

# **Module Manual**

Master of Science (M.Sc.)

## **Aircraft Systems Engineering**

Cohort: Winter Term 2021

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## Table of Contents

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Table of Contents	2
Program description	3
Core qualification	4
Module M0523: Business & Management	4
Module M0524: Non-technical Courses for Master	5
Module M0763: Aircraft Energy Systems	7
Module M0771: Flight Physics	9
Module M0812: Aircraft Design I (Civil Aircraft Design)	11
Module M1155: Aircraft Cabin Systems	13
Module M0846: Control Systems Theory and Design	15
Module M1738: Selected Topics of Aeronautical Systems Engineering (Alternative B: 12 LP)	17
Module M1193: Cabin Systems Engineering	29
Module M0832: Advanced Topics in Control	32
Module M1744: Selected Topics of Aeronautical Systems Engineering (Alternative A: 6 LP)	34
Module M0764: Flight Control Systems	46
Module M1156: Systems Engineering	48
Module M1339: Design optimization and probabilistic approaches in structural analysis	50
Module M1343: Structure and properties of fibre-polymer-composites	52
Module M1690: Aircraft Design II (Special Air Vehicle Design)	54
Module M1248: Compilers for Embedded Systems	56
Module M0803: Embedded Systems	58
Module M0752: Nonlinear Dynamics	60
Module M0714: Numerical Treatment of Ordinary Differential Equations	61
Module M0840: Optimal and Robust Control	63
Module M0837: Simulation of Communication Networks	65
Module M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )	66
Module M1616: Flight Control Law Design and Application	68
Module M1340: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	70
Module M1213: Avionics for safety-critical Systems	72
Module M1204: Modelling and Optimization in Dynamics	74
Module M0633: Industrial Process Automation	76
Module M0791: Computer Architecture	78
Module M0563: Robotics	80
Module M0806: Technical Acoustics II (Room Acoustics, Computational Methods)	82
Module M0808: Finite Elements Methods	84
Module M1024: Methods of Integrated Product Development	86
Module M0836: Communication Networks	88
Module M1399: System Development Projekt	90
Thesis	91
Module M-002: Master Thesis	91

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## Program description

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### Content

The consecutive Master program „Aircraft System Engineering“ prepares participating students for diverse kind of professions in the field of aviation and related industries. During studies the technical, mathematical and natural science orientated Bachelor of Engineering is deepened. Competences for the systematical, scientific and independent solution of responsible tasks in industry and research are taught.

Students learn how to use typical methods of systems engineering as well as the application of modern, computer-based techniques for system design, analysis and evaluation. This count among others methods such as model based systems engineering or model based / virtual testing. Furthermore required knowledge from different fields of aviation including aircraft systems, cabin systems, air transportation system, preliminary aircraft design, flight physics and material science is discussed.

Additionally students get insight into current research activities, e.g. in the area of fuel cells and electrical energy supply, actuators, virtual integration and aircraft level evaluation, avionics systems and software, hydraulic energy supply and integrated aircraft design.

Students are specializing in one of three fields of specialization and gaining the competence to work at the interfaces between these fields. According to their individual focuses students can adjust their studies very flexible due to the various numbers of offered elective courses.

### Career prospects

The consecutive Master program „Aircraft System Engineering“ prepares participating students for diverse kind of professions in the field of aviation and related industries. Graduates can, due to their specialization in one of the fields of Aircraft Systems Engineering, Cabin Systems, Air Transportation System or Preliminary Aircraft Design, work directly in one of these. Furthermore they have various methodically and interdisciplinary knowledge, so that they are prepared for multidisciplinary kind of jobs.

Graduates can work at Universities or other research institutes or apply directly for jobs in the industry. There they can start a carrier as a technical expert or qualify, with growing experiences, for technical management jobs such as project, group, team or development manager.

Besides starting their career in the aviation industry the master program allows, due to its system technical character, graduates to apply for jobs in other industries like the automotive or wind energy industry.

### Learning target

Graduates can:

- Analyze and solve problems in a scientific way, even if they are defined unusual or incomplete and having competitive specifications;
- Abstract and formulate complex problems from a new or developing part of their discipline;
- Apply innovative methods to fundamental problems and develop new scientific methods;
- Recognize information demand, find and supply information;
- Plan and conduct theoretical and experimental analysis;
- Interpret data in a critical way and draw conclusions from them;
- Investigate and evaluate the application of emerging technologies;

Graduates are able to:

- Develop concepts and solutions for fundamental, partly unusual problems if necessary by involving other disciplines;
- Create and develop new products, processes and methods;
- Use engineering judgment in order to work with complex, potentially incomplete information, recognize contradictions and deal with them;
- Classify methodically and combine systematically knowledge from different disciplines and deal with complexity;
- Work themselves systematically into new tasks within a short period of time;
- Reflect non-technical effects of engineers work systematically and take them responsible into account;
- Work out solutions that have a demand for depend methodical competences;
- Work scientifically with the goal to achieve a PhD degree.

### Program structure

The master program „Aircraft Systems Engineering“ is designed modular and oriented at the university wide program structure with an unified module size (multiples of six ECTS). It consists of a 60 ECTS curriculum of key qualifications that has to be taken by all students. It includes, among other, a so called system development project. Furthermore students have to choose one of the three offered curricula of specialization (30 ECTS), containing one obligatory module and a catalog of elective modules. The master program is completed by a master thesis.

All obligatory modules of the curriculum of key qualification and curricula of specializations are offered in the first two semesters of studies. The third semester only contains elective modules, which ease students to plan a semester abroad.

**Core qualification**

The students extend their knowledge and skills in advanced engineering, aviation related subjects. Besides technical knowledge students strengthen their methodical skills in the fields of Aircraft Systems Engineering, Cabin Systems, Aircraft Design, Flight Physics and Systems Engineering. By performing the Systems Engineering Development Project, students apply their acquired skills in teams on a practical engineering problem.

**Module M0523: Business & Management**

<b>Module Responsible</b>	Prof. Matthias Meyer
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	None
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>• Students are able to find their way around selected special areas of management within the scope of business management.</li> <li>• Students are able to explain basic theories, categories, and models in selected special areas of business management.</li> <li>• Students are able to interrelate technical and management knowledge.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>• Students are able to apply basic methods in selected areas of business management.</li> <li>• Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>• Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.</li> </ul>	
<b>Workload in Hours</b>	Depends on choice of courses
<b>Credit points</b>	6

**Courses**

**Information regarding lectures and courses can be found in the corresponding module handbook published separately.**

Module M0524: Non-technical Courses for Master	
<b>Module Responsible</b>	Dagmar Richter
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	None
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b> <i>Knowledge</i>	<p><b>The Nontechnical Academic Programms (NTA)</b></p> <p>imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its <b>teaching architecture</b>, in its <b>teaching and learning arrangements</b>, in <b>teaching areas</b> and by means of teaching offerings in which students can qualify by opting for <b>specific competences</b> and a <b>competence level</b> at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.</p> <p><b>The Learning Architecture</b></p> <p>consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses.</p> <p>The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles".</p> <p>The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies.</p> <p><b>Teaching and Learning Arrangements</b></p> <p>provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses.</p> <p><b>Fields of Teaching</b></p> <p>are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.</p> <p>The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.</p> <p><b>The Competence Level</b></p> <p>of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.</p> <p>This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.</p> <p><b>Specialized Competence (Knowledge)</b></p> <p>Students can</p> <ul style="list-style-type: none"> <li>• explain specialized areas in context of the relevant non-technical disciplines,</li> <li>• outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area,</li> <li>• different specialist disciplines relate to their own discipline and differentiate it as well as make connections,</li> <li>• sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity,</li> <li>• Can communicate in a foreign language in a manner appropriate to the subject.</li> </ul> <p><i>Skills</i> <b>Professional Competence (Skills)</b></p> <p>In selected sub-areas students can</p> <ul style="list-style-type: none"> <li>• apply basic and specific methods of the said scientific disciplines,</li> <li>• question a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,</li> <li>• to handle simple and advanced questions in aforementioned scientific disciplines in a successful manner,</li> <li>• justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.</li> </ul>

<p><b>Personal Competence</b> <i>Social Competence</i></p>	<p><b>Personal Competences (Social Skills)</b></p> <p>Students will be able</p> <ul style="list-style-type: none"> <li>• to learn to collaborate in different manner,</li> <li>• to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,</li> <li>• to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen),</li> <li>• to explain nontechnical items to auditorium with technical background knowledge.</li> </ul>
<p><i>Autonomy</i></p>	<p><b>Personal Competences (Self-reliance)</b></p> <p>Students are able in selected areas</p> <ul style="list-style-type: none"> <li>• to reflect on their own profession and professionalism in the context of real-life fields of application</li> <li>• to organize themselves and their own learning processes</li> <li>• to reflect and decide questions in front of a broad education background</li> <li>• to communicate a nontechnical item in a competent way in written form or verbally</li> <li>• to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)</li> </ul>
<p><b>Workload in Hours</b></p>	<p>Depends on choice of courses</p>
<p><b>Credit points</b></p>	<p>6</p>

**Courses**

**Information regarding lectures and courses can be found in the corresponding module handbook published separately.**

Module M0763: Aircraft Energy Systems				
Courses				
Title		Typ	Hrs/wk	CP
Aircraft Energy Systems (L0735)		Lecture	3	4
Aircraft Energy Systems (L0739)		Recitation Section (large)	2	2
<b>Module Responsible</b>	Prof. Frank Thielecke			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Thermodynamics</li> <li>• Electrical Engineering</li> <li>• Hydraulics</li> <li>• Control Systems</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• Describe essential components and design points of hydraulic, electrical and high-lift systems</li> <li>• Give an overview of the functionality of air conditioning systems</li> <li>• Explain the need for high-lift systems such as its functionality and effects</li> <li>• Assess the challenge during the design of supply systems of an aircraft</li> </ul> <p><i>Skills</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• Design hydraulic and electric supply systems of aircrafts</li> <li>• Design high-lift systems of aircrafts</li> <li>• Analyze the thermodynamic behaviour of air conditioning systems</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• Perform system design in groups and present and discuss results</li> </ul> <p><i>Autonomy</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• Reflect the contents of lectures autonomously</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	165 Minutes			
<b>Assignment for the Following Curricula</b>	Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			

Course L0735: Aircraft Energy Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Hydraulic Energy Systems (Fluids; pressure loss in valves and pipes; components of hydraulic systems like pumps, valves, etc.; pressure/flow characteristics; actuators; tanks; power and heat balances; emergency power)</li> <li>Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis)</li> <li>High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices)</li> <li>Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies; cabin pressure control systems)</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>Moir, Seabridge: Aircraft Systems</li> <li>Green: Aircraft Hydraulic Systems</li> <li>Torenbek: Synthesis of Subsonic Airplane Design</li> <li>SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes</li> </ul>

Course L0739: Aircraft Energy Systems	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course



Module M0771: Flight Physics			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Aerodynamics and Flight Mechanics I (L0727)		Lecture	3              3
Flight Mechanics II (L0730)		Lecture	2              2
Flight Mechanics II (L0731)		Recitation Section (large)	1              1
<b>Module Responsible</b>	Prof. Frank Thielecke		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Thermodynamics</li> <li>• Aviation</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 Minutes (WS) + 90 Minutes (SS)		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Course L0727: Aerodynamics and Flight Mechanics I	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Ralf Heinrich, Mike Montel
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Aerodynamics (fundamental equations of aerodynamics; compressible and incompressible flows; airfoils and wings; viscous flows)</li> <li>• Flight Mechanics (Equations of motion; flight performance; control surfaces; derivatives; lateral stability and control; trim conditions; flight maneuvers)</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II</li> <li>• Etkin, B.: Dynamics of Atmospheric Flight</li> <li>• Sachs/Hafer: Flugmechanik</li> <li>• Brockhaus: Flugregelung</li> <li>• J.D. Anderson: Introduction to flight</li> </ul>

Course L0730: Flight Mechanics II	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• stationary asymmetric flight</li> <li>• dynamics of lateral movement</li> <li>• methods of flight simulation</li> <li>• experimental methods of flight mechanics</li> <li>• model validation using system identification</li> <li>• wind tunnel techniques</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II</li> <li>• Etkin, B.: Dynamics of Atmospheric Flight</li> <li>• Sachs/Hafer: Flugmechanik</li> <li>• Brockhaus: Flugregelung</li> <li>• J.D. Anderson: Introduction to flight</li> </ul>

Course L0731: Flight Mechanics II	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0812: Aircraft Design I (Civil Aircraft Design)				
Courses				
Title	Typ	Hrs/wk	CP	
Aircraft Design I (Design of Transport Aircraft) (L0820)	Lecture	3	3	
Aircraft Design I (Design of Transport Aircraft) (L0834)	Recitation Section (large)	2	3	
<b>Module Responsible</b>	Prof. Volker Gollnick			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Bachelor Mech. Eng.</li> <li>• Bachelor Traffic Systems</li> <li>• Vordiplom Mech. Eng.</li> <li>• Module Air Transport Systems</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <ol style="list-style-type: none"> <li>1. Principle understanding of integrated and civil aircraft design</li> <li>2. Understanding of the interactions and contributions of the various disciplines</li> <li>3. Impact of the relevant design parameter on the civil aircraft design</li> <li>4. Introduction of the principle design methods</li> </ol> <p><i>Skills</i></p> <p>Understanding and application of design and calculation methods</p> <p>Understanding of interdisciplinary and integrative interdependencies</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Working in interdisciplinary teams</p> <p>Communication</p> <p><i>Autonomy</i></p> <p>Organization of workflows and -strategies</p>			
<b>Workload in Hours</b>				
<b>Credit points</b>				
<b>Course achievement</b>				
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	180 min			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			

