 Robotics for Human Health and Performance (RHHP)

Module leader:	Dr. Wiktor Sieklicki		
ECTS points:	3 ECTS	**Workload (h):**	90h
Type of module and position in the course of study:	Elective module taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	45h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	45h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge in area of biomechanics necessary to design instrumentation for human health and performance monitoring and assessment
- Student has basic knowledge in area of automatics necessary to design simple instrumentation for human health and performance monitoring and assessment
- Student has knowledge in area of sensors and signal acquisition necessary to assess human mobility

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student is able to design simple instrumentation for monitoring and assessing human health and fitness
- Student uses sensors to acquire the signals necessary to assess human mobility

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs.
- Understanding safety and reliability as part of scientific ethics

Course content:

- Introduction to biomechanics
- Introduction to sensors and signals: bio-signal sensors, holter-based measuring devices
- Introduction to robotic devices for human rehabilitation

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Robotics for Human Health and Performance	Wiktor Sieklicki	3	Lectures Laboratory Project	Lab exercises (EX)

1.17 Current Topics of Systems Engineering 1 (CURSE 1)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (HSB)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module taught in the 1. semester at the GDAŃSK TECH	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

In Elective Modules, students gain theoretical and practical knowledge and problem-solving skills with regard to a specialized, program-related topic. Elective modules may contribute to one or more than one study profile of the program (Computer Science, Electronics Engineering, or Space Technologies.

The catalogue of Elective Modules of the program comprises of the modules listed above. Further topics may be included based on the current research interests and project of GDAŃSK TECH's academic teaching staff. Students will receive information on the respective module selection in due time. Elective modules that are not listed in the examination regulations can be recognized for the module "Current Topics of Systems Engineering".

Course content:

The catalogue of Elective Modules of the program comprises of the modules listed above. Further topics may be included based on the current research interests and project of GDAŃSK TECH's academic teaching staff. Students will receive information on the respective module selection in due time. Elective modules that are not listed in the examination regulations can be recognized for the module "Current Topics of Systems Engineering".

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	To be announced
Further information:	To be announced

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
To be announced (tba)	tba	tba	tba	tba

1st Semester (GDAŃSK TECH): Optional Elective Modules

1.18 Polish Language for German Students (POL)

Module leader:	Msc. Maciej Zaremba		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module taught in the 1. Semester at the GDAŃSK TECH	**Contact hours (h):**	90h
Scope and frequency of teaching:	15 classes in summer term	**Self-study (h):**	90h
Type of module and position in other study programs or continuing education offers:			

Learning outcomes:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- Student has knowledge of grammatical structures and lexical resources needed to communicate in foreign language in terms of general and specialist language related to field of study
- A student knows how to get in touch and introduce themselves, can read and correctly pronounce Polish phonems. Knows numerals up to 1000. Can do shopping, knows the names of food products, garments. Can ask for directions.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Student is able to obtain and process information related to field of study and academic environment in foreign language
- Successful communication at university. Understanding technical texts and instructions, translating short technical texts and preparing presentations. Ability to write formal letters and summaries of technical texts.

Communication and cooperation

- Successful communication at university, in the workplace and in other environments.
- Successful communication in general and professional language
- Ability to communicate and cooperate in an international group.
- Understanding technical texts and instructions. Translating and summarising short technical texts. Preparing presentations. Comprehension of longer speeches and lectures

Reflection of academic and professional identity

- Student is ready to participate in lectures, seminars and laboratories given in the foreign language

Course content:

Teaching students the basics of the Polish language and to make further use of their previously acquired language skills and cultural competencies. Acquainting students with the Polish culture and everyday life in Poland.
Students learn:

- the singular and plural number of nouns and adjectives, to describe themselves, their family, friends and surroundings in greater detail;
- ordinal numbers and adverbs of time, to speak about schedules and dates;
- possessive pronouns, to describe one's surroundings in greater detail;
- vocabulary describing the weather; expressing feelings, emotions and one's own opinions;
- construction and syntax of complex sentences

Language of teaching:	
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Polish Language for German Students	MSc. Maciej Zaremba	4	Excercises	Oral exam

2nd Semester (HSB): Mandatory Modules

2.1 Space Systems Engineering (SPASE)			
Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4) and Prof. Dr. Antonio Garcia (FK5)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Mandatory module taught in the 2. Semester at the HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Possibly future elective module in Aerospace Technologies M. Sc.	

Learning outcomes:

The main goal of this module is to provide an overall understanding of space systems engineering illustrated in an example project as a theoretical and practical foundation for the in parallel ongoing interdisciplinary project (Module 2.2).

Knowledge and understanding

- Knowledge and understanding of systems engineering terms, principles, methods and processes
- Knowledge and understanding of norms and standards, competences and roles
- Knowledge and understanding of classical and agile approaches/process models
- Knowledge and practical understanding of requirements engineering methods, technical realization processes, operational aspects and project management methods
- Gaining and deepening knowledge of specific space systems engineering methodologies, tools and frameworks

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Elaborate stakeholder and mission requirements for a given space project example
- Define the concept of operation (CONOPS) for the given mission
- Define system requirement based on stakeholder and mission requirements
- Analyze and assess systems engineering and project management principles and methods in order to choose the appropriate one for a given example project
- Analyze possible design alternatives and choose the most appropriate one
- Create an overall design of the required space system including all necessary subsystems and facilities
- Perform appropriate project planning and cost calculation

Communication and cooperation

- Plan, organize and perform team work
- Support each other in understanding stakeholder and system requirements
- Shape work and learning process independently and take the responsibility for the results and consequences
- Address conflicts and come to solutions

Scientific self-image or professionalism

- Research complex tasks on state of the art of project management
- Reflect on one's own learning and work goals and those set by others
- Present complex project problems and solutions to experts

Course content:

Each topic is going to be illustrated and mapped to an example project in the space application domain

- Systems Engineering foundations and principles
- Term definitions (system, system types, system abstraction levels, system elements, subsystems, components and interfaces, system lifecycle)
    - System view of Spacecraft
    - Spacecraft Environment/Facilities
- Systems Engineering methods and processes
- Systems Engineering competences and roles
- Relevant norms and standards, especially the ECSS Space Standards
- Classical vs. agile approaches/process models (waterfall, V-Modell, spiral model, agile methods, lean SE)
- Systems vs. software engineering

