



# **Module Manual**

Master of Science

# **Aircraft Systems Engineering**

Cohort: Winter Term 2016

Updated: 28th June 2017

## Table of Contents

Table of Contents	2
Program description	3
Core qualification	4
Module M0523: Business & Management	4
Module M0524: Nontechnical Elective Complementary Courses for Master	5
Module M0763: Aircraft Systems I	7
Module M0771: Flight Physics	9
Module M0812: Aircraft Design	11
Module M1041: Systems Engineering Development Project I	13
Module M1155: Aircraft Cabin Systems	14
Module M0764: Aircraft Systems II	16
Module M1042: Systems Engineering Development Project II	18
Module M1156: Systems Engineering	19
Specialization Aircraft Systems	21
Module M0846: Control Systems Theory and Design	21
Module M0565: Mechatronic Systems	23
Module M0721: Air Conditioning	25
Module M0752: Nonlinear Dynamics	27
Module M0840: Optimal and Robust Control	28
Module M1043: Aircraft Systems Engineering	30
Module M1145: Automation and Simulation	39
Module M1043: Aircraft Systems Engineering	41
Module M0808: Finite Elements Methods	50
Module M1091: Flight Guidance and Airline Operations	52
Module M1193: Cabin Systems Engineering	54
Module M1204: Modelling and Optimization in Dynamics	57
Module M1213: Avionics for safety-critical Systems	59
Module M0832: Advanced Topics in Control	61
Module M0563: Robotics	63
Specialization Cabin Systems	65
Module M1032: Airport Planning and Operations	65
Module M1193: Cabin Systems Engineering	67
Module M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )	70
Module M1145: Automation and Simulation	72
Module M1043: Aircraft Systems Engineering	74
Module M0721: Air Conditioning	83
Module M1043: Aircraft Systems Engineering	85
Module M0806: Technical Acoustics II (Room Acoustics, Computational Methods)	94
Module M1024: Methods of Integrated Product Development	96
Module M1091: Flight Guidance and Airline Operations	98
Module M0633: Industrial Process Automation	100
Module M1340: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	102
Specialization Air Transportation Systems	104
Module M1091: Flight Guidance and Airline Operations	104
Module M1193: Cabin Systems Engineering	106
Module M0982: Transportation Modelling	109
Module M0992: Transportation Economics	110
Module M1043: Aircraft Systems Engineering	112
Module M1043: Aircraft Systems Engineering	121
Module M1032: Airport Planning and Operations	130
Module M1024: Methods of Integrated Product Development	132
Module M0808: Finite Elements Methods	134
Module M1340: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	136
Thesis	138
Module M-002: Master Thesis	138

---

---

## Program description

---

---

### 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> <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: Nontechnical Elective Complementary 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-disciplinary 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>
<i>Skills</i>	<p><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>
<b>Personal Competence</b>	



Module M0763: Aircraft Systems I				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Aircraft Systems I (L0735)		Lecture	3	4
Aircraft Systems I (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>				
<i>Knowledge</i>	Students are able to: <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 ist functionality and effects</li> <li>• Assess the challenge during the design of supply systems of an aircraft</li> </ul>			
<i>Skills</i>	Students are able to: <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>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• Perform system design in groups and present and discuss results</li> </ul>			
<i>Autonomy</i>	Students are able to: <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>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: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

Course L0735: Aircraft Systems I	
<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> <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>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 Systems I	
<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>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. Klaus-Uwe Hahn, Dr. Ralf Heinrich
<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. Klaus-Uwe Hahn, Dr. Gerko Wende
<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. Klaus-Uwe Hahn, Dr. Gerko Wende
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0812: Aircraft Design	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Aircraft Design I (L0820)	Lecture 2 2
Aircraft Design I (L0834)	Recitation Section (large) 1 1
Aircraft Design II (Detailed Design Methods for Aerodynamics and Aircraft Structures, Multidisciplinary Design) (L0844)	Lecture 2 2
Aircraft Design II (Detailed Design Methods for Aerodynamics and Aircraft Structures, Multidisciplinary Design) (L0847)	Project Seminar 1 1
<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>• 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>	
<i>Knowledge</i>	<ol style="list-style-type: none"> <li>1. Principle understanding of integrated 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 aircraft design</li> <li>4. Introduction of the principle design methods</li> </ol>
<i>Skills</i>	Understanding and application of design and calculation methods Understanding of interdisciplinary and integrative interdependencies
<b>Personal Competence</b>	
<i>Social Competence</i>	Working in interdisciplinary teams Communication
<i>Autonomy</i>	Organization of workflows and -strategies
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Credit points</b>	6
<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: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0820: Aircraft Design I	
<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. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Introduction into the aircraft design process <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. Principles of aircraft performance design (stability, V-n-diagramme)</li> <li>5. Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics)</li> <li>6. Principles of structural fuselage and wing design (mass analysis, beam/tube models, geometry)</li> <li>7. Principles of engine design and integration</li> <li>8. Cruise design</li> <li>9. Design of runway and landing field length</li> <li>10. Cabin design (fuselage dimensioning, cabin interior, loading systems)</li> <li>11. System- and equipment aspects</li> <li>12. Design variations and operating cost calculation</li> </ol>
<b>Literature</b>	J. Roskam: "Airplane Design" D.P. Raymer: "Aircraft Design - A Conceptual Approach" J.P. Fielding: "Introduction to Aircraft Design" Jenkinson, Simpkin, Rhoads: "Civil Jet Aircraft Design"