<b>Course L0820: Aircraft Design I (Design of Transport Aircraft)</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Volker Gollnick, Jens Thöben
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction into the aircraft design process</p> <ol style="list-style-type: none"> <li>1. Introduction/process of aircraft design/various aircraft configurations</li> <li>2. Requirements and design objectives, main design parameter (u.a. payload-range-diagramme)</li> <li>3. Statistical methods in overall aircraft design/data base methods</li> <li>4. Cabin design (fuselage sizing, cabin interior, loading systems)</li> <li>5. Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics)</li> <li>6. Wing Design</li> <li>7. Tail wings and landing gear</li> <li>8. Principles of engine design and integration</li> <li>9. Flight performance in cruise</li> <li>10. Take off and landing field length</li> <li>11. Loads and V-n-diagramme</li> <li>12. Operating cost calculation</li> </ol>
<b>Literature</b>	<p>J. Roskam: "Airplane Design"</p> <p>D.P. Raymer: "Aircraft Design - A Conceptual Approach"</p> <p>J.P. Fielding: "Introduction to Aircraft Design"</p> <p>Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"</p>

<b>Course L0834: Aircraft Design I (Design of Transport Aircraft)</b>	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Volker Gollnick, Jens Thöben
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1155: Aircraft Cabin Systems				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Aircraft Cabin Systems (L1545)		Lecture	3	4
Aircraft Cabin Systems (L1546)		Recitation Section (large)	1	2
<b>Module Responsible</b>	Prof. Ralf God			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Thermodynamics</li> <li>• Electrical Engineering</li> <li>• Control Systems</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• describe cabin operations, equipment in the cabin and cabin Systems</li> <li>• explain the functional and non-functional requirements for cabin Systems</li> <li>• elucidate the necessity of cabin operating systems and emergency Systems</li> <li>• assess the challenges human factors integration in a cabin environment</li> </ul> <p><i>Skills</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• design a cabin layout for a given business model of an Airline</li> <li>• design cabin systems for safe operations</li> <li>• design emergency systems for safe man-machine interaction</li> <li>• solve comfort needs and entertainment requirements in the cabin</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• understand existing system solutions and discuss their ideas with experts</li> </ul> <p><i>Autonomy</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• Reflect the contents of lectures and expert presentations self-dependent</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 Minutes			
<b>Assignment for the Following Curricula</b>	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

Course L1545: Aircraft Cabin Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge about aircraft cabin systems and cabin operations. A basic understanding of technological and systems engineering effort to maintain an artificial but comfortable and safe travel and working environment at cruising altitude is to be achieved.</p> <p>The course provides a comprehensive overview of current technology and cabin systems in modern passenger aircraft. The fulfillment of requirements for the cabin as the central system of work are covered on the basis of the topics comfort, ergonomics, human factors, operational processes, maintenance and energy supply:</p> <ul style="list-style-type: none"> <li>• Materials used in the cabin</li> <li>• Ergonomics and human factors</li> <li>• Cabin interior and non-electrical systems</li> <li>• Cabin electrical systems and lights</li> <li>• Cabin electronics, communication-, information- and IFE-systems</li> <li>• Cabin and passenger process chains</li> <li>• RFID Aircraft Parts Marking</li> <li>• Energy sources and energy conversion</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>- Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999</p> <p>- Rossow, C.-C., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014</p> <p>- Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008</p> <p>- Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003</p> <p>- Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006</p> <p>- Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006</p>

Course L1546: Aircraft Cabin Systems	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Module M0846: Control Systems Theory and Design</b>				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>	
Control Systems Theory and Design (L0656)	Lecture	2	4	
Control Systems Theory and Design (L0657)	Recitation Section (small)	2	2	
<b>Module Responsible</b>	Prof. Herbert Werner			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Introduction to Control Systems			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space</li> <li>They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively</li> <li>They can explain the significance of a minimal realisation</li> <li>They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection</li> <li>They can extend all of the above to multi-input multi-output systems</li> <li>They can explain the z-transform and its relationship with the Laplace Transform</li> <li>They can explain state space models and transfer function models of discrete-time systems</li> <li>They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation</li> <li>They can explain how a state space model can be constructed from a discrete-time impulse response</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>Students can transform transfer function models into state space models and vice versa</li> <li>They can assess controllability and observability and construct minimal realisations</li> <li>They can design LQG controllers for multivariable plants</li> <li>They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate</li> <li>They can identify transfer function models and state space models of dynamic systems from experimental data</li> <li>They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink)</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	<p>Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.</p> <p>They can assess their knowledge in weekly on-line tests and thereby control their learning progress.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	<p>Electrical Engineering: Core qualification: Compulsory</p> <p>Energy Systems: Core qualification: Elective Compulsory</p> <p>Aircraft Systems Engineering: Core qualification: Elective Compulsory</p> <p>Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory</p> <p>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory</p> <p>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory</p> <p>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory</p> <p>Mechatronics: Core qualification: Compulsory</p> <p>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory</p> <p>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory</p> <p>Product Development, Materials and Production: Core qualification: Elective Compulsory</p> <p>Theoretical Mechanical Engineering: Core qualification: Compulsory</p>			

Course L0656: Control Systems Theory and Design	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Herbert Werner
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>State space methods (single-input single-output)</p> <ul style="list-style-type: none"> <li>• State space models and transfer functions, state feedback</li> <li>• Coordinate basis, similarity transformations</li> <li>• Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem</li> <li>• Controllability and pole placement</li> <li>• State estimation, observability, Kalman decomposition</li> <li>• Observer-based state feedback control, reference tracking</li> <li>• Transmission zeros</li> <li>• Optimal pole placement, symmetric root locus</li> </ul> <p>Multi-input multi-output systems</p> <ul style="list-style-type: none"> <li>• Transfer function matrices, state space models of multivariable systems, Gilbert realization</li> <li>• Poles and zeros of multivariable systems, minimal realization</li> <li>• Closed-loop stability</li> <li>• Pole placement for multivariable systems, LQR design, Kalman filter</li> </ul> <p>Digital Control</p> <ul style="list-style-type: none"> <li>• Discrete-time systems: difference equations and z-transform</li> <li>• Discrete-time state space models, sampled data systems, poles and zeros</li> <li>• Frequency response of sampled data systems, choice of sampling rate</li> </ul> <p>System identification and model order reduction</p> <ul style="list-style-type: none"> <li>• Least squares estimation, ARX models, persistent excitation</li> <li>• Identification of state space models, subspace identification</li> <li>• Balanced realization and model order reduction</li> </ul> <p>Case study</p> <ul style="list-style-type: none"> <li>• Modelling and multivariable control of a process evaporator using Matlab and Simulink</li> </ul> <p>Software tools</p> <ul style="list-style-type: none"> <li>• Matlab/Simulink</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Werner, H., Lecture Notes „Control Systems Theory and Design“</li> <li>• T. Kailath "Linear Systems", Prentice Hall, 1980</li> <li>• K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997</li> <li>• L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999</li> </ul>

Course L0657: Control Systems Theory and Design	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Herbert Werner
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course



<b>Module M1738: Selected Topics of Aeronautical Systems Engineering (Alternative B: 12 LP)</b>			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Advanced Training Course SE-ZERT (L2739)	Project-/problem-based Learning	2	3
Airline Operations (L1310)	Lecture	3	3
Fatigue & Damage Tolerance (L0310)	Lecture	2	3
Flight Guidance (L0848)	Lecture	2	2
Flight Guidance (L0854)	Recitation Section (large)	1	1
Airport Operations (L1276)	Lecture	3	3
Airport Planning (L1275)	Lecture	2	2
Airport Planning (L1469)	Recitation Section (small)	1	1
Lightweight Design Practical Course (L1258)	Project-/problem-based Learning	3	3
Aviation Security (L1549)	Lecture	2	2
Aviation Security (L1550)	Recitation Section (small)	1	1
Aviation and Environment (L2376)	Lecture	3	3
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture	2	2
Mission Management (L2374)	Lecture	2	2
Mission Management (L2375)	Recitation Section (small)	1	1
Turbo Jet Engines (L0908)	Lecture	2	3
Structural Mechanics of Fibre Reinforced Composites (L1514)	Lecture	2	3
Structural Mechanics of Fibre Reinforced Composites (L1515)	Recitation Section (large)	1	1
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Materials Testing (L0949)	Lecture	2	2
Reliability in Engineering Dynamics (L0176)	Lecture	2	2
Reliability in Engineering Dynamics (L1303)	Recitation Section (small)	1	2
Reliability of Aircraft Systems (L0749)	Lecture	2	3
<b>Module Responsible</b>	Prof. Frank Thielecke		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Thermodynamics</li> <li>• Electrical Engineering</li> <li>• Hydraulics</li> <li>• Control Systems</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> <li>• Students are able to find their way through selected special areas within systems engineering, air transportation system and material science</li> <li>• Students are able to explain basic models and procedures in selected special areas.</li> <li>• Students are able to interrelate scientific and technical knowledge.</li> </ul> <p><i>Skills</i></p> <p>Students are able to apply basic methods in selected areas of engineering.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i></p> <p><i>Autonomy</i></p> <p>Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.</p>		
<b>Workload in Hours</b>	Depends on choice of courses		
<b>Credit points</b>	12		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory		

Course L2739: Advanced Training Course SE-ZERT	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	120 min
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2.  ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).

Course L1310: Airline Operations	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Karl Echtermeyer
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction and overview</li> <li>2. Airline business models</li> <li>3. Interdependencies in flight planning (network management, slot management, network structures, aircraft circulation)</li> <li>4. Operative flight preparation (weight &amp; balance, payload/range, etc.)</li> <li>5. fleet policy</li> <li>6. Aircraft assessment and fleet planning</li> <li>7. Airline organisation</li> <li>8. Aircraft maintenance, repair and overhaul</li> </ol>
<b>Literature</b>	Volker Gollnick, Dieter Schmitt: The Air Transport System, Springer Berlin Heidelberg New York, 2014  Paul Clark: "Buying the Big Jets", Ashgate 2008  Mike Hirst: The Air Transport System, AIAA, 2008

Course L0310: Fatigue & Damage Tolerance	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	45 min
<b>Lecturer</b>	Dr. Martin Flamm
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
<b>Literature</b>	Jaap Schijve, Fatigue of Structures and Materials. Kluwer Academic Publisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L0848: Flight Guidance	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.)</p> <p>Cockpit systems and Avionics (cockpit design, cockpit equipment, displays, computers and bus systems)</p> <p>Principles of flight measurement techniques (Measurement of position (geometric methods, distance measurement, direction measurement) Determination of the aircraft attitude (magnetic field- and inertial sensors) Measurement of speed</p> <p>Principles of Navigation</p> <p>Radio navigation</p> <p>Satellite navigation</p> <p>Airspace surveillance (radar systems)</p> <p>Communication systems</p> <p>Integrated Navigation and Guidance Systems</p>
<b>Literature</b>	<p>Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2011</p> <p>Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013</p> <p>Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2016</p> <p>R.P.G. Collinson „Introduction to Avionics“, Springer Berlin Heidelberg New York 2003</p>

Course L0854: Flight Guidance	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1276: Airport Operations	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	Prof. Volker Gollnick, Peter Willems (geb. Bießlich)
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground handling Terminal operations
<b>Literature</b>	Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003

Course L1275: Airport Planning	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Ulrich Hap
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction, definitions, overviewg</li> <li>2. Runway systems</li> <li>3. Air space strcutres around airports</li> <li>4. Airfield lightings, marking and information</li> <li>5. Airfield and terminal configuration</li> </ol>
<b>Literature</b>	<p>N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley &amp; Sons, 1991</p> <p>Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003</p>

Course L1469: Airport Planning	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Ulrich Hap
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1258: Lightweight Design Practical Course	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Prof. Dieter Krause
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Development of a sandwich structure made of fibre reinforced plastics</p> <ul style="list-style-type: none"> <li>• getting familiar with fibre reinforced plastics as well as lightweight design</li> <li>• Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA)</li> <li>• Determination of material properties based on sample tests</li> <li>• manufacturing of the structure in the composite lab</li> <li>• Testing of the developed structure</li> <li>• Concept presentation</li> <li>• Self-organised teamwork</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005.</li> <li>• Puck, A., „Festigkeitsanalyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996.</li> <li>• R&amp;G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009.</li> <li>• VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“</li> <li>• Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006.</li> <li>• Klein, B., „Leichtbau-Konstruktion“, Vieweg &amp; Sohn, Braunschweig, 1989.</li> <li>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986.</li> <li>• Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986.</li> <li>• Backmann, B.F., „Composite Structures, Design, Safety and Innovation“, Oxford (UK), Elsevier, 2005.</li> <li>• Krause, D., „Leichtbau“, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.</li> <li>• Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials“, Hamburg, TUHH - TuTech Innovation GmbH, 2005.</li> </ul>

Course L1549: Aviation Security	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.</p> <p>The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:</p> <ul style="list-style-type: none"> <li>• Historical development</li> <li>• The special role of air transport</li> <li>• Motive and attack vectors</li> <li>• The human factor</li> <li>• Threats and risk</li> <li>• Regulations and law</li> <li>• Organization and implementation of aviation security tasks</li> <li>• Passenger and baggage checks</li> <li>• Cargo screening and secure supply chain</li> <li>• Safety technologies</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Giumulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</li> <li>- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</li> </ul>

<b>Course L1550: Aviation Security</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.</p> <p>The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:</p> <ul style="list-style-type: none"> <li>• Historical development</li> <li>• The special role of air transport</li> <li>• Motive and attack vectors</li> <li>• The human factor</li> <li>• Threats and risk</li> <li>• Regulations and law</li> <li>• Organization and implementation of aviation security tasks</li> <li>• Passenger and baggage checks</li> <li>• Cargo screening and secure supply chain</li> <li>• Safety technologies</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</p> <p>- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</p>