	- Requirements Engineering (mission requirements, context diagram, classical and agile methods for requirements elicitation, documentation, verification, traceability and management) - Mission definition/statement - CONOPS (concept of operations) → use cases - Product assurance & safety - Mission analysis (orbital mechanics, launch vehicles) - Mission requirements - System requirements - Functional analysis - System specification ▪ Technical realisation processes - Design decisions/trade-offs - System architectural design and interface definition ▪ Main budgets and analysis ▪ Bus and payload module design ▪ FDIR design ▪ Software system • On-board software system and data handling (OBC, AOCS/GNC, FDIR, PL) • Ground Software System (AIT, V&V and MCC) • Consistency between all software components ▪ Electrical power system ▪ Attitude determination and control system ▪ Telecommunications ▪ Structure & mechanics ▪ Thermal design ▪ Propulsion and de-orbiting systems ▪ Deployable systems and mechanisms - Implementation and realization strategies - System assembly, integration and verification/validation including reviews ▪ Foundations and principles of model-driven engineering ▪ Operational aspects (operations and maintenance strategy, continuous improvement, quality management, reuse and disposal strategies) - Ground segment (test and simulation facilities) - Launch site operations and disposal - In-Orbit spacecraft operations (mission control center) ▪ Introduction to project management interfaces - Product vs. project vs. process - Project preparation and planning - Work organization, team building and social skills - Project execution, monitoring and evaluation - Project- vs. system configuration management, change management, interface management
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	▪ Project Management Institute (PMI) – A Guide to the Project Management Body of Knowledge (PMBOK Guide) - 5th Edition, 2013 ▪ K. Schwaber, J. Sutherland, The Scrum Guide, 2020 ▪ INCOSE Systems Engineering Handbook, 2015 ▪ NASA Systems Engineering Handbook, Rev. 2, 2020 ▪ Systems Engineering Body of Knowledge, v. 2.4, 2021 ▪ ISO/IEC/IEEE 15288:2015 - Systems and software engineering -- System life cycle processes ▪ ISO/IEC/IEEE 16326:2009 - Systems and software engineering -- Life cycle processes -- Project management ▪ ECSS-S-ST-E-10 Standard on Space System Engineering ▪ ECSS-S-ST-E-40 Standard on Space Software Engineering ▪ ECSS-S-ST-E-70 Standard on Space Ground Systems and Operations Engineering ▪ ECSS-Q-ST Standards on Space Product Assurance

	- ECSS-M-ST Standards on Space Project Management If necessary, students will receive additional reading lists at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Space Systems Engineering	Prof. Dr.-Ing. Jasminka Matevska and Prof. Dr. Antonio Garcia	3	Seminar	Written exam (KL), 90 min.
Space Systems Engineering	Prof. Dr.-Ing. Jasminka Matevska and Prof. Dr. Antonio Garcia	1	Exercises	

2.2 Project Management (PROMAN)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Mandatory module taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Elective module in Informatik M.Sc/ KSS, possibly future elective module in Aerospace Technologies M.Sc./AT	

Learning outcomes:

Knowledge and understanding

- Knowledge and understanding of project management terms, principles, methods and processes
- Knowledge and understanding of classical and agile methods for requirements engineering
- Knowledge of relevant project management norms und standards especially in the space domain

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Elaborate stakeholder and project requirements
- Analyse and assess project management principles and methods in order to choose the appropriate one for a given example project
- Apply the chosen methods for the example projects in order to perform project preparation including appropriate risk analysis, planning and execution
- Prepare project management aspects of concrete proposal for an example ESA - Invitation to tender (ITT)

Communication and cooperation

- Plan, organise and perform team work
- Support each other in understanding stakeholder and system requirements
- Shape work and learning process independently and take the responsibility for the results and consequences
- Address conflicts and come to solutions

Scientific self-image or professionalism

- Research complex tasks on state of the art of project management
- Reflect on one's own learning and work goals and those set by others
- Present complex project problems and solutions to experts

Course content:

- Basics of project management
- Cost/time/quality
- Requirements engineering
- Design thinking
- Agile project management
- Organisation of companies
- Project preparation (goals, stakeholder analysis, project chart, contract, kick-off, risks and chances, milestones, deliverables)
- Organisation of the project (team roles and responsibilities, RACI, meetings)
- Project planning (Work Breakdown Structure (WBS), Organisational Breakdown Structure (OBS), Cost Breakdown Structure (CBS), Work packages)
- Business plan
- Project configuration management
- Project execution, monitoring and control
- Project finalization and evaluation
- Project management in the Space Application Domain
  - Methods und Standards (especially ECSS Space Project Management Standard)
  - Proposal for an example project according to ESA - Invitation to tender (ITT) process
- Project Management Tools
- Teambuilding, communication and conflict management
- Cultural management, gender management

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	▪ Project Management Institute (PMI) – A Guide to the Project Management Body of Knowledge (PMBOK Guide) - 5th Edition, 2013 ▪ K. Schwaber, J. Sutherland, The Scrum Guide, 2020 ▪ INCOSE Systems Engineering Handbook, 2015 ▪ H. Meyer, H.-J. Reher – Projektmanagement, 2016 ▪ ECSS-M-ST Standards on Space Project Management ▪ ISO/IEC/IEEE 15288:2008 - Systems and software engineering -- System life cycle processes ▪ ISO/IEC/IEEE 16326:2009 - Systems and software engineering -- Life cycle processes -- Project management ▪ M. Broy, M. Kuhrmann - Projektorganisation und Management im Software Engineering, 2013 If necessary, students will receive additional reading list at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Project Management	Prof. Dr.-Ing. Jasminka Matevska	2	Seminar	Project work (PA)
Project Management	Prof. Dr.-Ing. Jasminka Matevska	2	Project	

2.3 Interdisciplinary One Year Project Part 2 (IOYP 2)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4) and Prof. Dr. Antonio Garcia (FK5)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Mandatory module taught in the 2. semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Mandatory module in the 2. semester in Aerospace Technologies M.Sc.	

Learning outcomes:

This module is using and applying the methods and principles presented and trained within the modules Space Systems Engineering (2.1) and Project Management (2.2) in a realistic space project scenario.

Knowledge and understanding

- Gain a practical understanding of the organization and implementation of interdisciplinary space projects
- Gaining and deepening knowledge of specific space systems engineering methodologies, tools and frameworks

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Elaborate stakeholder and mission use cases and requirements
- Define the mission and the mission statement
- Define the mission concept of operation (CONOPS) for the given realistic mission
- Define system requirement based on stakeholder and mission requirements
- Design, develop and implement the space system including all necessary (sub)systems and facilities
- Plan and perform assembly, verification and validation of the defined systems
- Organize project management using current methodologies and tools
- Perform cost calculation for the given project
- Plan and carry out project considering the scientific and technical status of the respective field of application
- Critically evaluate project goals and revise them if necessary
- Prepare a concrete proposal for an example ESA - Invitation to tender (ITT)

Communication and cooperation

- Plan, discuss and prioritize project goals
- Introduce, discuss and evaluate system technical solutions
- Support each other in understanding the mission and the system
- Evaluate and approve the subsystem and system solutions of others
- Reporting and lessons learned
- Reflect on one's own learning and work goals and those set by others and take responsibility, as well as draw conclusions for the work processes in the team
- Addressing conflicts and come to solutions

Reflection of academic and professional identity

- Research complex tasks on project-related topics from science and practice
- Present complex technical problems and solutions to experts
- Publish project results scientifically

Course content:

This module is the continuation of the studies embedded in the module Interdisciplinary one year project 1 (IOYP1). Students deal with the realistic systems in the space domain in the context of teamwork and customer requirements based on the research activities of the university institutes or business partners.