Course L2376: Aviation and Environment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>The lecture provides the necessary basics and methods for understanding the interactions between air traffic and the environment, both in terms of the effects of weather / climate on flying and with regard to the effects of air traffic on pollutant emissions, noise and climate.</p> <p>The following topics are covered:</p> <ul style="list-style-type: none"> <li>• Atmospheric physics / chemistry <ul style="list-style-type: none"> <li>◦ Structure and statics</li> <li>◦ Dynamics (water cycle, formation of weather events, high and low pressure areas, wind, gusts and turbulence)</li> <li>◦ Cloud physics (thermodynamics, contrails)</li> <li>◦ Radiation physics (energy balance, greenhouse effect)</li> <li>◦ Photochemistry (ozone chemistry)</li> </ul> </li> <li>• Impact of weather on flying <ul style="list-style-type: none"> <li>◦ Atmospheric influences on flight performance</li> <li>◦ Flight planning</li> <li>◦ Disturbances due to weather, e.g. thunderstorms, winter weather (icing), clear air turbulence, visibility</li> <li>◦ Effects of climate change and adaptation</li> </ul> </li> <li>• Effects of air traffic on the environment and climate <ul style="list-style-type: none"> <li>◦ Aviation pollutant emissions</li> <li>◦ Effect of emissions on concentrations in the atmosphere</li> <li>◦ Climate metrics / models and background scenarios</li> <li>◦ Emissions inventories</li> </ul> </li> <li>• Mitigation measures <ul style="list-style-type: none"> <li>◦ Technological measures, e.g. climate-optimized aircraft design</li> <li>◦ Alternative fuels</li> <li>◦ Operational measures, e.g. climate-optimized flight planning</li> <li>◦ Environmental policy measures, e.g. EU-ETS, CORSIA</li> <li>◦ Potentials and comparison, concept of eco-efficiency</li> </ul> </li> <li>• Local environmental impacts <ul style="list-style-type: none"> <li>◦ Local air quality (particulate matter, other emissions near the ground)</li> <li>◦ Noise (noise sources, noise metrics, noise impact, measurement, certification, psychoacoustics, noise mitigation)</li> <li>◦ Health effects</li> </ul> </li> <li>• Aspects of sustainability <ul style="list-style-type: none"> <li>◦ Other aspects, including life cycle emissions, disposal/recycling</li> <li>◦ Relation to global goals, e.g. United Nations goals for sustainable development, Paris climate agreement</li> </ul> </li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Ruijgrok, G.: Elements of Aircraft Pollution, Delft University Press, 2005</li> <li>• Friedrich, R., Reis, S.: Emissions of Air Pollutants, Springer 2004</li> <li>• Janic, M.: The Sustainability of Air Transportation, Ashgate, 2007</li> <li>• Schumann, U. (ed.): Atmospheric Physics: Background - Methods - Trends, Springer, Berlin, Heidelberg, 2012</li> <li>• Spiridonov, V., Curic, M.: Fundamentals of Meteorology, Springer, 2021</li> <li>• Kaltschmitt, M., Neuling, U.: Biokerosene - Status and Prospects, Springer, 2018</li> <li>• Roedel, W., Wagner, T.: Physik unserer Umwelt: Die Atmosphäre, Springer, 2017</li> <li>• W. Bräunling: Flugzeugtriebwerke. Springer-Verlag Berlin, Deutschland, 2009</li> <li>• G. Brüning, X. Hafer, G. Sachs: Flugleistungen, Springer, 1993</li> </ul>

Course L0950: Mechanisms, Systems and Processes of Materials Testing	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Dr. Jan Oke Peters
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Application, analysis and discussion of basic and advanced testing methods to ensure correct selection of applicable testing procedure for investigation of part/materials deficiencies</p> <ul style="list-style-type: none"> <li>• Stress-strain relationships</li> <li>• Strain gauge application</li> <li>• Visko elastic behavior</li> <li>• Tensile test (strain hardening, necking, strain rate)</li> <li>• Compression test, bending test, torsion test</li> <li>• Crack growth upon static loading (J-Integral)</li> <li>• Crack growth upon cyclic loading (micro- und macro cracks)</li> <li>• Effect of notches</li> <li>• Creep testing (physical creep test, influence of stress and temperature, Larson Miller parameter)</li> <li>• Wear testing</li> <li>• Non destructive testing application for overhaul of jet engines</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• E. Macherauch: Praktikum in Werkstoffkunde, Vieweg</li> <li>• G. E. Dieter: Mechanical Metallurgy, McGraw-Hill</li> <li>• R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg</li> <li>• R. Bürgel: Werkstoffe sicher beurteilen und richtig einsetzen, Vieweg</li> </ul>

Course L2374: Mission Management	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	<p>Brockhaus, Alles, Luckner: Flugregelung, Springer Verlag, 2011</p> <p>R.P.G Collinson: Introduction to Avionics Systems, Springer Verlag, 2011</p>

Course L2375: Mission Management	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course



Course L0908: Turbo Jet Engines	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	45 min
<b>Lecturer</b>	Dr. Burkhard Andrich
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Cycle of the gas turbine</li> <li>• Thermodynamics of gas turbine components</li> <li>• Wing-, grid- and stage-sizing</li> <li>• Operating characteristics of gas turbine components</li> <li>• Sizing criteria's for jet engines</li> <li>• Development trends of gas turbines and jet engines</li> <li>• Maintenance of jet engines</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Bräunling: Flugzeugtriebwerke</li> <li>• Engmann: Technologie des Fliegens</li> <li>• Kerrebrock: Aircraft Engines and Gas Turbines</li> </ul>

Course L1514: Structural Mechanics of Fibre Reinforced Composites	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Classical laminate theory</p> <p>Rules of mixture</p> <p>Failure mechanisms and criteria of composites</p> <p>Boundary value problems of isotropic and anisotropic shells</p> <p>Stability of composite structures</p> <p>Optimization of laminated composites</p> <p>Modelling composites in FEM</p> <p>Numerical multiscale analysis of textile composites</p> <p>Progressive failure analysis</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, aktuelle Auflage.</li> <li>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, , aktuelle Auflage.</li> <li>• Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells“, CRC Publishing, Boca Raton et al., current edition.</li> <li>• Jones, R.M., „Mechanics of Composite Materials“, Scripta Book Co., Washington, current edition.</li> <li>• Timoshenko, S.P., Gere, J.M., „Theory of elastic stability“, McGraw-Hill Book Company, Inc., New York, current edition.</li> <li>• Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates“, Chapman and Hall, London, current edition.</li> <li>• Herakovich, C.T., „Mechanics of fibrous composites“, John Wiley and Sons, Inc., New York, current edition.</li> <li>• Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate“, aktuelle Auflage.</li> </ul>

Course L1515: Structural Mechanics of Fibre Reinforced Composites	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1820: System Simulation	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Dr. Stefan Wischhusen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> <li>• Instruction and modelling of physical processes</li> <li>• Modelling and limits of model</li> <li>• Time constant, stiffness, stability, step size</li> <li>• Terms of object orientated programming</li> <li>• Differential equations of simple systems</li> <li>• Introduction into Modelica</li> <li>• Introduction into simulation tool</li> <li>• Example:Hydraulic systems and heat transfer</li> <li>• Example: System with different subsystems</li> </ul>
<b>Literature</b>	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", <a href="http://book.xogeny.com">http://book.xogeny.com</a>, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

Course L1821: System Simulation	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Dr. Stefan Wischhusen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L0949: Materials Testing	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Dr. Jan Oke Peters
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Application and analysis of basic mechanical as well as non-destructive testing of materials <ul style="list-style-type: none"> <li>• Determination elastic constants</li> <li>• Tensile test</li> <li>• Fatigue test (testing with constant stress, strain, or plastiv strain amplitude, low and high cycle fatigue, mean stress effect)</li> <li>• Crack growth upon static loading (stress intensity factor, fracture toughness)</li> <li>• Creep test</li> <li>• Hardness test</li> <li>• Charpy impact test</li> <li>• Non destructive testing</li> </ul>
<b>Literature</b>	E. Macherauch: Praktikum in Werkstoffkunde, Vieweg G. E. Dieter: Mechanical Metallurgy, McGraw-Hill

Course L0176: Reliability in Engineering Dynamics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min.
<b>Lecturer</b>	NN
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	Method for calculation and testing of reliability of dynamic machine systems <ul style="list-style-type: none"> <li>• Modeling</li> <li>• System identification</li> <li>• Simulation</li> <li>• Processing of measurement data</li> <li>• Damage accumulation</li> <li>• Test planning and execution</li> </ul>
<b>Literature</b>	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

Course L1303: Reliability in Engineering Dynamics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	NN
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Course L0749: Reliability of Aircraft Systems</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wiczorek
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Functions of reliability and safety (regulations, certification requirements)</li> <li>• Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment)</li> <li>• Reliability analysis of electrical and mechanical systems</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• CS 25.1309</li> <li>• SAE ARP 4754</li> <li>• SAE ARP 4761</li> </ul>

Module M1193: Cabin Systems Engineering				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Computer and communication technology in cabin electronics and avionics (L1557)		Lecture	2	2
Computer and communication technology in cabin electronics and avionics (L1558)		Recitation Section (small)	1	1
Model-Based Systems Engineering (MBSE) with SysML/UML (L1551)		Project-/problem-based Learning	3	3
<b>Module Responsible</b>	Prof. Ralf God			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Thermodynamics</li> <li>• Electrical Engineering</li> <li>• Control Systems</li> </ul> Previous knowledge in: <ul style="list-style-type: none"> <li>• Systems Engineering</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• describe the structure and operation of computer architectures</li> <li>• explain the structure and operation of digital communication Networks</li> <li>• explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraft Data Communication Network (ADCN)</li> <li>• understand the approach of Model-Based Systems Engineering (MBSE) in the design of hardware and software-based cabin systems</li> </ul> <p><i>Skills</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• understand, operate and maintain a Minicomputer</li> <li>• build up a network communication and communicate with other network participants</li> <li>• connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network</li> <li>• model system functions by means of formal languages SysML/UML and generate software code from the models</li> <li>• execute software code on a minicomputer</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• elaborate partial results and merge with others to form a complete solution</li> </ul> <p><i>Autonomy</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• organize and schedule their practical tasks</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 minutes			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			

<b>Course L1557: Computer and communication technology in cabin electronics and avionics</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.</p> <p>The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:</p> <ul style="list-style-type: none"> <li>• History of computer and network technology</li> <li>• Layer model in computer technology</li> <li>• Computer architectures (PC, IPC, Embedded Systems)</li> <li>• BIOS, UEFI and operating system (OS)</li> <li>• Programming languages (machine code and high-level languages)</li> <li>• Applications and Application Programming Interfaces</li> <li>• External interfaces (serial, USB, Ethernet)</li> <li>• Layer model in network technology</li> <li>• Network topologies</li> <li>• Network components</li> <li>• Bus access procedures</li> <li>• Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)</li> <li>• Cabin electronics and cabin networks</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003</p> <p>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004</p> <p>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006</p>

<b>Course L1558: Computer and communication technology in cabin electronics and avionics</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.</p> <p>The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:</p> <ul style="list-style-type: none"> <li>• History of computer and network technology</li> <li>• Layer model in computer technology</li> <li>• Computer architectures (PC, IPC, Embedded Systems)</li> <li>• BIOS, UEFI and operating system (OS)</li> <li>• Programming languages (machine code and high-level languages)</li> <li>• Applications and Application Programming Interfaces</li> <li>• External interfaces (serial, USB, Ethernet)</li> <li>• Layer model in network technology</li> <li>• Network topologies</li> <li>• Network components</li> <li>• Bus access procedures</li> <li>• Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)</li> <li>• Cabin electronics and cabin networks</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003</p> <p>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004</p> <p>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006</p>

<b>Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):</p> <ul style="list-style-type: none"> <li>• What is a model?</li> <li>• What is Systems Engineering?</li> <li>• Survey of MBSE methodologies</li> <li>• The modelling languages SysML /UML</li> <li>• Tools for MBSE</li> <li>• Best practices for MBSE</li> <li>• Requirements specification, functional architecture, specification of a solution</li> <li>• From model to software code</li> <li>• Validation and verification: XIL methods</li> <li>• Accompanying MBSE project</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>- Weilkens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008</p> <p>- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering &amp; Tech, 2011</p>

Module M0832: Advanced Topics in Control				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Advanced Topics in Control (L0661)		Lecture	2	3
Advanced Topics in Control (L0662)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Herbert Werner			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Students can explain the advantages and shortcomings of the classical gain scheduling approach</li> <li>• They can explain the representation of nonlinear systems in the form of quasi-LPV systems</li> <li>• They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions</li> <li>• They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems</li> <li>• They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures</li> </ul> <ul style="list-style-type: none"> <li>• Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems</li> <li>• They can explain the convergence properties of first order consensus protocols</li> <li>• They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models</li> </ul> <ul style="list-style-type: none"> <li>• Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array</li> <li>• They can explain (in outline) the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions for distributed controllers</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Students are capable of constructing LPV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, LFT or general LPV models</li> <li>• They are able to use standard software tools (Matlab robust control toolbox) for these tasks</li> </ul> <ul style="list-style-type: none"> <li>• Students are able to design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided</li> </ul> <ul style="list-style-type: none"> <li>• Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can work in small groups and arrive at joint results.			
<i>Autonomy</i>	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			



Course L0661: Advanced Topics in Control	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Herbert Werner
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Linear Parameter-Varying (LPV) Gain Scheduling                             <ul style="list-style-type: none"> <li>- Linearizing gain scheduling, hidden coupling</li> <li>- Jacobian linearization vs. quasi-LPV models</li> <li>- Stability and induced L2 norm of LPV systems</li> <li>- Synthesis of LPV controllers based on the two-sided projection lemma</li> <li>- Simplifications: controller synthesis for polytopic and LFT models</li> <li>- Experimental identification of LPV models</li> <li>- Controller synthesis based on input/output models</li> <li>- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator</li> </ul> </li> <li>• Control of Multi-Agent Systems                             <ul style="list-style-type: none"> <li>- Communication graphs</li> <li>- Spectral properties of the graph Laplacian</li> <li>- First and second order consensus protocols</li> <li>- Formation control, stability and performance</li> <li>- LPV models for agents subject to nonholonomic constraints</li> <li>- Application: formation control for a team of quadrotor helicopters</li> </ul> </li> <li>• Linear and Nonlinear Model Predictive Control based on LMIs</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Werner, H., Lecture Notes "Advanced Topics in Control"</li> <li>• Selection of relevant research papers made available as pdf documents via StudIP</li> </ul>

Course L0662: Advanced Topics in Control	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Herbert Werner
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1744: Selected Topics of Aeronautical Systems Engineering (Alternative A: 6 LP)			
Courses			
Title	Typ	Hrs/wk	CP
Advanced Training Course SE-ZERT (L2739)	Project-/problem-based Learning	2	3
Airline Operations (L1310)	Lecture	3	3
Fatigue & Damage Tolerance (L0310)	Lecture	2	3
Flight Guidance (L0848)	Lecture	2	2
Flight Guidance (L0854)	Recitation Section (large)	1	1
Airport Operations (L1276)	Lecture	3	3
Airport Planning (L1275)	Lecture	2	2
Airport Planning (L1469)	Recitation Section (small)	1	1
Lightweight Design Practical Course (L1258)	Project-/problem-based Learning	3	3
Aviation Security (L1549)	Lecture	2	2
Aviation Security (L1550)	Recitation Section (small)	1	1
Aviation and Environment (L2376)	Lecture	3	3
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture	2	2
Mission Management (L2374)	Lecture	2	2
Mission Management (L2375)	Recitation Section (small)	1	1
Turbo Jet Engines (L0908)	Lecture	2	3
Structural Mechanics of Fibre Reinforced Composites (L1514)	Lecture	2	3
Structural Mechanics of Fibre Reinforced Composites (L1515)	Recitation Section (large)	1	1
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Materials Testing (L0949)	Lecture	2	2
Reliability in Engineering Dynamics (L0176)	Lecture	2	2
Reliability in Engineering Dynamics (L1303)	Recitation Section (small)	1	2
Reliability of Aircraft Systems (L0749)	Lecture	2	3
<b>Module Responsible</b>	Prof. Frank Thielecke		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Thermodynamics</li> <li>• Electrical Engineering</li> <li>• Hydraulics</li> <li>• Control Systems</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Students are able to find their way through selected special areas within systems engineering, air transportation system and material science</li> <li>• Students are able to explain basic models and procedures in selected special areas.</li> <li>• Students are able to interrelate scientific and technical knowledge.</li> </ul>		
<i>Knowledge</i>			
<i>Skills</i>	Students are able to apply basic methods in selected areas of engineering.		
<b>Personal Competence</b>			
<i>Social Competence</i>			
<i>Autonomy</i>	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.		
<b>Workload in Hours</b>	Depends on choice of courses		
<b>Credit points</b>	6		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Course L2739: Advanced Training Course SE-ZERT	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	120 min
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2.  ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).

Course L1310: Airline Operations	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Karl Echtermeyer
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction and overview</li> <li>2. Airline business models</li> <li>3. Interdependencies in flight planning (network management, slot management, network structures, aircraft circulation)</li> <li>4. Operative flight preparation (weight &amp; balance, payload/range, etc.)</li> <li>5. fleet policy</li> <li>6. Aircraft assessment and fleet planning</li> <li>7. Airline organisation</li> <li>8. Aircraft maintenance, repair and overhaul</li> </ol>
<b>Literature</b>	Volker Gollnick, Dieter Schmitt: The Air Transport System, Springer Berlin Heidelberg New York, 2014  Paul Clark: "Buying the Big Jets", Ashgate 2008  Mike Hirst: The Air Transport System, AIAA, 2008

Course L0310: Fatigue & Damage Tolerance	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	45 min
<b>Lecturer</b>	Dr. Martin Flamm
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
<b>Literature</b>	Jaap Schijve, Fatigue of Structures and Materials. Kluwer Academic Puplicher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L0848: Flight Guidance	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.)</p> <p>Cockpit systems and Avionics (cockpit design, cockpit equipment, displays, computers and bus systems)</p> <p>Principles of flight measurement techniques (Measurement of position (geometric methods, distance measurement, direction measurement) Determination of the aircraft attitude (magnetic field- and inertial sensors) Measurement of speed</p> <p>Principles of Navigation</p> <p>Radio navigation</p> <p>Satellite navigation</p> <p>Airspace surveillance (radar systems)</p> <p>Communication systems</p> <p>Integrated Navigation and Guidance Systems</p>
<b>Literature</b>	<p>Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2011</p> <p>Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013</p> <p>Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2016</p> <p>R.P.G. Collinson „Introduction to Avionics“, Springer Berlin Heidelberg New York 2003</p>

Course L0854: Flight Guidance	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1276: Airport Operations	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	Prof. Volker Gollnick, Peter Willems (geb. Bießlich)
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground handling Terminal operations
<b>Literature</b>	Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003

Course L1275: Airport Planning	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Ulrich Hüp
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction, definitions, overviewg</li> <li>2. Runway systems</li> <li>3. Air space strcutres around airports</li> <li>4. Airfield lightings, marking and information</li> <li>5. Airfield and terminal configuration</li> </ol>
<b>Literature</b>	<p>N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley &amp; Sons, 1991</p> <p>Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003</p>

Course L1469: Airport Planning	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Ulrich Hüp
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1258: Lightweight Design Practical Course	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Prof. Dieter Krause
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Development of a sandwich structure made of fibre reinforced plastics</p> <ul style="list-style-type: none"> <li>• getting familiar with fibre reinforced plastics as well as lightweight design</li> <li>• Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA)</li> <li>• Determination of material properties based on sample tests</li> <li>• manufacturing of the structure in the composite lab</li> <li>• Testing of the developed structure</li> <li>• Concept presentation</li> <li>• Self-organised teamwork</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005.</li> <li>• Puck, A., „Festigkeitsanalyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996.</li> <li>• R&amp;G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009.</li> <li>• VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“</li> <li>• Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006.</li> <li>• Klein, B., „Leichtbau-Konstruktion“, Vieweg &amp; Sohn, Braunschweig, 1989.</li> <li>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986.</li> <li>• Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986.</li> <li>• Backmann, B.F., „Composite Structures, Design, Safety and Innovation“, Oxford (UK), Elsevier, 2005.</li> <li>• Krause, D., „Leichtbau“, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.</li> <li>• Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials“, Hamburg, TUHH - TuTech Innovation GmbH, 2005.</li> </ul>

Course L1549: Aviation Security	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.</p> <p>The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:</p> <ul style="list-style-type: none"> <li>• Historical development</li> <li>• The special role of air transport</li> <li>• Motive and attack vectors</li> <li>• The human factor</li> <li>• Threats and risk</li> <li>• Regulations and law</li> <li>• Organization and implementation of aviation security tasks</li> <li>• Passenger and baggage checks</li> <li>• Cargo screening and secure supply chain</li> <li>• Safety technologies</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</li> <li>- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</li> </ul>

<b>Course L1550: Aviation Security</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.</p> <p>The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:</p> <ul style="list-style-type: none"> <li>• Historical development</li> <li>• The special role of air transport</li> <li>• Motive and attack vectors</li> <li>• The human factor</li> <li>• Threats and risk</li> <li>• Regulations and law</li> <li>• Organization and implementation of aviation security tasks</li> <li>• Passenger and baggage checks</li> <li>• Cargo screening and secure supply chain</li> <li>• Safety technologies</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</p> <p>- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</p>

Course L2376: Aviation and Environment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>The lecture provides the necessary basics and methods for understanding the interactions between air traffic and the environment, both in terms of the effects of weather / climate on flying and with regard to the effects of air traffic on pollutant emissions, noise and climate.</p> <p>The following topics are covered:</p> <ul style="list-style-type: none"> <li>• Atmospheric physics / chemistry <ul style="list-style-type: none"> <li>◦ Structure and statics</li> <li>◦ Dynamics (water cycle, formation of weather events, high and low pressure areas, wind, gusts and turbulence)</li> <li>◦ Cloud physics (thermodynamics, contrails)</li> <li>◦ Radiation physics (energy balance, greenhouse effect)</li> <li>◦ Photochemistry (ozone chemistry)</li> </ul> </li> <li>• Impact of weather on flying <ul style="list-style-type: none"> <li>◦ Atmospheric influences on flight performance</li> <li>◦ Flight planning</li> <li>◦ Disturbances due to weather, e.g. thunderstorms, winter weather (icing), clear air turbulence, visibility</li> <li>◦ Effects of climate change and adaptation</li> </ul> </li> <li>• Effects of air traffic on the environment and climate <ul style="list-style-type: none"> <li>◦ Aviation pollutant emissions</li> <li>◦ Effect of emissions on concentrations in the atmosphere</li> <li>◦ Climate metrics / models and background scenarios</li> <li>◦ Emissions inventories</li> </ul> </li> <li>• Mitigation measures <ul style="list-style-type: none"> <li>◦ Technological measures, e.g. climate-optimized aircraft design</li> <li>◦ Alternative fuels</li> <li>◦ Operational measures, e.g. climate-optimized flight planning</li> <li>◦ Environmental policy measures, e.g. EU-ETS, CORSIA</li> <li>◦ Potentials and comparison, concept of eco-efficiency</li> </ul> </li> <li>• Local environmental impacts <ul style="list-style-type: none"> <li>◦ Local air quality (particulate matter, other emissions near the ground)</li> <li>◦ Noise (noise sources, noise metrics, noise impact, measurement, certification, psychoacoustics, noise mitigation)</li> <li>◦ Health effects</li> </ul> </li> <li>• Aspects of sustainability <ul style="list-style-type: none"> <li>◦ Other aspects, including life cycle emissions, disposal/recycling</li> <li>◦ Relation to global goals, e.g. United Nations goals for sustainable development, Paris climate agreement</li> </ul> </li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Ruijgrok, G.: Elements of Aircraft Pollution, Delft University Press, 2005</li> <li>• Friedrich, R., Reis, S.: Emissions of Air Pollutants, Springer 2004</li> <li>• Janic, M.: The Sustainability of Air Transportation, Ashgate, 2007</li> <li>• Schumann, U. (ed.): Atmospheric Physics: Background - Methods - Trends, Springer, Berlin, Heidelberg, 2012</li> <li>• Spiridonov, V., Curic, M.: Fundamentals of Meteorology, Springer, 2021</li> <li>• Kaltschmitt, M., Neuling, U.: Biokerosene - Status and Prospects, Springer, 2018</li> <li>• Roedel, W., Wagner, T.: Physik unserer Umwelt: Die Atmosphäre, Springer, 2017</li> <li>• W. Bräunling: Flugzeugtriebwerke. Springer-Verlag Berlin, Deutschland, 2009</li> <li>• G. Brüning, X. Hafer, G. Sachs: Flugleistungen, Springer, 1993</li> </ul>



Course L0950: Mechanisms, Systems and Processes of Materials Testing	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Dr. Jan Oke Peters
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Application, analysis and discussion of basic and advanced testing methods to ensure correct selection of applicable testing procedure for investigation of part/materials deficiencies</p> <ul style="list-style-type: none"> <li>• Stress-strain relationships</li> <li>• Strain gauge application</li> <li>• Visko elastic behavior</li> <li>• Tensile test (strain hardening, necking, strain rate)</li> <li>• Compression test, bending test, torsion test</li> <li>• Crack growth upon static loading (J-Integral)</li> <li>• Crack growth upon cyclic loading (micro- und macro cracks)</li> <li>• Effect of notches</li> <li>• Creep testing (physical creep test, influence of stress and temperature, Larson Miller parameter)</li> <li>• Wear testing</li> <li>• Non destructive testing application for overhaul of jet engines</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• E. Macherauch: Praktikum in Werkstoffkunde, Vieweg</li> <li>• G. E. Dieter: Mechanical Metallurgy, McGraw-Hill</li> <li>• R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg</li> <li>• R. Bürgel: Werkstoffe sicher beurteilen und richtig einsetzen, Vieweg</li> </ul>

Course L2374: Mission Management	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	<p>Brockhaus, Alles, Luckner: Flugregelung, Springer Verlag, 2011</p> <p>R.P.G Collinson: Introduction to Avionics Systems, Springer Verlag, 2011</p>

Course L2375: Mission Management	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L0908: Turbo Jet Engines	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	45 min
<b>Lecturer</b>	Dr. Burkhard Andrich
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Cycle of the gas turbine</li> <li>• Thermodynamics of gas turbine components</li> <li>• Wing-, grid- and stage-sizing</li> <li>• Operating characteristics of gas turbine components</li> <li>• Sizing criteria's for jet engines</li> <li>• Development trends of gas turbines and jet engines</li> <li>• Maintenance of jet engines</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Bräunling: Flugzeugtriebwerke</li> <li>• Engmann: Technologie des Fliegens</li> <li>• Kerrebrock: Aircraft Engines and Gas Turbines</li> </ul>

Course L1514: Structural Mechanics of Fibre Reinforced Composites	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Classical laminate theory</p> <p>Rules of mixture</p> <p>Failure mechanisms and criteria of composites</p> <p>Boundary value problems of isotropic and anisotropic shells</p> <p>Stability of composite structures</p> <p>Optimization of laminated composites</p> <p>Modelling composites in FEM</p> <p>Numerical multiscale analysis of textile composites</p> <p>Progressive failure analysis</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, aktuelle Auflage.</li> <li>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, , aktuelle Auflage.</li> <li>• Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells“, CRC Publishing, Boca Raton et al., current edition.</li> <li>• Jones, R.M., „Mechanics of Composite Materials“, Scripta Book Co., Washington, current edition.</li> <li>• Timoshenko, S.P., Gere, J.M., „Theory of elastic stability“, McGraw-Hill Book Company, Inc., New York, current edition.</li> <li>• Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates“, Chapman and Hall, London, current edition.</li> <li>• Herakovich, C.T., „Mechanics of fibrous composites“, John Wiley and Sons, Inc., New York, current edition.</li> <li>• Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate“, aktuelle Auflage.</li> </ul>

Course L1515: Structural Mechanics of Fibre Reinforced Composites	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1820: System Simulation	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Dr. Stefan Wischhusen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> <li>• Instruction and modelling of physical processes</li> <li>• Modelling and limits of model</li> <li>• Time constant, stiffness, stability, step size</li> <li>• Terms of object orientated programming</li> <li>• Differential equations of simple systems</li> <li>• Introduction into Modelica</li> <li>• Introduction into simulation tool</li> <li>• Example:Hydraulic systems and heat transfer</li> <li>• Example: System with different subsystems</li> </ul>
<b>Literature</b>	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", <a href="http://book.xogeny.com">http://book.xogeny.com</a>, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