The contents are e.g.

- Use the methods and principles of Space Systems Engineering
- Work according to Systems Engineering processes
- Define Systems Engineering roles
- Use relevant norms and standards (especially ECSS Space Standards)
- Perform all necessary phases (Requirements Engineering, System Architecture and Component Design, Development, Verification & Validation) using classical and/or agile methods

▪ Define necessary operational concepts (Operations, Maintenance, Evolution, Quality management, Reuse, Disposal) ▪ Use project management methods and tools (both classical and agile according to the context)	
Language of teaching:	English
Prerequisites:	Successful participation at the predecessor module IOYP 1 is strongly recommended.
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Interdisciplinary One Year Project Part 2	Professors of the degree program	4	Project	Project work (PA)

2.4 Special Mandatory Module 2 (Placeholder)

Module leader:	Prof. Dr. Jasminka Matevksa (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Placeholder for Special Mandatory Module taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module is a placeholder for the Special Mandatory Module to be selected in the 2. Semester at HSB. With a defined selection of special mandatory modules and electives, the program can be completed with a specialization in either Computer Science, Electronics Engineering, or Space Technologies. For each specialization, the module to be selected for the Special Mandatory Module placeholder is defined as follows:

- SPECIALIZATION SPACE TECHNOLOGIES: Module 2.6 Design and Modeling of Space Propulsion Systems (DMSP)
- SPECIALIZATION COMPUTER SCIENCE: Module 2.7 Methods for Developing Complex Software Systems (MKSS)
- SPECIALIZATION ELECTRONICS ENGINEERING: Module 2.8 Measurement and Instrumentation (MIN)

Students can also complete the program without choosing a specialization.

By completing the respective module, students acquire theoretical and practical competencies in either Space Technologies, Computer Science or Electronics Engineering relevant for the engineering and management of space systems. These competencies can be applied to solve practice-related problems in management and engineering of space systems. A detailed description of the respective learning outcomes is given within the module descriptions of the modules 2.6, 2.7 and 2.8.

Course content:

A detailed description of the respective course contents is given within the module descriptions of the modules 2.6, 2.7 and 2.8.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	See module description of the modules 2.6, 2.7 and 2.8.
Further information:	See module description of the modules 2.6, 2.7 and 2.8.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
See module descriptions 2.6, 2.7 and 2.8	See module descriptions 2.6, 2.7 and 2.8	2	See module descriptions 2.6, 2.7 and 2.8	See module descriptions 2.6, 2.7 and 2.8
See module descriptions 2.6, 2.7 and 2.8	See module descriptions 2.6, 2.7 and 2.8	2	See module descriptions 2.6, 2.7 and 2.8	

2.5 Elective Module 2 (Placeholder)

Module leader:	Prof. Dr. Jasminka Matevksa (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Placeholder for Elective Module taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module is a placeholder for the Elective module to be selected in the 2. Semester at HSB. With a defined selection of special mandatory modules and electives, the program can be completed with a specialization in either Computer Science, Electronics Engineering, or Space Technologies. For the Elective Module placeholder, students are required to choose one of the elective modules listed below. Please note the assignment of the modules to the specializations:

- 2.9 Non-Chemical Space Propulsion Systems (NCSP) – SPECIALIZATION SPACE TECHNOLOGIES
- 2.10 Orbital Mechanics (OM) – SPECIALIZATION SPACE TECHNOLOGIES
- 2.11 On-Board Software Engineering (OBSW) – SPECIALIZATION COMPUTER SCIENCE
- 2.12 Optical Communications (OCO) - SPECIALIZATION ELECTRONICS ENGINEERING
- 2.13 IoT (Internet of Things) Architectures (IOTAR) – SPECIALIZATIONS COMPUTER SCIENCE and ELECTRONICS ENGINEERING
- 2.14 Model-based Systems Engineering – ALL SPECIALIZATIONS
- 2.15 Satellite Communications (SCO) – ALL SPECIALIZATIONS
- 2.16 Space Mission Operations (SMO) – ALL SPECIALIZATIONS
- 2.17 Unmanned Aerial Vehicles (UAV) – ALL SPECIALIZATIONS
- 2.18 Current Topics of Systems Engineering 2 (CURSE 2) – SPECIALIZATION DENPENDING ON THE TOPIC

By completing the respective module, students acquire theoretical and practical competencies relevant for the engineering and management of space systems. These competencies can be applied to solve practice-related problems in management and engineering of space systems. A detailed description of the respective learning outcomes of each elective is given within the module descriptions of the modules 2.9 – 2.18.

Course content:

A detailed description of the course contents is given within the module descriptions of the modules 2.9 – 2.18.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	See module descriptions 2.9 – 2.18.
Further information:	See module descriptions 2.9 – 2.18.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
See module descriptions 2.9 – 2.18	See module descriptions 2.9 – 2.18	2	See module descriptions 2.9 – 2.18	See module descriptions 2.9 – 2.18
See module descriptions 2.9 – 2.18	See module descriptions 2.9 – 2.18	2	See module descriptions 2.9 – 2.18	

2nd Semester (HSB): Special Mandatory Modules

2.6 Design and Modelling of Space Propulsion Systems (DMSP)

<table>
<tr><td>Module leader:</td><td colspan="3">Prof. Dr.-Ing. Uwe Apel (FK5)</td></tr>
<tr><td>ECTS points:</td><td>6 ECTS</td><td>Workload (h):</td><td>180h</td></tr>
<tr><td>Type of module/position within the program:</td><td>Mandatory module for ST specialization
taught in the 2. Semester at HSB</td><td>Contact hours (h):</td><td>56h</td></tr>
<tr><td>Scope and frequency of teaching:</td><td>14 classes
in winter term</td><td>Self-study (h):</td><td>124h</td></tr>
<tr><td colspan="2">Type of module and position in other study programs or continuing education offers:</td><td colspan="2">Semi-elective module in Aerospace Technologies M.Sc.</td></tr>
</table>

Learning outcomes:

Knowledge and understanding

- Knowledge of the classification of space propulsion systems and their applications
- Understanding the functions of liquid propellant space propulsion system and their subsystems/components
- Knowledge of requirements definition and verification of space projects

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Ability to define and analyze a space mission
- Ability to analyze and model liquid propellant chemical space propulsion systems and their components
- Ability to define and design a liquid propellant chemical space propulsion systems

Communication and cooperation

- Ability to interact in a group of 3-6 persons by performing a complex space system design project
- Ability to present and outline results of a complex space design project in a comprehensive way

Course content:

Lectures:

- Space Mission Design and ΔV calculation
- Space Propulsion System Design
  - Components of Space Propulsion Systems
  - Propellants and their Characteristics
  - Materials
  - Performance Parameters
- Component Analysis and Modelling
  - Tanks
  - Valves and Lines
  - Turbines and Pumps
  - Injectors
  - Ignition Systems
  - Combustors
  - Nozzles
- Propulsion System Dynamics
  - Steady Flow Operations
  - Transient Behaviour

Design Project:

- Design a liquid propellant propulsion system for a space mission based on given mission requirements.