Course L1821: System Simulation	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Examination Form</b>	Mündliche Prüfung
<b>Examination duration and scale</b>	30 min
<b>Lecturer</b>	Dr. Stefan Wischhusen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L0949: Materials Testing	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Dr. Jan Oke Peters
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Application and analysis of basic mechanical as well as non-destructive testing of materials</p> <ul style="list-style-type: none"> <li>• Determination elastic constants</li> <li>• Tensile test</li> <li>• Fatigue test (testing with constant stress, strain, or plastiv strain amplitude, low and high cycle fatigue, mean stress effect)</li> <li>• Crack growth upon static loading (stress intensity factor, fracture toughness)</li> <li>• Creep test</li> <li>• Hardness test</li> <li>• Charpy impact test</li> <li>• Non destructive testing</li> </ul>
<b>Literature</b>	<p>E. Macherauch: Praktikum in Werkstoffkunde, Vieweg                      G. E. Dieter: Mechanical Metallurgy, McGraw-Hill</p>

Course L0176: Reliability in Engineering Dynamics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min.
<b>Lecturer</b>	NN
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Method for calculation and testing of reliability of dynamic machine systems</p> <ul style="list-style-type: none"> <li>• Modeling</li> <li>• System identification</li> <li>• Simulation</li> <li>• Processing of measurement data</li> <li>• Damage accumulation</li> <li>• Test planning and execution</li> </ul>
<b>Literature</b>	<p>Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4</p> <p>Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737</p> <p>Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936.</p> <p>VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412</p>

Course L1303: Reliability in Engineering Dynamics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 min
<b>Lecturer</b>	NN
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Course L0749: Reliability of Aircraft Systems</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wiczorek
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Functions of reliability and safety (regulations, certification requirements)</li> <li>• Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment)</li> <li>• Reliability analysis of electrical and mechanical systems</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• CS 25.1309</li> <li>• SAE ARP 4754</li> <li>• SAE ARP 4761</li> </ul>

Module M0764: Flight Control Systems				
Courses				
Title	Typ	Hrs/wk	CP	
Flight Control Systems (L0736)	Lecture	3	4	
Flight Control Systems (L0740)	Recitation Section (large)	2	2	
<b>Module Responsible</b>	Prof. Frank Thielecke			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	basic knowledge of: <ul style="list-style-type: none"> <li>• mathematics</li> <li>• mechanics</li> <li>• thermo dynamics</li> <li>• electronics</li> <li>• fluid technology</li> <li>• control technology</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to...</p> <ul style="list-style-type: none"> <li>• describe the structure of primary flight control systems as well as actuation-, avionic-, high lift systems in general along with corresponding properties and applications.</li> <li>• explain different configurations and designs and their origins</li> <li>•</li> </ul> <p><i>Skills</i> Students are able to...</p> <ul style="list-style-type: none"> <li>• size primary flight control actuation systems</li> <li>• perform a controller design process for the flight control actuators</li> <li>• design high-lift kinematics</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• Develop joint solutions in mixed teams</li> </ul> <p><i>Autonomy</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• derive requirements and perform appropriate yet simplified design processes for aircraft systems from complex issues and circumstances in a self-reliant manner</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	165 Minutes			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			

Course L0736: Flight Control Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Actuation (Principles of actuators; electro-mechanical actuators; modeling, analysis and sizing of position control systems; hydro-mechanic actuation systems)</li> <li>• Flight Control Systems (control surfaces, hinge moments; requirements of stability and controllability, actuation power; principles of reversible and irreversible flight control systems; servo actuation systems)</li> <li>• Landing Gear Systems (Configurations and geometries; analysis of landing gear systems with respect to damper dynamics, dynamics of the breaking aircraft and power consumption; design and analysis of breaking systems with respect to energy and heat; anti-skid systems)</li> <li>• Fuel Systems (Architectures; aviation fuels; system components; fueling system; tank inerting system; fuel management; trim tank)</li> <li>• De- and Anti-Ice Systems: (Atmospheric icing conditions; principles of de- and anti-ice systems)</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Moir, Seabridge: Aircraft Systems</li> <li>• Torenbek: Synthesis of Subsonic Airplane Design</li> <li>• Curry: Aircraft Landing Gear Design: Principles and Practices</li> </ul>

Course L0740: Flight Control Systems	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1156: Systems Engineering				
Courses				
Title	Typ	Hrs/wk	CP	
Systems Engineering (L1547)	Lecture	3	4	
Systems Engineering (L1548)	Recitation Section (large)	1	2	
<b>Module Responsible</b>	Prof. Ralf God			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Thermodynamics</li> <li>• Electrical Engineering</li> <li>• Control Systems</li> </ul> Previous knowledge in: <ul style="list-style-type: none"> <li>• Aircraft Cabin Systems</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	Students are able to: <ul style="list-style-type: none"> <li>• understand systems engineering process models, methods and tools for the development of complex Systems</li> <li>• describe innovation processes and the need for technology Management</li> <li>• explain the aircraft development process and the process of type certification for aircraft</li> <li>• explain the system development process, including requirements for systems reliability</li> <li>• identify environmental conditions and test procedures for airborne Equipment</li> <li>• value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE)</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>	Students are able to: <ul style="list-style-type: none"> <li>• plan the process for the development of complex Systems</li> <li>• organize the development phases and development Tasks</li> <li>• assign required business activities and technical Tasks</li> <li>• apply systems engineering methods and tools</li> </ul>			
<b>Personal Competence</b>	Students are able to: <ul style="list-style-type: none"> <li>• understand their responsibilities within a development team and integrate themselves with their role in the overall process</li> </ul>			
<i>Social Competence</i>				
<i>Autonomy</i>	Students are able to: <ul style="list-style-type: none"> <li>• interact and communicate in a development team which has distributed tasks</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 Minutes			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			



<b>Course L1547: Systems Engineering</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.</p> <p>Key aspects of the course are processes for innovation and technology management, system design, system integration and certification as well as tools and methods for systems engineering:</p> <ul style="list-style-type: none"> <li>• Innovation processes</li> <li>• IP-protection</li> <li>• Technology management</li> <li>• Systems engineering</li> <li>• Aircraft program</li> <li>• Certification issues</li> <li>• Systems development</li> <li>• Safety objectives and fault tolerance</li> <li>• Environmental and operating conditions</li> <li>• Tools for systems engineering</li> <li>• Requirements-based engineering (RBE)</li> <li>• Model-based requirements engineering (MBRE)</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>- diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)</p> <p>- Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010</p> <p>- NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007</p> <p>- Hirsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation Luftfahrttechnischer Betriebe. Springer, 2010</p> <p>- De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010</p> <p>- Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008</p>

<b>Course L1548: Systems Engineering</b>	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Ralf God
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1339: Design optimization and probabilistic approaches in structural analysis			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Design Optimization and Probabilistic Approaches in Structural Analysis (L1873)		Lecture	2                  3
Design Optimization and Probabilistic Approaches in Structural Analysis (L1874)		Recitation Section (large)	2                  3
<b>Module Responsible</b>	Prof. Benedikt Kriegesmann		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Technical mechanics</li> <li>• Higher math</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Design optimization                             <ul style="list-style-type: none"> <li>◦ Gradient based methods</li> <li>◦ Genetic algorithms</li> <li>◦ Optimization with constraints</li> <li>◦ Topology optimization</li> </ul> </li> <li>• Reliability analysis                             <ul style="list-style-type: none"> <li>◦ Stochastic basics</li> <li>◦ Monte Carlo methods</li> <li>◦ Semi-analytic approaches</li> </ul> </li> <li>• robust design optimization                             <ul style="list-style-type: none"> <li>◦ Robustness measures</li> <li>◦ Coupling of design optimization and reliability analysis</li> </ul> </li> </ul>		
<i>Knowledge</i>			
<i>Skills</i>			
<b>Personal Competence</b>			
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Application of optimization algorithms and probabilistic methods in the design of structures</li> <li>• Programming with Matlab</li> <li>• Implementation of algorithms</li> <li>• Debugging</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Team work</li> <li>• Oral explanation of the the work</li> </ul>		
	<ul style="list-style-type: none"> <li>• Application of methods learned in the framework of a home work</li> <li>• Familiarizing with source code provided</li> <li>• Description of approaches and results</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	10 pages		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory		

Course L1873: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>In the course the theoretic basics for design optimization and reliability analysis are taught, where the focus is on the application of such methods. The lectures will consist of presentations as well as computer exercises. In the computer exercises, the methods learned will be implemented in Matlab for understanding the practical realization.</p> <p>The following contents will be considered:</p> <ul style="list-style-type: none"> <li>• Design optimization <ul style="list-style-type: none"> <li>◦ Gradient based methods</li> <li>◦ Genetic algorithms</li> <li>◦ Optimization with constraints</li> <li>◦ Topology optimization</li> </ul> </li> <li>• Reliability analysis <ul style="list-style-type: none"> <li>◦ Stochastic basics</li> <li>◦ Monte Carlo methods</li> <li>◦ Semi-analytic approaches</li> </ul> </li> <li>• robust design optimization <ul style="list-style-type: none"> <li>◦ Robustness measures</li> <li>◦ Coupling of design optimization and reliability analysis</li> </ul> </li> </ul>
<b>Literature</b>	<p>[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011.</p> <p>[2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley &amp; Sons New York/Chichester, UK, 2000.</p>

Course L1874: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	Matlab exercises complementing the lecture
<b>Literature</b>	siehe Vorlesung

Module M1343: Structure and properties of fibre-polymer-composites			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Structure and properties of fibre-polymer-composites (L1894)	Lecture	2	3
Structure and properties of fibre-polymer-composites (L2614)	Project-/problem-based Learning	2	2
Structure and properties of fibre-polymer-composites (L2613)	Recitation Section (large)	1	1
<b>Module Responsible</b>	Prof. Bodo Fiedler		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basics: chemistry / physics / materials science		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> Students can use the knowledge of fiber-reinforced composites (FRP) and its constituents to play (fiber / matrix) and define the necessary testing and analysis.</p> <p>They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, their processing with the different fiber types, including to explain neighboring contexts (e.g. sustainability, environmental protection).</p> <p><i>Skills</i> Students are capable of</p> <ul style="list-style-type: none"> <li>• using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.</li> <li>• approximate sizing using the network theory of the structural elements implement and evaluate.</li> <li>• selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can</p> <ul style="list-style-type: none"> <li>• arrive at funded work results in heterogenius groups and document them.</li> <li>• provide appropriate feedback and handle feedback on their own performance constructively.</li> </ul> <p><i>Autonomy</i> Students are able to</p> <ul style="list-style-type: none"> <li>- assess their own strengths and weaknesses.</li> <li>- assess their own state of learning in specific terms and to define further work steps on this basis.</li> <li>- assess possible consequences of their professional activity.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory Mechanical Engineering and Management: Core qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

<b>Course L1894: Structure and properties of fibre-polymer-composites</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Bodo Fiedler
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Microstructure and properties of the matrix and reinforcing materials and their interaction</li> <li>- Development of composite materials</li> <li>- Mechanical and physical properties</li> <li>- Mechanics of Composite Materials</li> <li>- Laminate theory</li> <li>- Test methods</li> <li>- Non destructive testing</li> <li>- Failure mechanisms</li> <li>- Theoretical models for the prediction of properties</li> <li>- Application</li> </ul>
<b>Literature</b>	Hall, Clyne: Introduction to Composite materials, Cambridge University Press Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press Mallick: Fibre-Reinforced Composites, Marcel Dekker, New York

<b>Course L2614: Structure and properties of fibre-polymer-composites</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Bodo Fiedler
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	

<b>Course L2613: Structure and properties of fibre-polymer-composites</b>	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Bodo Fiedler
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	

Module M1690: Aircraft Design II (Special Air Vehicle Design)				
Courses				
Title	Typ	Hrs/wk	CP	
Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV) (L0844)	Lecture	3	3	
Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV) (L0847)	Recitation Section (large)	2	3	
<b>Module Responsible</b>	Prof. Volker Gollnick			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Aircraft Design I (Design of Transport Aircraft) Air Transportation Systems			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p>Understanding of various flight systems and its special characteristics (supersonic aircraft, rotorcraft, high performance aircraft, unmanned air systems)</p> <p>Understanding of pro's and con's and physical characteristics of different air systems</p> <p>Understanding of special mission requirements and its impact on systems definition and conceptual design</p> <p>Intensified knowledge of performance design on various air systems</p> <p><i>Skills</i></p> <p>Understanding and application of design and calculation methods</p> <p>Understanding of interdisciplinary and integrative interdependencies</p> <p>mission oriented technical definition of air systems</p> <p>special conceptual calculation methods for special equipment characteristics</p> <p>assessment of different design solutions</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Working in teams for focused solutions</p> <p>communication, assertiveness, technical persuasion</p> <p><i>Autonomy</i></p> <p>Organisation of workflows and strategies for solutions</p> <p>structured task analysis and definition of solutions</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	180 min			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			

<b>Course L0844: Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV)</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Bernd Liebhardt, Jens Thöben
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Design of supersonic civil aircraft</li> <li>2. Principles of high performance and special operations aircraft design</li> <li>3. Principles of Rotorcraft Design</li> <li>4. Principles of Unmanned Air Systems design, air taxis, electric aircraft</li> </ol>
<b>Literature</b>	<p>Gareth Padfield: Helicopter Flight Dynamics, Butterworth Ltd.</p> <p>Raymond Prouty: Helicopter Performance Stability and Control, Krieger Publ.</p> <p>Klaus Hünecke: Das Kampfflugzeug von Heute, Motorbuch Verlag</p> <p>Jay Gundelach: Designing Unmanned Aircraft Systems - Configurative Approach, AIAA</p>