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Design and Modelling of Space Propulsion Systems	Prof. Dr.-Ing. Uwe Apel	2	Seminar (Lectures, Exercises)	Project work (PA)
Design and Modelling of Space Propulsion Systems	Prof. Dr.-Ing. Uwe Apel	2	Laboratory (Exercises, Project work guidance)	

2.7 Methods for Developing Complex Software Systems (MKSS)

Module leader:	Prof. Dr. Lars Braubach (FK4)		
ECTS-Points:	6 ECTS	**Total workload:**	180h
Type of module and position in the course of study:	Mandatory module for CS specialization taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Mandatory module in Informatik M.Sc./ KSS	

Learning outcomes:

Knowledge and understanding

- Describe and explain concepts and methods of software development for complex systems and apply them in self-contained tasks
- Gain an overview of different software development paradigms and concepts and gain an understanding of their possible application scenarios
- Understand typical problems in software development and internalize solution strategies

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Understand different methods and frameworks and use them on the basis of exercises

Communication and cooperation

- Present and communicate solutions of exercises, discuss correctness and appropriateness and suggestions for improvement

Scientific self-image or professionalism

- Independently deepen and document basic practical knowledge based on the tasks

Course content:

Building on solid knowledge of programming and software technology, the module conveys scientific, methodological and practical skills in the field of analysis, conception and development of complex software systems. It also promotes the ability to work independently. As part of the scientific examination of concepts and methods for the implementation of complex software systems, the students deal with the following topics, among others:

- Techniques and procedures for the analysis, design and construction of software systems
  - Software architecture with architecture and design patterns
  - Distribution and concurrency
  - Software development paradigms
  - Modelling of software systems
  - Model-Driven Engineering
  - Software Product Lines
- Selected chapters on the current state of research

Language of teaching:	German (Englisch if necessary)
Prerequisites:	None
Preparation / literature:	Current reading lists are given out at the beginning of the semester
Further Information:	Lecture and work materials are made available via the AULIS learning platform.

Zugehörige Lehrveranstaltungen

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Methods for Developing Complex Software Systems	Prof. Dr. Lars Braubach	2	Seminar	Written exam (KL), 90 min or Portfolio (PF)
Methods for Developing Complex Software Systems	Prof. Dr. Lars Braubach	2	Laboratory exercises	

2.8 Measurement and Instrumentation (MIN)

Module leader:	Prof. Dr.-Ing. Friedrich Fleischmann (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Mandatory module for EE specialization taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Semi-elective module in Electronics Engineering M.Sc.	

Learning outcomes: After completion of the module, students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … distinguish between different classes of sensors,
- … are aware of the impact of mathematical basics of probability theory,
- … know principles of design of experiments,
- … are able to use NIST-GUM,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … apply statistical methods to evaluate significance of measurement results,
- ... assess decisive characteristics of acquisition hardware,
- … develop signal conditioning HW/SW,
- … apply systemic thinking in systems design including aspects of EMI control,
- … design meaningful experiments,

Communication and cooperation

- … do project work in a team,
- … decide autonomous about organization and conduct of experiments,
- … present progress and results to supervisors and peers,
- … assess results from experiment, evaluate in team and document scientifically,

Reflection of academic and professional identity

- … reflect system design and test setup with regard to alternative designs,
- … adhere to standards of professional action and documentation.

Course content:

- ANOVA, MANOVA, Hypothesis testing
- Uncertainty in measurement
- Design of experiments
- EMC/EMI in measurement applications
- Interfaces and bus systems
- Sensor signal conditioning
- Examples of electrical measurement of non-electrical properties

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Measurement and Instrumentation (S)	Prof. Dr. Friedrich Fleischmann	2	Seminar	Oral examination (30 min) or written work under supervision (90 min) and Scientific experimental work incl. documentation (40%)
Measurement and Instrumentation (L)	Prof. Dr. Friedrich Fleischmann	2	Exp. lab work	

2nd Semester (HSB): Elective Modules

2.9 Non-Chemical Space Propulsion Systems (NCSP)			
Module leader:	Prof. Dr.-Ing. Uwe Apel (FK5)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module for ST specialization taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Elective module in Aerospace Technologies M.Sc./AT	

Learning outcomes:

Knowledge and understanding

- Knowledge on the classification of non-chemical space propulsion systems and their applications
- Understanding the structure and functions of different non-chemical space propulsion systems and their subsystems/components
- Knowledge of requirements definition and verification of space propulsion systems

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Ability to define and analyse a space mission
- Ability to analyse the applicability of propulsion system options and to select a suitable one
- Ability to analyse, model and to do preliminary design calculations on non-chemical space propulsion systems and their components

Communication and cooperation

- …

Reflection of academic and professional identity

- …

Course content:

Lectures:

1. Classification of Space Propulsion Systems
   a. Types of Space Propulsion Systems
   b. Performance Parameters
   c. Mission Design and Propulsion System Selection
2. Electrical Space Propulsion
   a. Electrothermal Propulsion
   b. Electromagnetic Propulsion
   c. Electrostatic Propulsion
3. Nuclear Space Propulsion
   a. Isotope Propulsion
   b. Solid Core Reactors
   c. Liquid and Gas Core Reactors
4. Solar Space Propulsion
   a. Solar Thermal Propulsion
   b. Solar Electric Propulsion
   c. Solar Sails
   d. Laser Propulsion
5. Further Propulsion Concepts

Exercises:

Calculation exercises on mission design and different types of non-chemical space propulsion systems

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.

Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Non-Chemical Space Propulsion Systems	Prof. Dr.-Ing. Uwe Apel	2.5	Lecture	Written Examination (KL) on knowledge, understanding and example application of the learning outcomes, 3h duration
Non-Chemical Space Propulsion Systems	Prof. Dr.-Ing. Uwe Apel	1.5	Calculation Exercises	

2.10 Orbital Mechanics (OM)

Module leader:	Prof. Dr. Antonio Garcia (FK5)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module for ST specialization taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Elective module in Aerospace Technologies M.Sc./AT	

Learning outcomes:

Students learn to use the orbital mechanics basics to calcalute space missions of spacecrafts with special emphasis on the required systems. They are able to calculate near earth, moon and interplanetary orbital missions within our solar system under strict regard of the system requirements and the feasibility limits.