<b>Course L0847: Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV)</b>	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Volker Gollnick, Dr. Bernd Liebhardt, Jens Thöben
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1248: Compilers for Embedded Systems				
Courses				
Title	Typ	Hrs/wk	CP	
Compilers for Embedded Systems (L1692)	Lecture	3	4	
Compilers for Embedded Systems (L1693)	Project-/problem-based Learning	1	2	
<b>Module Responsible</b>	Prof. Heiko Falk			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Module "Embedded Systems" C/C++ Programming skills			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p>The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be executed on embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application areas of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized processors impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this course, the students are able</p> <ul style="list-style-type: none"> <li>• to illustrate the structure and organization of such compilers,</li> <li>• to distinguish and explain intermediate representations of various abstraction levels, and</li> <li>• to assess optimizations and their underlying problems in all compiler phases.</li> </ul> <p>The high demands on compilers for embedded systems make effective code optimizations mandatory. The students learn in particular,</p> <ul style="list-style-type: none"> <li>• which kinds of optimizations are applicable at the source code level,</li> <li>• how the translation from source code to assembly code is performed,</li> <li>• which kinds of optimizations are applicable at the assembly code level,</li> <li>• how register allocation is performed, and</li> <li>• how memory hierarchies can be exploited effectively.</li> </ul> <p>Since compilers for embedded systems often have to optimize for multiple objectives (e.g., average- or worst-case execution time, energy dissipation, code size), the students learn to evaluate the influence of optimizations on these different criteria.</p> <p><i>Skills</i></p> <p>After successful completion of the course, students shall be able to translate high-level program code into machine code. They will be enabled to assess which kind of code optimization should be applied most effectively at which abstraction level (e.g., source or assembly code) within a compiler.</p> <p>While attending the labs, the students will learn to implement a fully functional compiler including optimizations.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Students are able to solve similar problems alone or in a group and to present the results accordingly.</p> <p><i>Autonomy</i></p> <p>Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory			



Course L1692: Compilers for Embedded Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction and Motivation</li> <li>• Compilers for Embedded Systems - Requirements and Dependencies</li> <li>• Internal Structure of Compilers</li> <li>• Pre-Pass Optimizations</li> <li>• HIR Optimizations and Transformations</li> <li>• Code Generation</li> <li>• LIR Optimizations and Transformations</li> <li>• Register Allocation</li> <li>• WCET-Aware Compilation</li> <li>• Outlook</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2<sup>nd</sup> Edition, Springer, 2012.</li> <li>• Steven S. Muchnick. Advanced Compiler Design and Implementation. Morgan Kaufmann, 1997.</li> <li>• Andrew W. Appel. Modern compiler implementation in C. Oxford University Press, 1998.</li> </ul>

Course L1693: Compilers for Embedded Systems	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0803: Embedded Systems				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Embedded Systems (L0805)		Lecture	3	4
Embedded Systems (L0806)		Recitation Section (small)	1	2
<b>Module Responsible</b>	Prof. Heiko Falk			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Computer Engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Embedded systems can be defined as information processing systems embedded into enclosing products. This course teaches the foundations of such systems. In particular, it deals with an introduction into these systems (notions, common characteristics) and their specification languages (models of computation, hierarchical automata, specification of distributed systems, task graphs, specification of real-time applications, translations between different models).</p> <p>Another part covers the hardware of embedded systems: Sensors, A/D and D/A converters, real-time capable communication hardware, embedded processors, memories, energy dissipation, reconfigurable logic and actuators. The course also features an introduction into real-time operating systems, middleware and real-time scheduling. Finally, the implementation of embedded systems using hardware/software co-design (hardware/software partitioning, high-level transformations of specifications, energy-efficient realizations, compilers for embedded processors) is covered.</p>			
<i>Skills</i>	After having attended the course, students shall be able to realize simple embedded systems. The students shall realize which relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall be able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge in which areas of embedded system design specific risks exist.			
<b>Personal Competence</b>	<p><i>Social Competence</i> Students are able to solve similar problems alone or in a group and to present the results accordingly.</p> <p><i>Autonomy</i> Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Subject	theoretical and practical work
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes, contents of course and labs			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Electrical Engineering: Core qualification: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory Computational Science and Engineering: Core qualification: Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Core qualification: Elective Compulsory Microelectronics and Microsystems: Specialisation Embedded Systems: Elective Compulsory			

Course L0805: Embedded Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Specifications and Modeling</li> <li>• Embedded/Cyber-Physical Systems Hardware</li> <li>• System Software</li> <li>• Evaluation and Validation</li> <li>• Mapping of Applications to Execution Platforms</li> <li>• Optimization</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2<sup>nd</sup> Edition, Springer, 2012., Springer, 2012.</li> </ul>

Course L0806: Embedded Systems	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0752: Nonlinear Dynamics				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
<b>Module Responsible</b>	Prof. Norbert Hoffmann			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Calculus</li> <li>• Linear Algebra</li> <li>• Engineering Mechanics</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.</p> <p><i>Skills</i> Students are able to apply existing methods and procedures of Nonlinear Dynamics and to develop novel methods and procedures.</p>			
<b>Personal Competence</b>	<p><i>Social Competence</i> Students can reach working results also in groups.</p> <p><i>Autonomy</i> Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	2 Hours			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			

Course L0702: Nonlinear Dynamics	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Norbert Hoffmann
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Fundamentals of Nonlinear Dynamics.
<b>Literature</b>	S. Strogatz: Nonlinear Dynamics and Chaos. Perseus, 2013.

Module M0714: Numerical Treatment of Ordinary Differential Equations			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Numerical Treatment of Ordinary Differential Equations (L0576)		Lecture	2                  3
Numerical Treatment of Ordinary Differential Equations (L0582)		Recitation Section (small)	2                  3
<b>Module Responsible</b>	Prof. Daniel Ruprecht		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Mathematik I, II, III für Ingenieurstudierende (deutsch oder englisch) oder Analysis &amp; Lineare Algebra I + II sowie Analysis III für Technomathematiker</li> <li>• Basic MATLAB knowledge</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are able to		
	<ul style="list-style-type: none"> <li>• list numerical methods for the solution of ordinary differential equations and explain their core ideas,</li> <li>• repeat convergence statements for the treated numerical methods (including the prerequisites tied to the underlying problem),</li> <li>• explain aspects regarding the practical execution of a method.</li> <li>• select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results</li> </ul>		
<i>Skills</i>	Students are able to		
	<ul style="list-style-type: none"> <li>• implement (MATLAB), apply and compare numerical methods for the solution of ordinary differential equations,</li> <li>• to justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm,</li> <li>• for a given problem, develop a suitable solution approach, if necessary by the composition of several algorithms, to execute this approach and to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to		
	<ul style="list-style-type: none"> <li>• work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.</li> </ul>		
<i>Autonomy</i>	Students are capable		
	<ul style="list-style-type: none"> <li>• to assess whether the supporting theoretical and practical exercises are better solved individually or in a team,</li> <li>• to assess their individual progress and, if necessary, to ask questions and seek help.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Computer Science: Specialisation III. Mathematics: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Interdisciplinary Mathematics: Specialisation II. Numerical - Modelling Training: Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory		

Course L0576: Numerical Treatment of Ordinary Differential Equations	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Daniel Ruprecht
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Numerical methods for Initial Value Problems</p> <ul style="list-style-type: none"> <li>• single step methods</li> <li>• multistep methods</li> <li>• stiff problems</li> <li>• differential algebraic equations (DAE) of index 1</li> </ul> <p>Numerical methods for Boundary Value Problems</p> <ul style="list-style-type: none"> <li>• multiple shooting method</li> <li>• difference methods</li> <li>• variational methods</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• E. Hairer, S. Noersett, G. Wanner: Solving Ordinary Differential Equations I: Nonstiff Problems</li> <li>• E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems</li> </ul>

Course L0582: Numerical Treatment of Ordinary Differential Equations	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Daniel Ruprecht
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0840: Optimal and Robust Control				
Courses				
Title	Typ	Hrs/wk	CP	
Optimal and Robust Control (L0658)	Lecture	2	3	
Optimal and Robust Control (L0659)	Recitation Section (small)	2	3	
<b>Module Responsible</b>	Prof. Herbert Werner			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Classical control (frequency response, root locus)</li> <li>• State space methods</li> <li>• Linear algebra, singular value decomposition</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Students can explain the significance of the matrix Riccati equation for the solution of LQ problems.</li> <li>• They can explain the duality between optimal state feedback and optimal state estimation.</li> <li>• They can explain how the H2 and H-infinity norms are used to represent stability and performance constraints.</li> <li>• They can explain how an LQG design problem can be formulated as special case of an H2 design problem.</li> <li>• They can explain how model uncertainty can be represented in a way that lends itself to robust controller design</li> <li>• They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant.</li> <li>• They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities.</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Students are capable of designing and tuning LQG controllers for multivariable plant models.</li> <li>• They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it.</li> <li>• They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed-sensitivity design.</li> <li>• They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller.</li> <li>• They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers for solving them.</li> <li>• They can carry out all of the above using standard software tools (Matlab robust control toolbox).</li> </ul>			
<b>Personal Competence</b> <i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			

Course L0658: Optimal and Robust Control	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Herbert Werner
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Optimal regulator problem with finite time horizon, Riccati differential equation</li> <li>• Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system</li> <li>• Kalman's identity, phase margin of LQR controllers, spectral factorization</li> <li>• Optimal state estimation, Kalman filter, LQG control</li> <li>• Generalized plant, review of LQG control</li> <li>• Signal and system norms, computing H2 and H<math>\infty</math> norms</li> <li>• Singular value plots, input and output directions</li> <li>• Mixed sensitivity design, H<math>\infty</math> loop shaping, choice of weighting filters</li> <li>• Case study: design example flight control</li> <li>• Linear matrix inequalities, design specifications as LMI constraints (H2, H<math>\infty</math> and pole region)</li> <li>• Controller synthesis by solving LMI problems, multi-objective design</li> <li>• Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Werner, H., Lecture Notes: "Optimale und Robuste Regelung"</li> <li>• Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994</li> <li>• Skogestad, S. and I. Postlewaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996</li> <li>• Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988</li> <li>• Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998</li> </ul>

Course L0659: Optimal and Robust Control	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Herbert Werner
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course



Module M0837: Simulation of Communication Networks				
<b>Courses</b>				
<b>Title</b>	Simulation of Communication Networks (L0887)		<b>Typ</b>	Project-/problem-based Learning
			<b>Hrs/wk</b>	5
			<b>CP</b>	6
<b>Module Responsible</b>	Prof. Andreas Timm-Giel			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Knowledge of computer and communication networks</li> <li>• Basic programming skills</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students are able to explain the necessary stochastics, the discrete event simulation technology and modelling of networks for performance evaluation.			
<i>Skills</i>	Students are able to apply the method of simulation for performance evaluation to different, also not practiced, problems of communication networks. The students can analyse the obtained results and explain the effects observed in the network. They are able to question their own results.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to acquire expert knowledge in groups, present the results, and discuss solution approaches and results. They are able to work out solutions for new problems in small teams.			
<i>Autonomy</i>	Students are able to transfer independently and in discussion with others the acquired method and expert knowledge to new problems. They can identify missing knowledge and acquire this knowledge independently.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems: Elective Compulsory Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Networks: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory			

Course L0887: Simulation of Communication Networks	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	5
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70
<b>Lecturer</b>	Prof. Andreas Timm-Giel
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	In the course necessary basic stochastics and the discrete event simulation are introduced. Also simulation models for communication networks, for example, traffic models, mobility models and radio channel models are presented in the lecture. Students work with a simulation tool, where they can directly try out the acquired skills, algorithms and models. At the end of the course increasingly complex networks and protocols are considered and their performance is determined by simulation.
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Skript des Instituts für Kommunikationsnetze</li> </ul> Further literature is announced at the beginning of the lecture.

Module M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics ) (L0516)		Lecture	2	3
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics ) (L0518)		Recitation Section (large)	2	3
<b>Module Responsible</b>	Prof. Otto von Estorff			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students possess an in-depth knowledge in acoustics regarding acoustic waves, noise protection, and psycho acoustics and are able to give an overview of the corresponding theoretical and methodical basis.			
<i>Skills</i>	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			
Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )				
<b>Typ</b>	Lecture			
<b>Hrs/wk</b>	2			
<b>CP</b>	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
<b>Lecturer</b>	Prof. Otto von Estorff			
<b>Language</b>	EN			
<b>Cycle</b>	SoSe			
<b>Content</b>	<ul style="list-style-type: none"> <li>- Introduction and Motivation</li> <li>- Acoustic quantities</li> <li>- Acoustic waves</li> <li>- Sound sources, sound radiation</li> <li>- Sound energy and intensity</li> <li>- Sound propagation</li> <li>- Signal processing</li> <li>- Psycho acoustics</li> <li>- Noise</li> <li>- Measurements in acoustics</li> </ul>			
<b>Literature</b>	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg			

<b>Course L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )</b>	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1616: Flight Control Law Design and Application				
Courses				
Title		Typ	Hrs/wk	CP
Flight Control Law Design and Application (L2448)		Lecture	2	4
Flight Control Law Design and Application (L2449)		Project-/problem-based Learning	2	2
<b>Module Responsible</b>	Prof. Frank Thielecke			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic Knowledge in: <ul style="list-style-type: none"> <li>* Mathematics (Linear Algebra and ordinary differential equations)</li> <li>* Control Systems (Transfer functions and state space representation)</li> <li>* Mechanics (Rigid-body kinetics)</li> <li>* Flight Mechanics</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	Students are able to: <ul style="list-style-type: none"> <li>* describe and understand flight dynamics models for control tasks</li> <li>* assess handling qualities and understand the need for augmentation through control systems</li> <li>* identify fundamental limitations on performance of control laws</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>	Students are able to: <ul style="list-style-type: none"> <li>* design model-based control laws for stability augmentation</li> <li>* design model-based flight control laws</li> <li>* assess robustness and performance of control laws</li> </ul>			
<b>Personal Competence</b>	Students are able to: <ul style="list-style-type: none"> <li>* design control laws in groups as well as discuss the requirements and results</li> </ul>			
<i>Social Competence</i>				
<i>Autonomy</i>	Students are able to: <ul style="list-style-type: none"> <li>* reflect on the contents of lectures and extend their knowledge through literature research</li> <li>* solve control design tasks with software tools</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 min			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory			