Course content:

- Introduction
  - Historical Review of Orbital Mechanics
  - Actual Spacecraft Mission Design Application
- Two-Body Motion
  - Circular Orbits
  - General Solution
  - Elliptical Orbits
  - Parabolic Orbits
  - Hyperbolic Orbits
  - Time Systems
  - Coordinate Systems
  - Orbital Elements
- Orbital Maneuvers
  - In-Plane Orbit Changes
  - Hohmann Transfer
  - Bielliptical Transfer
  - Plane Changes
  - Combined Maneuvers
  - Propulsion for Maneuvers
- Observing the Central Body
  - Effect of the Launch Site
  - Orbit Perturbations
  - Ground Track
  - Spacecraft Horizon
- Special Earth Orbits
  - Geosynchronous Orbit
  - Sun-Synchronous Orbit
  - Molniya Orbit
  - Low Earth Orbit
- Interplanetary Missions
  - Patched Conic Approximation
  - Highly Simplified Example
  - Patched Conic Procedure
  - Locating the Planets
  - Design of the Transfer Ellipse
  - Design of the Departure Trajectory
  - Design of the Arrival Trajectory
  - Gravity-Assist Maneuver
  - Establishing a Planetary Orbit
- Lunar Trajectories

- Motion of the Earth-Moon System - Time of Flight and Injection Velocity - Sphere of Influence - Lunar Patched Conic	
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Orbital Mechanics	Prof. Dr. Antonio Garcia	4	Seminar	Written exam

2.11 On-Board Software Engineering (OBSW)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Elective module for CS specialization taught in the 2. Semester at the HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Possibly future elective module in Aerospace Technologies M. Sc. and Informatik M.Sc./KSS	

Learning outcomes:

Knowledge and understanding (broadening of knowledge, deepening knowledge, understanding of knowledge)

- Knowledge and understanding of on-board software engineering terms, principles and methods
- Knowledge and understanding of norms and standards and processes
- Knowledge and practical understanding of requirements engineering, design of on-board software architecture and realisation principles and methods and validation approaches
- Knowledge of product assurance, security, reliability, availability, maintainability and safety
- Gaining and deepening knowledge of specific tools and frameworks

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Apply knowledge of principles, methods, standards and processes to plan the development of on-board software for a given space mission
- Prepare a Software Development Plan with an appropriate risk management
- Apply knowledge of methods for requirements engineering to elaborate on-board software requirements for a given space mission
- Apply knowledge of on-board software design methods, tools, standards and frameworks to define an on-board software architecture fitting the requirements
- Propose a technical specification based of Trade-offs for SW components and HW/SW-Co-Design
- Implement and validate/test against the requirements (part of) the designed on-board software

Communication and cooperation

- Plan, organise and perform team work
- Collaborate in understanding stakeholder and on-board software system requirements
- Shape work and learning process independently and take the responsibility for the results and consequences
- Address conflicts and come to solutions

Scientific self-image or professionalism

- Research complex tasks on state of the art of on-board software system
- Present solutions to experts

Course content:

- On-board Software Engineering terms, principles, methods and processes
  - System and onboard-software development standard and norms
    - European Cooperation for Space Standardization (ECSS) standards
    - Packet Utilisation Standard (PUS)
    - Consultative Committee for Space Data Systems (CCSDS)
    - other standards (e.g. MISRA-C coding standard, project and/or company specific coding standards)
  - Synchronizing the Software Development Approach with the System Life-Cycle
  - Agile techniques and methods for on-board software development
- Mission Analysis and System Design – Define the On-board Software System Requirements
  - System modes, transitions and FDIR
  - Level of autonomy and operational interfaces
  - On-board software functions and external software interfaces

- Allocation of On-board software functions to subsystems (HW) and or products (OBDH, AOCS/GNC, Mission Management, System Management/FDIR, PL) - On-board Software System Architecture Design - Static Architecture (main components and interfaces, OS and drivers, TM/TC, Subsystem manager, Mission Manager, etc.) - Dynamic Architecture (task scheduler, bus communication, time snchronisation, etc.) - Operational interfaces (TM/TC, PUS, CCSDS, etc.) - Reference on-board software architectures and frameworks - Modelling of software system architecture - Design/modelling tools (UML) - On-Board Software (OBSW) and On-Board Data Handling (OBDH) Detailed Design - Platform subsystems: On-Board Computer (OBC), Command Pulse Distribution Unit (CPDU), Electrical Power Subsystem (EPS), Communications (Com, TT&R) subsystem, Thermal Control Subsystem (TCS), Electrical/Chemical Propulsion Subsystem (EPPS, CPPS), Attitude and Orbit Control System (AOCS/GNC) - Payload subsystems (mission specific) - On-board interfaces: data interfaces (MIL bus, CAN bus, analogue and discrete lines, etc.) and power interfaces (High-Power Commands (HPCs), Latching Current Limiters (LCLs)) - Fault Detection, Isolation, and Recovery (FDIR) - Software layer structure: Real-Time Operating System (RTOS), Hardware Encapsulation Layer, Service Layer, Application Layer - Basic terms and characteristics of Real-Time Operating Systems (RTOS): tasks, mutexes, etc. - Redundancy aspects (primary and secondary on-board computer) - Safety and security aspects - Satellite Reference Database (SRDB) - Mission Information Base (MIB) - On-board Software Realization - Software configuration management and change management - On-board SW coding tools and languages, compiler toolchain, continuous integration - On-board software frameworks and software re-use - Software validation & verification (V&V) - Levels of V&V activities (RB, TS, architectural/integration, units) - Review of specification documents - Inspection of source code and other software artefacts - Software test on the different applicable levels (unit, integration, TS, RB) - Checking of compliance with applicable coding standards - Analysis of runtime behavior - Determination and reporting of software metrics - Consistency between components - V&V tools (test, code review, code analysis, etc.)	
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	- INCOSE Systems Engineering Handbook, 2015 - NASA Systems Engineering Handbook, Rev. 2, 2020 - Systems Engineering Body of Knowledge, v. 2.4, 2021 - ISO/IEC/IEEE 16326:2009 - Systems and software engineering -- Life cycle processes -- Project management - ECSS-E-ST-40C Standard on Space Software Engineering - ECSS-Q-ST-80 Standard on Software Product Assurance - ECSS-E-ST-70-XX Ground System Operations Standards - ECSS-E-ST-50-XX: Communications Standards - Onboard Computers, Onboard Software and Satellite Operations: An Introduction By Jens Eickhoff If necessary, students will receive additional reading list at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching methods**	**Examination method(s), scope and duration**
On-board Software Engineering	Prof. Dr.-Ing. Jasminka Matevska	2	Seminar	Exam (KL), 90 min.
On-board Software Engineering	Prof. Dr.-Ing. Jasminka Matevska	2	Laboratory exercises	

2.12 Optical Communications (OCO)

Module leader:	Prof. Dr. rer.nat. Carsten Reinhardt (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Elective module for EE specialization taught in the 2. Semester at the HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Semi-elective module in the study program Electronics Engineering M. Sc.	