Course L2448: Flight Control Law Design and Application	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>* flight dynamics (equations of motion, trim and linearization, linear models of longitudinal and lateral-directional motion, eigenforms)</li> <li>* stability augmentation (modal dynamics, damper design with root-loci, eigenstructure assignment)</li> <li>* autopilots (control law design with loopshaping, robustness criteria and analysis, cascaded control loops, gain-scheduling)</li> <li>* design of flight control laws</li> <li>* verification of flight control laws in simulation</li> <li>* implementation and application of flight control laws in embedded systems</li> <li>* flight testing of flight control laws</li> </ul>
<b>Literature</b>	<p>B. Stevens, F. Lewis: Aircraft Control and Simulation</p> <p>D. Schmidt: Modern Flight Dynamics</p> <p>D. McGruer, D. Graham, I. Ashkenas: Aircraft Dynamics and Automatic Control</p> <p>G. Stein: Respect the Unstable, in: IEEE Control Systems Magazine SAE Aerospace Standard 94900 - Flight Control Systems</p> <p>The MathWorks: Control Systems Design Toolbox User Guide</p> <p>The MathWorks: Embedded Coder Support Package for PX4 Autopilots User Guide</p>

Course L2449: Flight Control Law Design and Application	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1340: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility				
Courses				
Title	Typ	Hrs/wk	CP	
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4	
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2	
<b>Module Responsible</b>	Prof. Christian Schuster			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic principles of physics and electrical engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students can explain the basic principles, relationships, and methods for the design of waveguides and antennas as well as of Electromagnetic Compatibility. Specific topics are:</p> <ul style="list-style-type: none"> <li>- Fundamental properties and phenomena of electrical circuits</li> <li>- Steady-state sinusoidal analysis of electrical circuits</li> <li>- Fundamental properties and phenomena of electromagnetic fields and waves</li> <li>- Steady-state sinusoidal description of electromagnetic fields and waves</li> <li>- Useful microwave network parameters</li> <li>- Transmission lines and basic results from transmission line theory</li> <li>- Plane wave propagation, superposition, reflection and refraction</li> <li>- General theory of waveguides</li> <li>- Most important types of waveguides and their properties</li> <li>- Radiation and basic antenna parameters</li> <li>- Most important types of antennas and their properties</li> <li>- Numerical techniques and CAD tools for waveguide and antenna design</li> <li>- Fundamentals of Electromagnetic Compatibility</li> <li>- Coupling mechanisms and countermeasures</li> <li>- Shielding, grounding, filtering</li> <li>- Standards and regulations</li> <li>- EMC measurement techniques</li> </ul> <p><i>Skills</i> Students know how to apply various methods and models for characterization and choice of waveguides and antennas. They are able to assess and qualify their basic electromagnetic properties. They can apply results and strategies from the field of Electromagnetic Compatibility to the development of electrical components and systems.</p>			
<b>Personal Competence</b>	<p><i>Social Competence</i> Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).</p> <p><i>Autonomy</i> Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can discuss technical problems and physical effects in English.</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	45 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Electrical Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory			

<b>Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Schuster
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed.</p> <p>Topics:</p> <ul style="list-style-type: none"> <li>- Fundamental properties and phenomena of electrical circuits</li> <li>- Steady-state sinusoidal analysis of electrical circuits</li> <li>- Fundamental properties and phenomena of electromagnetic fields and waves</li> <li>- Steady-state sinusoidal description of electromagnetic fields and waves</li> <li>- Useful microwave network parameters</li> <li>- Transmission lines and basic results from transmission line theory</li> <li>- Plane wave propagation, superposition, reflection and refraction</li> <li>- General theory of waveguides</li> <li>- Most important types of waveguides and their properties</li> <li>- Radiation and basic antenna parameters</li> <li>- Most important types of antennas and their properties</li> <li>- Numerical techniques and CAD tools for waveguide and antenna design</li> <li>- Fundamentals of Electromagnetic Compatibility</li> <li>- Coupling mechanisms and countermeasures</li> <li>- Shielding, grounding, filtering</li> <li>- Standards and regulations</li> <li>- EMC measurement techniques</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)</li> <li>- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)</li> <li>- D. M. Pozar, "Microwave Engineering", Wiley (2011)</li> <li>- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)</li> <li>- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)</li> <li>- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)</li> </ul>

<b>Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Schuster
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1213: Avionics for safety-critical Systems				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Avionics of Safty Critical Systems (L1640)		Lecture	2	3
Avionics of Safty Critical Systems (L1641)		Recitation Section (small)	1	1
Avionics of Safty Critical Systems (L1652)		Practical Course	1	2
<b>Module Responsible</b>	Dr. Martin Halle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Electrical Engineering</li> <li>• Informatics</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students can: <ul style="list-style-type: none"> <li>• describe the most important principles and components of safety-critical avionics</li> <li>• denote processes and standards of safety-critical software development</li> <li>• depict the principles of Integrated Modular Avionics (IMA)</li> <li>• can compare hardware and bus systems used in avionics</li> <li>• assess the difficulties of developing a safety-critical avionics system correctly</li> </ul>			
<i>Skills</i>	Students can ... <ul style="list-style-type: none"> <li>• operate real-time hardware and simulations</li> <li>• program A653 applications</li> <li>• plan avionics architectures up to a certain extend</li> <li>• create test scripts and assess test results</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can: <ul style="list-style-type: none"> <li>• jointly develop solutions in inhomogeneous teams</li> <li>• exchange information formally with other teams</li> <li>• present development results in a convenient way</li> </ul>			
<i>Autonomy</i>	Students can: <ul style="list-style-type: none"> <li>• understand the requirements for an avionics system</li> <li>• autonomously derive concepts for systems based on safety-critical avionics</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	None	Subject	theoretical and practical work
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			



Course L1640: Avionics of Safty Critical Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Martin Halle
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Avionics are all kinds off flight electronics. Today there is no aircraft system function without avionics, and avionics are one main source of innovation in aerospace industry. Since many system functions are highly safety critical, the development of avionics hardware and software underlies mandatory constraints, technics, and processes. It is inevitable for system developers and computer engineers in aerospace industry to understand and master these. This lecture teaches the risks and techniques of developing safety critical hardware and software; major avionics components; integration; and test with a practical orientation. A focus is on Integrated Modular Avionics (IMA). The lecture is accompanied by a mandatory and laboratory exercises.</p> <p>Content:</p> <ol style="list-style-type: none"> <li>1. Introduction and Fundamentals</li> <li>2. History and Flight Control</li> <li>3. Concepts and Redundancy</li> <li>4. Digital Computers</li> <li>5. Interfaces and Signals</li> <li>6. Busses</li> <li>7. Networks</li> <li>8. Aircraft Cockpit</li> <li>9. Software Development</li> <li>10. Model-based Development</li> <li>11. Integrated Modular Avionics I</li> <li>12. Integrated Modular Avionics II</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Moir, I.; Seabridge, A. &amp; Jukes, M., Civil Avionics Systems Civil Avionics Systems, John Wiley &amp; Sons, Ltd, 2013</li> <li>• Spitzer, C. R. Spitzer, Digital Avionics Handbook, CRC Press, 2007</li> <li>• FAA, Advanced Avionics Handbook U.S. Department of Transportation Federal Aviation Administration, 2009</li> <li>• Moir, I. &amp; Seabridge, A. Aircraft Systems, Wiley, 2008, 3</li> </ul>

Course L1641: Avionics of Safty Critical Systems	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Martin Halle
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1652: Avionics of Safty Critical Systems	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Martin Halle
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1204: Modelling and Optimization in Dynamics				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Flexible Multibody Systems (L1632)		Lecture	2	3
Optimization of dynamical systems (L1633)		Lecture	2	3
<b>Module Responsible</b>	Prof. Robert Seifried			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Mathematics I, II, III</li> <li>• Mechanics I, II, III, IV</li> <li>• Simulation of dynamical Systems</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students demonstrate basic knowledge and understanding of modeling, simulation and analysis of complex rigid and flexible multibody systems and methods for optimizing dynamic systems after successful completion of the module.			
<i>Skills</i>	Students are able + to think holistically + to independently, securely and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems + to describe dynamics problems mathematically + to optimize dynamics problems			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.			
<i>Autonomy</i>	Students are able to + assess their knowledge by means of exercises. + acquaint themselves with the necessary knowledge to solve research oriented tasks.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

Course L1632: Flexible Multibody Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Robert Seifried, Dr. Alexander Held
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Basics of Multibody Systems</li> <li>2. Basics of Continuum Mechanics</li> <li>3. Linear finite element modelles and modell reduction</li> <li>4. Nonlinear finite element Modelles: absolute nodal coordinate formulation</li> <li>5. Kinematics of an elastic body</li> <li>6. Kinetics of an elastic body</li> <li>7. System assembly</li> </ol>
<b>Literature</b>	<p>Schwertassek, R. und Wallrapp, O.: Dynamik flexibler Mehrkörpersysteme. Braunschweig, Vieweg, 1999.</p> <p>Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.</p> <p>Shabana, A.A.: Dynamics of Multibody Systems. Cambridge Univ. Press, Cambridge, 2004, 3. Auflage.</p>

Course L1633: Optimization of dynamical systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Robert Seifried
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Formulation and classification of optimization problems</li> <li>2. Scalar Optimization</li> <li>3. Sensitivity Analysis</li> <li>4. Unconstrained Parameter Optimization</li> <li>5. Constrained Parameter Optimization</li> <li>6. Stochastic optimization</li> <li>7. Multicriteria Optimization</li> <li>8. Topology Optimization</li> </ol>
<b>Literature</b>	<p>Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994.</p> <p>Nocedal, J. , Wright , S.J. : Numerical Optimization. New York: Springer, 2006.</p>

Module M0633: Industrial Process Automation				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Industrial Process Automation (L0344)		Lecture	2	3
Industrial Process Automation (L0345)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Alexander Schlaefer			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	mathematics and optimization methods principles of automata principles of algorithms and data structures programming skills			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students can evaluate and assess discrete event systems. They can evaluate properties of processes and explain methods for process analysis. The students can compare methods for process modelling and select an appropriate method for actual problems. They can discuss scheduling methods in the context of actual problems and give a detailed explanation of advantages and disadvantages of different programming methods. The students can relate process automation to methods from robotics and sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'.			
<i>Skills</i>	The students are able to develop and model processes and evaluate them accordingly. This involves taking into account optimal scheduling, understanding algorithmic complexity, and implementation using PLCs.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students work in teams to solve problems.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	10 %	Exercises	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes			
<b>Assignment for the Following Curricula</b>	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

<b>Course L0344: Industrial Process Automation</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Alexander Schlaefer
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- foundations of problem solving and system modeling, discrete event systems</li> <li>- properties of processes, modeling using automata and Petri-nets</li> <li>- design considerations for processes (mutex, deadlock avoidance, liveness)</li> <li>- optimal scheduling for processes</li> <li>- optimal decisions when planning manufacturing systems, decisions under uncertainty</li> <li>- software design and software architectures for automation, PLCs</li> </ul>
<b>Literature</b>	<p>J. Lunze: „Automatisierungstechnik“, Oldenbourg Verlag, 2012</p> <p>Reisig: Petrinetze: Modellierungstechnik, Analysemethoden, Fallstudien; Vieweg+Teubner 2010</p> <p>Hrúz, Zhou: Modeling and Control of Discrete-event Dynamic Systems; Springer 2007</p> <p>Li, Zhou: Deadlock Resolution in Automated Manufacturing Systems, Springer 2009</p> <p>Pinedo: Planning and Scheduling in Manufacturing and Services, Springer 2009</p>

<b>Course L0345: Industrial Process Automation</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Alexander Schlaefer
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0791: Computer Architecture				
Courses				
Title	Typ	Hrs/wk	CP	
Computer Architecture (L0793)	Lecture	2	3	
Computer Architecture (L0794)	Project-/problem-based Learning	2	2	
Computer Architecture (L1864)	Recitation Section (small)	1	1	
<b>Module Responsible</b>	Prof. Heiko Falk			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Module "Computer Engineering"			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> This module presents advanced concepts from the discipline of computer architecture. In the beginning, a broad overview over various programming models is given, both for general-purpose computers and for special-purpose machines (e.g., signal processors). Next, foundational aspects of the micro-architecture of processors are covered. Here, the focus particularly lies on the so-called pipelining and the methods used for the acceleration of instruction execution used in this context. The students get to know concepts for dynamic scheduling, branch prediction, superscalar execution of machine instructions and for memory hierarchies.</p> <p><i>Skills</i> The students are able to describe the organization of processors. They know the different architectural principles and programming models. The students examine various structures of pipelined processor architectures and are able to explain their concepts and to analyze them w.r.t. criteria like, e.g., performance or energy efficiency. They evaluate different structures of memory hierarchies, know parallel computer architectures and are able to distinguish between instruction- and data-level parallelism.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to solve similar problems alone or in a group and to present the results accordingly.</p> <p><i>Autonomy</i> Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.</p>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	15 %	Subject theoretical and practical work	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes, contents of course and 4 attestations from the PBL "Computer architecture"			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory Microelectronics and Microsystems: Specialisation Embedded Systems: Elective Compulsory			

Course L0793: Computer Architecture	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• VHDL Basics</li> <li>• Programming Models</li> <li>• Realization of Elementary Data Types</li> <li>• Dynamic Scheduling</li> <li>• Branch Prediction</li> <li>• Superscalar Machines</li> <li>• Memory Hierarchies</li> </ul> <p>The theoretical tutorials amplify the lecture's content by solving and discussing exercise sheets and thus serve as exam preparation. Practical aspects of computer architecture are taught in the FPGA-based PBL on computer architecture whose attendance is mandatory.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• D. Patterson, J. Hennessy. Rechnerorganisation und -entwurf. Elsevier, 2005.</li> <li>• A. Tanenbaum, J. Goodman. Computerarchitektur. Pearson, 2001.</li> </ul>

Course L0794: Computer Architecture	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1864: Computer Architecture	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0563: Robotics				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Robotics: Modelling and Control (L0168)		Integrated Lecture	4	4
Robotics: Modelling and Control (L1305)		Project-/problem-based Learning	2	2
<b>Module Responsible</b>	Dr. Martin Gomse			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Fundamentals of electrical engineering Broad knowledge of mechanics Fundamentals of control theory			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<i>Knowledge</i> Students are able to describe fundamental properties of robots and solution approaches for multiple problems in robotics. <i>Skills</i> Students are able to derive and solve equations of motion for various manipulators. Students can generate trajectories in various coordinate systems. Students can design linear and partially nonlinear controllers for robotic manipulators.			
<b>Personal Competence</b>	<i>Social Competence</i> Students are able to work goal-oriented in small mixed groups. <i>Autonomy</i> Students are able to recognize and improve knowledge deficits independently. With instructor assistance, students are able to evaluate their own knowledge level and define a further course of study.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechanical Engineering and Management: Core qualification: Compulsory Mechatronics: Core qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory			
Course L0168: Robotics: Modelling and Control				
<b>Typ</b>	Integrated Lecture			
<b>Hrs/wk</b>	4			
<b>CP</b>	4			
<b>Workload in Hours</b>	Independent Study Time 64, Study Time in Lecture 56			
<b>Lecturer</b>	Dr. Martin Gomse			
<b>Language</b>	EN			
<b>Cycle</b>	WiSe			
<b>Content</b>	Fundamental kinematics of rigid body systems Newton-Euler equations for manipulators Trajectory generation Linear and nonlinear control of robots			
<b>Literature</b>	Craig, John J.: Introduction to Robotics Mechanics and Control, Third Edition, Prentice Hall. ISBN 0201-54361-3 Spong, Mark W.; Hutchinson, Seth; Vidyasagar, M. : Robot Modeling and Control. WILEY. ISBN 0-471-64990-2			



<b>Course L1305: Robotics: Modelling and Control</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Martin Gomse
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0806: Technical Acoustics II (Room Acoustics, Computational Methods)				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Technical Acoustics II (Room Acoustics, Computational Methods) (L0519)		Lecture	2	3
Technical Acoustics II (Room Acoustics, Computational Methods) (L0521)		Recitation Section (large)	2	3
<b>Module Responsible</b>	Prof. Otto von Estorff			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics) Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<i>Knowledge</i> The students possess an in-depth knowledge in acoustics regarding room acoustics and computational methods and are able to give an overview of the corresponding theoretical and methodical basis. <i>Skills</i> The students are capable to handle engineering problems in acoustics by theory-based application of the demanding computational methods and procedures treated within the module. <b>Personal Competence</b> <i>Social Competence</i> Students can work in small groups on specific problems to arrive at joint solutions. <i>Autonomy</i> The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	20-30 Minuten			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L0519: Technical Acoustics II (Room Acoustics, Computational Methods)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	- Room acoustics - Sound absorber  - Standard computations - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Geometrical acoustics - Special formulations  - Practical applications - Hands-on Sessions: Programming of elements (Matlab)
<b>Literature</b>	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

<b>Course L0521: Technical Acoustics II (Room Acoustics, Computational Methods)</b>	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0808: Finite Elements Methods				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
<b>Module Responsible</b>	Prof. Otto von Estorff			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of the theoretical and methodical basis of the method.			
<i>Skills</i>	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	20 %	Midterm	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory			

Course L0291: Finite Element Methods	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- General overview on modern engineering</li> <li>- Displacement method</li> <li>- Hybrid formulation</li> <li>- Isoparametric elements</li> <li>- Numerical integration</li> <li>- Solving systems of equations (statics, dynamics)</li> <li>- Eigenvalue problems</li> <li>- Non-linear systems</li> <li>- Applications</li>   <li>- Programming of elements (Matlab, hands-on sessions)</li> <li>- Applications</li> </ul>
<b>Literature</b>	Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

Course L0804: Finite Element Methods	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1024: Methods of Integrated Product Development				
Courses				
Title	Typ	Hrs/wk	CP	
Integrated Product Development II (L1254)	Lecture	3	3	
Integrated Product Development II (L1255)	Project-/problem-based Learning	2	3	
<b>Module Responsible</b>	Prof. Dieter Krause			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge of Integrated product development and applying CAE systems			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> After passing the module students are able to:</p> <ul style="list-style-type: none"> <li>explain technical terms of design methodology,</li> <li>describe essential elements of construction management,</li> <li>describe current problems and the current state of research of integrated product development.</li> </ul> <p><i>Skills</i> After passing the module students are able to:</p> <ul style="list-style-type: none"> <li>select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundary conditions,</li> <li>solve product development problems with the assistance of a workshop based approach,</li> <li>choose and execute appropriate moderation techniques.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> After passing the module students are able to:</p> <ul style="list-style-type: none"> <li>prepare and lead team meetings and moderation processes,</li> <li>work in teams on complex tasks,</li> <li>represent problems and solutions and advance ideas.</li> </ul> <p><i>Autonomy</i> After passing the module students are able to:</p> <ul style="list-style-type: none"> <li>give a structured feedback and accept a critical feedback,</li> <li>implement the accepted feedback autonomously.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 Minuten			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L1254: Integrated Product Development II	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Dieter Krause
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p><b>Lecture</b></p> <p>The lecture extends and enhances the learned content of the module "Integrated Product Development and lightweight design" and is based on the knowledge and skills acquired there.</p> <p>Topics of the course include in particular:</p> <ul style="list-style-type: none"> <li>• Methods of product development,</li> <li>• Presentation techniques,</li> <li>• Industrial Design,</li> <li>• Design for variety</li> <li>• Modularization methods,</li> <li>• Design catalogs,</li> <li>• Adapted QFD matrix,</li> <li>• Systematic material selection,</li> <li>• Assembly oriented design,</li> </ul> <p>Construction management</p> <ul style="list-style-type: none"> <li>• CE mark, declaration of conformity including risk assessment,</li> <li>• Patents, patent rights, patent monitoring</li> <li>• Project management (cost, time, quality) and escalation principles,</li> <li>• Development management for mechatronics,</li> <li>• Technical Supply Chain Management.</li> </ul> <p><b>Exercise (PBL)</b></p> <p>In the exercise the content presented in the lecture "Integrated Product Development II" and methods of product development and design management will be enhanced.</p> <p>Students learn an independently moderated and workshop based approach through industry related practice examples to solve complex and currently existing issues in product development. They will learn the ability to apply important methods of product development and design management autonomous and acquire further expertise in the field of integrated product development. Besides personal skills, such as teamwork, guiding discussions and representing work results will be acquired through the workshop based structure of the event under its own planning and management.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Andreasen, M.M., Design for Assembly, Berlin, Springer 1985.</li> <li>• Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007.</li> <li>• Beckmann, H.: Supply Chain Management, Berlin, Springer 2004.</li> <li>• Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und Trainer, Weinheim, Beltz 2007.</li> <li>• Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006.</li> <li>• Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000.</li> <li>• Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York, Springer 2013.</li> </ul>

Course L1255: Integrated Product Development II	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Dieter Krause
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0836: Communication Networks			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Selected Topics of Communication Networks (L0899)		Project-/problem-based Learning	2              2
Communication Networks (L0897)		Lecture	2              2
Communication Networks Exercise (L0898)		Project-/problem-based Learning	1              2
<b>Module Responsible</b>	Prof. Andreas Timm-Giel		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Fundamental stochastics</li> <li>• Basic understanding of computer networks and/or communication technologies is beneficial</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are able to describe the principles and structures of communication networks in detail. They can explain the formal description methods of communication networks and their protocols. They are able to explain how current and complex communication networks work and describe the current research in these examples.		
<i>Skills</i>	Students are able to evaluate the performance of communication networks using the learned methods. They are able to work out problems themselves and apply the learned methods. They can apply what they have learned autonomously on further and new communication networks.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to define tasks themselves in small teams and solve these problems together using the learned methods. They can present the obtained results. They are able to discuss and critically analyse the solutions.		
<i>Autonomy</i>	Students are able to obtain the necessary expert knowledge for understanding the functionality and performance capabilities of new communication networks independently.		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Presentation		
<b>Examination duration and scale</b>	1.5 hours colloquium with three students, therefore about 30 min per student. Topics of the colloquium are the posters from the previous poster session and the topics of the module.		
<b>Assignment for the Following Curricula</b>	Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Networks: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory		

Course L0899: Selected Topics of Communication Networks	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Andreas Timm-Giel
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Example networks selected by the students will be researched on in a PBL course by the students in groups and will be presented in a poster session at the end of the term.
<b>Literature</b>	<ul style="list-style-type: none"> <li>• see lecture</li> </ul>



Course L0897: Communication Networks	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Andreas Timm-Giel, Dr.-Ing. Koojana Kuladinithi
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Skript des Instituts für Kommunikationsnetze</li> <li>• Tannenbaum, Computernetzwerke, Pearson-Studium</li> </ul> <p>Further literature is announced at the beginning of the lecture.</p>

Course L0898: Communication Networks Exercise	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Andreas Timm-Giel
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Part of the content of the lecture Communication Networks are reflected in computing tasks in groups, others are motivated and addressed in the form of a PBL exercise.
<b>Literature</b>	<ul style="list-style-type: none"> <li>• announced during lecture</li> </ul>

Module M1399: System Development Projekt				
<b>Courses</b>				
<b>Title</b>	Systems Engineering Development Project I+II (Block Event) (L1993)	<b>Typ</b>	Project-/problem-based Learning	<b>Hrs/wk</b> 12 <b>CP</b> 12
<b>Module Responsible</b>	Prof. Frank Thielecke			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in: <ul style="list-style-type: none"> <li>• Mathematics</li> <li>• Mechanics</li> <li>• Electrical Engineering</li> <li>• Control Systems</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	Students are able to... <ul style="list-style-type: none"> <li>• Name and explain all phases of the systems engineering process (V-Model)</li> <li>• Describe tools for systems engineering</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>	Students are able to... <ul style="list-style-type: none"> <li>• Define requirements for a system</li> <li>• Document and evaluate the system development process by using suitable tools</li> <li>• Design a system</li> <li>• Plan, execute and interpret system tests</li> </ul>			
<b>Personal Competence</b>	Students are able to... <ul style="list-style-type: none"> <li>• Perform a complete system design in small groups</li> <li>• Develop technical solutions in small groups as well as discuss, prepare and present these solutions to a plenum</li> <li>• Lead team meetings and group work</li> </ul>			
<i>Social Competence</i>				
<i>Autonomy</i>	Students are able to... <ul style="list-style-type: none"> <li>• Define tasks and tap required knowledge</li> <li>• Choose suitable methods for different systems engineering tasks</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 192, Study Time in Lecture 168			
<b>Credit points</b>	12			
<b>Course achievement</b>	None			
<b>Examination</b>	Written elaboration			
<b>Examination duration and scale</b>	approx. 60 - 200 pages			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Core qualification: Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory			

Course L1993: Systems Engineering Development Project I+II (Block Event)	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	12
<b>CP</b>	12
<b>Workload in Hours</b>	Independent Study Time 192, Study Time in Lecture 168
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	Wird in der Veranstaltung bekannt gegeben

**Thesis**

In their master's thesis students work independently on research-oriented problems, structuring the task into different sub-aspects and apply systematically the specialized competences they have acquired in the course of the study program.

Special importance is attached to a scientific approach to the problem including, in addition to an overview of literature on the subject, its classification in relation to current issues, a description of the theoretical foundations, and a critical analysis and assessment of the results.

<b>Module M-002: Master Thesis</b>			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
<b>Module Responsible</b>	Professoren der TUHH		
<b>Admission Requirements</b>	<ul style="list-style-type: none"> <li>According to General Regulations §21 (1):</li> </ul> <p>At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.</p>		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues.</li> <li>The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them.</li> <li>The students can place a research task in their subject area in its context and describe and critically assess the state of research.</li> </ul>		
<i>Knowledge</i>			
<i>Skills</i>	<p>The students are able:</p> <ul style="list-style-type: none"> <li>To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question.</li> <li>To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way.</li> <li>To develop new scientific findings in their subject area and subject them to a critical assessment.</li> </ul>		
<b>Personal Competence</b>	<p>Students can</p> <ul style="list-style-type: none"> <li>Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way.</li> <li>Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly.</li> </ul>		
<i>Social Competence</i>			
<i>Autonomy</i>	<p>Students are able:</p> <ul style="list-style-type: none"> <li>To structure a project of their own in work packages and to work them off accordingly.</li> <li>To work their way in depth into a largely unknown subject and to access the information required for them to do so.</li> <li>To apply the techniques of scientific work comprehensively in research of their own.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 900, Study Time in Lecture 0		
<b>Credit points</b>	30		
<b>Course achievement</b>	None		
<b>Examination</b>	Thesis		
<b>Examination duration and scale</b>	According to General Regulations		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy and Environmental Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computational Science and Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory		

International Management and Engineering: Thesis: Compulsory  
Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory  
Logistics, Infrastructure and Mobility: Thesis: Compulsory  
Materials Science: Thesis: Compulsory  
Mechanical Engineering and Management: Thesis: Compulsory  
Mechatronics: Thesis: Compulsory  
Biomedical Engineering: Thesis: Compulsory  
Microelectronics and Microsystems: Thesis: Compulsory  
Product Development, Materials and Production: Thesis: Compulsory  
Renewable Energies: Thesis: Compulsory  
Naval Architecture and Ocean Engineering: Thesis: Compulsory  
Ship and Offshore Technology: Thesis: Compulsory  
Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory  
Theoretical Mechanical Engineering: Thesis: Compulsory  
Process Engineering: Thesis: Compulsory  
Water and Environmental Engineering: Thesis: Compulsory  
~~Certification in Engineering & Advisory in Aviation: Thesis: Compulsory~~