Learning outcomes:

This module conveys systematic skills to design and apply fiber optic transmission systems and sensor systems.

Knowledge and understanding (broadening of knowledge, deepening knowledge, understanding of knowledge)

- Knowledge and understanding of fiber optic systems, optical fibers ans optical sources foundations
- Distinguish between different fiber types regarding attenuation, dispersion and interconnection techniques
- Knowledge and practical understanding of optical interconnection, splicing, optical systems and networks

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Determine parameters of using LED or LD in optical transmitters and PIN or APD in optical receivers
- Integrate components into a system considering power, spectrum and modulation of sources and mutual interaction between laser and fiber regarding optical feedback into lasers and interaction of spectrum and dispersion of fiber
- Evaluate quality of a transmission line by measuring receiver sensitivity, bit error ratio and eye pattern
- Design transmission systems with direct detection, WDM, optical amplifier and coherent detection

Communication and cooperation

- Perform project work in an international team of engineers with different scientific background (optics, electronics, transmission, testing, networking)

Scientific self-image or professionalism

- Present solutions to experts

Course content:

- Introduction to fiber optic systems
- Economic significance of photonics
- Optical fibers, SM, MM, POF (optical transmission line)
- Optical sources, LED, LD (optical transmitter)
- Photodiodes, PIN, APD (optical receiver)
- Optical interconnection, splicing (covered by lab work)
- Optical systems and networks (including lab work)

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	▪ Agrawal, Lightwave Technology, Vol. 1,2, Wiley Interscience ▪ Keiser, Optical Fiber Communications, McGraw-Hill Intern. ▪ Derickson, Fiber Optic Test and Measurement, Prentice Hall ▪ Senior, Optical Fiber Communications, Prentice Hall ▪ Voges, Petermann, Optische Kommunikationstechnik, Springer If necessary, students will receive additional reading list at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration

Optical Communications	Prof. Dr. rer.nat. Carsten Reinhardt	2	Seminar	Oral examination (MP), 30 min. or written work under supervision (KL), 90 min. and scientific experimental work (EX)
Optical Communications	Prof. Dr. rer.nat. Carsten Reinhardt	2	Laboratory exercises	

2.13 IoT (Internet of Things) Architectures (IOTAR)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module for CS and EE specializations taught in the 1. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Elective module in the Informatik M.Sc./KSS	

Learning outcomes:

Knowledge and understanding

- Understand the foundations of the Industry 4.0 Agenda
- Understand, analyze and assess terms, principles, protocols and structure of IoT architectures
- Know the IEEE Standard for an Architectural Framework for the Internet of Things
- Understand, differentiate and assess the basic structure and functionality of the Message Queuing Telemetry Transport (MQTT) architecture, Open Platform Communications Unified Architecture (OPC / UA), Advanced Message Queuing Protocol (AMQP) architecture and Representational State Transfer (REST) architecture
- Understand the basics of Edge Computing
- Know and differentiate between the most widespread IoT cloud services
- Understand the importance of IoT architectures for data science

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Identify and analyze requirements for a specific IoT system and assess the effort / benefit / risk potential
- Develop, analyze, assess and compare different design alternatives, implementation, verification and validation methods and to select an option
- Create a draft of the IoT architecture for the specific project
- Implement and test the specific system based on the draft

Communication and cooperation

- Plan, organise and perform team work
- Support each other in understanding user and system requirements
- Shape work and learning process independently and take the responsibility for the results and consequences
- Address conflicts and come to solutions

Reflection of academic and professional identity

- Reflect on one's own learning and work goals and those set by others
- Research complex tasks on state of the art of model-based systems engineering
- Research on possibilities of model import of different disciplines in order to enable the single source model approach

Course content:

Each topic is going to be illustrated and mapped to an example IoT project.

- Industry 4.0 Agenda - Foundations
- Basic Structure of an IoT (Internet of Things) Architecture
  - Devices/Sensors/Control
  - IoT Hub/Data Transmission
  - Data Persistence
  - Logic/Data Processing
  - Application Programming Interface (API)
  - IoT Communication Protocols (HTTP, WebSocket, MQTT, AMQP)
- IEEE Standard for an Architectural Framework for the Internet of Things (IEEE Std 2413™-2019)
- Message Queuing Telemetry Transport (MQTT) Architecture
- Open Platform Communications Unified Architecture (OPC/UA)
- Advanced Message Queuing Protocol (AMQP) Architecture
- Representational State Transfer (REST) Architecture
- Edge Computing

▪ IoT Cloud Services
  ○ Amazon Web Services
  ○ Microsoft Azure
  ○ Google Cloud
  ○ Siemens MindSphere
▪ IoT Architectures for Data Science (especially Big Data und Aritifcal Intelligence)	

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	▪ OMG Systems Modeling Language (OMG SysML™), Version 1.6, https://www.omg.org/spec/SysML/1.6/, 2019 ▪ Unified Architecture Framework Profile (UAFP) Version 1.1, https://www.omg.org/spec/UAF/1.1, 2020 ▪ INCOSE Systems Engineering Handbook, 2015 ▪ NASA Systems Engineering Handbook, Rev. 2, 2020 ▪ L.E. Hart, Introduction To Model-Based System Engineering and SysML, 2015 ▪ R. Karban et al., The OpenSE Cookbook: A practical, recipe based collection of patterns, procedures, and best practices for executable systems engineering for the Thirty Meter Telescope, 2018 ▪ CubeSat Challenge Team, Using MBSE for Operational Analysis, 2013 *If necessary, students will receive additional reading list at the beginning of the semester.*
Further information:	*Lecture and work materials will be provided via the AULIS learning platform.*

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
IoT (Internet of Things) Architechtures	Prof. Dr.-Ing. Jasminka Matevska	2	Seminar	Portfolio (PF)
IoT (Internet of Things) Architechtures	Prof. Dr.-Ing. Jasminka Matevska	2	Laboratory	

2.14 Model-based Systems Engineering (MBSE)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module for all specializations taught in the 2. semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Elective Module in Informatik M.Sc. (PO 2022)	

Learning outcomes:

Knowledge and understanding

- Understand the relevance of systematic systems engineering approach and gain knowledge of the main principles
- Gaining knowledge and understanding of different system abstraction level and other possibilities of system structuring
- Gaining and deepening knowledge of methods and principles of model-based systems engineering
- Gaining knowledge of SysML (System Modeling Language) and deepening knowledge of UML (Unified Modeling Language) modelling methods, views and elements

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Usage of SysML (System Modeling Language) /UML (Unified Modeling Language) Use Case Diagrams for elaboration and definition of user and system requirements for an example project
- Asses, analyse and design different SysML (System Modeling Language) /UML (Unified Modeling Language) diagrams applicable for the given project
- Apply concepts and different diagrams and design for concrete example systems
- Use appropriate modeling methods end embed them into a corresponding systems engineering process for development and simulation of the example system
- Critically evaluate the effort and benefit of model-based systems engineering

Communication and cooperation

- Plan, organise and perform team work
- Shape work and learning process independently and take the responsibility for the results and consequences
- Address conflicts and come to solutions

Scientific self-image or professionalism

- Reflect on one's own learning and work goals and those set by others
- Research complex tasks on state of the art of model-based systems engineering
- Research on possibilities of import of different models and data formats for different disciplines in order to enable the single source model approach

Course content:

- Foundations and principles of systems engineering
- Overview of methods and processes of systems engineering
- System definition, system abstraction levels, system elements, subsystems, components and interfaces
- Foundations and principles of model-based systems engineering
- Modeling with SysML (System Modeling Language) /UML (Unified Modeling Language)
    - Use case and requirement diagrams for elicitation, analysis and definition of requirements
    - Data flow diagrams
    - Control flow diagram
    - Functional flow block diagram
    - Structure diagrams (block definition, internal block, package and component diagram)
    - Behavior- and interaction diagrams (state machine diagrams, activity diagrams, sequence diagrams and timing diagrams)
    - SysML Tools
- Application of different diagrams for designing concrete example systems
- Usage of additional models and data formats for development and simulation of different subsystems
- Embedding different views and models into the systems engineering process

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	▪ OMG Systems Modeling Language (OMG SysML™), Version 1.6, https://www.omg.org/spec/SysML/1.6/, 2019 ▪ Unified Architecture Framework Profile (UAFP) Version 1.1, https://www.omg.org/spec/UAF/1.1, 2020 ▪ INCOSE Systems Engineering Handbook, 2015 ▪ NASA Systems Engineering Handbook, Rev. 2, 2020 ▪ L.E. Hart, Introduction To Model-Based System Engineering and SysML, 2015 ▪ R. Karban et al., The OpenSE Cookbook: A practical, recipe based collection of patterns, procedures, and best practices for executable systems engineering for the Thirty Meter Telescope, 2018 ▪ CubeSat Challenge Team, Using MBSE for Operational Analysis, 2013 If necessary, students will receive additional reading list at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Model-based Systems Engineering	Prof. Dr.-Ing. Jasminka Matevska	2	Seminar	Portfolio (PF)
Model-based Systems Engineering	Prof. Dr.-Ing. Jasminka Matevska	2	Exercises	

2.15 Satellite Communications (SCO)

Module leader:	Prof. Dr. Sören Peik (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position within the program:	Elective module for all specializations taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Elective module in Electronics Engineering M.Sc. and Aerospace Technologies M.Sc.	

Learning outcomes:

The module provides a comprehensive introduction to satellite communications and a thorough grounding in the design issues of orbit selection, link design, and signal processing. Throughout the term references to and discussions of today's satellite systems are included. After completion of this module the students are able to …

Knowledge and understanding

- … describe the orbital movement of satellites
- … compute the satellite location in space and with respect to a ground station

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … evaluate the extraordinary design goals for a space environment
- … set up a link budget
- … assess the risks and hazards of space flight
- … apply engineering project management to space flight applications

Communication and cooperation

- … perform project work in an international team

Course content:

- Introduction
- Orbital Mechanics
- Satellite Launch Systems
- The Space Segment
- The Ground Segment
- Space System Project Management
- Space System Engineering
- The Communication Link
- Satellite Based Navigation

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	E.g. link to Aulis, if applicable

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Satellite Communications	Prof. Dr. Sören Peik	2	Seminar	Oral examination (MP), 30 min. or written work under supervision (KL), 90 min. and scientific experimental work (EX)
Satellite Communications	Prof. Dr. Sören Peik	2	Laboratory	

2.16 Space Mission Operations (SMO)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Elective module for all specializations taught in the 2. Semester at the HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Possibly future elective module in Aerospace Technologies M.Sc./AT	

Learning outcomes:

Knowledge and understanding (broadening of knowledge, deepening knowledge, understanding of knowledge)

- Knowledge and understanding of space mission operations terms, principles, methods and processes
- Knowledge and understanding of the operational environment, control center design, ground station network, ground facilities and launch site
- Knowledge and practical understanding of mission planning
- Knowledge and practical understanding of the different aspects of an in-orbit spacecraft operations
- Gaining and deepening knowledge of specific tools and frameworks

Use, application and generation of knowledge (use and transfer, scientific innovation)

- Perform mission planning for a given example mission
- Identify and define the necessary operational environment and ground facilities
- Define and design the in-orbit spacecraft operational aspects

Communication and cooperation

- Plan, organise and perform team work
- Shape learning process independently and take the responsibility for the results and consequences
- Address conflicts and come to solutions

Scientific self-image or professionalism

- Reflect on one's own learning and work goals and those set by others
- Present solutions to experts

Course content:

- Mission Planning
  - Mission Timeline
  - Mission Planning System
  - Unmanned Mission
  - Human Spaceflight Mission
- Introduction to Spacecraft Operational Environment
- Control Center Design
  - Infrastructure
  - Control Center Network
  - Control Center Software System
- Ground Station Network
  - Station Selection
  - Station Communication
  - LEOP and Routine Operations
- In-Orbit Spacecraft Operations
  - Telemetry, Commanding and Ranging Subsystem
  - On-Board Data-Handling Subsystem Operations
  - Attitude and Orbit Control Subsystem Operations
  - Power and Thermal Operations
  - Propulsion Subsystem Operations
- Ground Segment (Test and Simulation Facilities)
- Launch site operations and disposal

Language of teaching:	English

Prerequisites:	None
Preparation/literature:	▪ INCOSE Systems Engineering Handbook, 2015 ▪ NASA Systems Engineering Handbook, Rev. 2, 2020 ▪ Systems Engineering Body of Knowledge, v. 2.4, 2021 ▪ Space Mission Engineering: The New SMAD (Space Mission Analysis and Design), 2021 ▪ Mission Operations. Thomas Uhlig, Florian Sellmaier, and Michael Schmidhuber, Springer, 2014 If necessary, students will receive additional reading list at the beginning of the semester.
Further information:	Lecture and work materials will be provided via the AULIS learning platform.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Space Mission Operations	Prof. Dr.-Ing. Jasminka Matevska	2	Seminar	Exam (KL), 90 min.
Space Mission Operations	Prof. Dr.-Ing. Jasminka Matevska	2	Laboratory exercises	

2.17 Unmanned Aerial Vehicles (UAV)

Module leader:	Prof. Dr.-Ing. Olaf Frommann (FK5)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module for all specializations taught in the 2. Semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		Elective module in Aerospace Technologies M.Sc.	

Learning outcomes:

Knowledge and understanding

- Required elements of a self-controlling and/or autonomous system and their requirements
- Development/extension of electronic circuits, application of schematic diagrams
- Programming of microcontrollers, data handling, wireless transmission of video and data

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- Application of autopilots for fixed wing and multi-rotor aircraft
- Tuning control parameters for reliable flights
- Setting up autonomous missions and testing them

Communication and cooperation

- Teamwork/team organizing and project planning skills
- Professional technical communication with other scientists

Reflection of academic and professional identity

- Working on current research topics aids in understanding scientific needs
- Understanding safety and reliability as part of scientific ethics

Course content:

- Introduction into electronic and electro-mechanical systems
- Theoretical and experimental design
- Modeling of mechanical and electrical systems
- Sensors
- Actuators
- Micro controllers
- Software
- Practical application of autopilot systems
- Enhancement of existing UAV systems
- Integration into research projects of the Institute of Aerospace Technology

Language of teaching:	English
Prerequisites:	Basic knowledge in mechanical and electrical engineering recommended
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	AULIS learning group will be provided.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
Unmanned Aerial Vehicles	Prof. Dr.-Ing. Olaf Frommann	4	Project	Project work (PA)

2.18 Current Topics of Systems Engineering 2 (CURSE 2)

Module leader:	Prof. Dr.-Ing. Jasminka Matevska (FK4)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module taught in the 2. semester at HSB	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:		/	

Learning outcomes:

In Elective Modules, students gain theoretical and practical knowledge and problem-solving skills with regard to a specialized, program-related topic. Elective modules may contribute to one or more than one study profile of the program (Computer Science, Electronics Engineering, or Space Technologies.

The catalogue of Elective Modules of the program comprises of the modules listed below. Further topics may be included based on the current research interests and project of HSB's academic teaching staff. Students will receive information on the respective module selection in due time. Elective modules that are not listed in the examination regulations can be recognized for the module "Current Topics of Systems Engineering".

Course content:

The catalogue of Elective Modules of the program comprises of the modules listed below. Further topics may be included based on the current research interests and project of HSB's academic teaching staff. Students will receive information on the respective module selection in due time. Elective modules that are not listed in the examination regulations can be recognized for the module "Current Topics of Systems Engineering".

Language of teaching:	English
Prerequisites:	None
Preparation/literature:	See module descriptions of the Elective Modules
Further information:	See module descriptions of the Elective Modules

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
To be announced (tba)	tba	tba	tba	tba

2nd Semester (HSB): Optional Elective Modules

2.19 Deutsch als Fremdsprache / German as a Foreign Language (GERMAN)			
Module leader:	Reil, Kirstin (Programme Manager Foreign Language Studies), Centre for Teaching and Learning		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module/position within the program:	Elective module for polish students taught in the 2. semester	**Contact hours (h):**	60h
Scope and frequency of teaching:	14 classes in winter term	**Self-study (h):**	120h
Type of module and position in other study programs or continuing education offers:			
German courses refer to the Common European Framework of Reference (CEFR); learning outcomes are given here for levels A 1 and A 2: A 1= Can understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. Can introduce him/herself and others and can ask and answer questions about personal details such as where he/she lives, people he/she knows and things he/she has. Can interact in a simple way provided the other person talks slowly and clearly and is prepared to help. A 2= Can understand sentences and frequently used expressions related to areas of most immediate relevance (e.g. very basic personal and family information, shopping, local geography, employment). Can communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters. Can describe in simple terms aspects of his/her background, immediate environment and matters in areas of immediate need.			
Course content: Courses are taught on the basis of a course book (see literature)			
Language of teaching:	German / English		
Prerequisites:	Completion of the previous level		
Preparation/literature:	Course book for levels A 1 – B 1: “Netzwerk”, Klett-Verlag (to be purchased by students)		
Further information:	AULIS link will be sent to students at the start of the respective course.		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration
German for Polish students (at HSB’s Centre for Teaching and Learning)	German lecturers (contract base),	4		Written exam (KL)

3rd Semester (HSB or GDAŃSK TECH)

3.1 Master Thesis

Module leader:	Professors of the degree program		
ECTS points:	30 ECTS	**Workload (h):**	900h
Type of module/position within the program:	Mandatory module taught in the 3. Semester at GDAŃSK TECH or HSB	**Contact hours (h):**	120h
Scope and frequency of teaching:	2 block courses per semester for the master's seminar (winter term and summer term	**Self-study (h):**	780h
Use of the module in other courses of study or scientific continuing education offers:			/

Learning outcomes:

Knowledge and understanding
- Familiarize yourself thoroughly with a scientific topic and sift through and read the literature for it

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)
- Summarize relevant topics of systems engineering in a well-founded manner while maintaining scientific principles
- Investigate scientific problems and approaches in a systematic way
- Identify deficits in the status quo of an area and derive suitable scientific questions from them
- Search for and use appropriate literature
- Achieve and evaluate own solutions to these questions
- Achieve a well-founded presentation of the solutions that appropriately emphasizes the importance of your own approach
- Evaluate the solution and write thesis work including use of references

Communication and cooperation
- Apply time management in theoretical and experimental investigations
- Work under supervision in a self-directed, autonomous way to complete master thesis
- Present the results of your own work at different work statuses twice in the master's seminar and deal with questions and criticism and present the final results in the colloquium for the master's thesis
- present complex content on topics from science and practice

Reflection of academic and professional identity
- Consider the role and responsibilities of systems engineers in industry and society in their actions and outcomes
- To a large extent independent work; however, they are accompanied and supported by a professor of the degree program

Course content:
- The students deal with a current scientific question and, for the most part, independently develop the current state of research on this. Based on the current state of research, a novel solution concept is being developed and evaluated.
- The master seminar includes an introduction into the methods and techniques of scientific work
    - literature research in relevant specialist databases
    - scientific writing including setting topics, reasoning and correct quoting
    - scientific review process, giving feedback
- Results of the work are presented and discussed in the master's seminar
- The final results will be presented in a colloquium.

Language of teaching:	English
Prerequisites:	48 ECTS
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	If necessary, lecture and work materials are made available via AULIS.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching methods	Examination method(s), scope and duration

Master seminar	Professors of the degree program	8	Presentation and discussion	ungraded
Master thesis	Professors of the degree program		Supervised independent work	Master thesis + Colloquium