Course L0834: Aircraft Design I	
<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. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Training in applying MatLab Application of design methods for civil aircraft concerning: Fuselage and Cabin sizing and design Calculation of aircraft masses Aerodynamic and geometric wing design TakeOff, landing cruise performance calculation Manoeuvre and gust load calculation
<b>Literature</b>	J. Roskam: "Airplane Design" D.P. Raymer: "Aircraft Design - A Conceptual Approach" J.P. Fielding: "Introduction to Aircraft Design" Jenkinson, Simpkin, Rhoads: "Civil Jet Aircraft Design"

Course L0844: Aircraft Design II (Detailed Design Methods for Aerodynamics and Aircraft Structures, Multidisciplinary Design)	
<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. Volker Gollnick, Björn Nagel
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Physical modelling in aircraft design Introduction - Numerical design process Parameterization and data formats Numerical beam models and lifting line Data base driven engine design Coupling (interpolation, time incremental process Aeroelastic effects Optimization methods in aircraft design Light weight design aspects in aircraft design Limits of simple design methods Numerical wing design
<b>Literature</b>	Horst Kossira: "Grundlagen des Leichtbaus. Einführung in die Theorie dünnwandiger stabförmiger Tragwerke" Johannes Wiedemann: "Leichtbau - Elemente und Konstruktion"

Course L0847: Aircraft Design II (Detailed Design Methods for Aerodynamics and Aircraft Structures, Multidisciplinary Design)	
<b>Typ</b>	Project Seminar
<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. Volker Gollnick, Björn Nagel
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1041: Systems Engineering Development Project I			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Systems Engineering Development Project I (L1307)		Problem-based Learning	6                  6
<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>	<p><i>Knowledge</i> Students are able to...</p> <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> <p><i>Skills</i> Students are able to...</p> <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> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to...</p> <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> <p><i>Autonomy</i> Students are able to...</p> <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 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	approx. 30 - 150 pages		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering; Core qualification: Compulsory		

Course L1307: Systems Engineering Development Project I	
<b>Typ</b>	Problem-based Learning
<b>Hrs/wk</b>	6
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<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

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></p> <p>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></p> <p>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></p> <p>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></p> <p>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>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 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: 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>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999</li> <li>- Rossow, C.-C., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014</li> <li>- Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008</li> <li>- Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003</li> <li>- Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006</li> <li>- Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006</li> </ul>

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

Module M0764: Aircraft Systems II				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Aircraft Systems II (L0736)		Lecture	3	4
Aircraft Systems II (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>				
<i>Knowledge</i>	Students are able to... <ul style="list-style-type: none"> <li>• describe the structure of primary flight control systems as well as actuation-, avionic-, fuel- and landing gear-systems in general along with corresponding properties and applications.</li> <li>• explain different configurations and designs and their origins</li> <li>• explain atmospheric conditions for icing such as the functionality of anti-ice systems</li> </ul>			
<i>Skills</i>	Students are able to... <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> <li>• design and analyse landing gear systems</li> <li>• design anti-ice systems</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• Develop joint solutions in mixed teams</li> </ul>			
<i>Autonomy</i>	Students are able to: <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>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: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			



Course L0736: Aircraft Systems II	
<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> </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: Aircraft Systems II	
<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 M1042: Systems Engineering Development Project II			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>
Systems Engineering Development Project II (L1308)		Problem-based Learning	6
<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>	<p><i>Knowledge</i> Students are able to...</p> <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> <p><i>Skills</i> Students are able to...</p> <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> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to...</p> <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> <p><i>Autonomy</i> Students are able to...</p> <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 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	approx. 30 - 150 pages		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering; Core qualification: Compulsory		

Course L1308: Systems Engineering Development Project II	
<b>Typ</b>	Problem-based Learning
<b>Hrs/wk</b>	6
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Lecturer</b>	Prof. Frank Thielecke
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	Wird in der Veranstaltung bekannt gegeben

Module M1156: Systems Engineering				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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>	<p><i>Knowledge</i></p> <p>Students are able to:</p> <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> <p><i>Skills</i></p> <p>Students are able to:</p> <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> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Students are able to:</p> <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> <p><i>Autonomy</i></p> <p>Students are able to:</p> <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>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			

Course L1547: Systems Engineering	
<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>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)</li> <li>- Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010</li> <li>- NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007</li> <li>- Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010</li> <li>- De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010</li> <li>- Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008</li> </ul>

Course L1548: Systems Engineering	
<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

## Specialization Aircraft Systems

By specializing in Aircraft Systems Engineering students learn how to work on complex system design problems in an analytical and methodical way. They are deepening existing and getting new competences in the field of control design, simulation, system modelling and other parts of system design. Choosing an open module allows students furthermore to participate in various lectures in the field of aviation.

### Module M0846: Control Systems Theory and Design

#### Courses

Title	Typ	Hrs/wk	CP
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>	<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>Knowledge</i>			
<i>Skills</i>			
<b>Personal Competence</b>	<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>		
<i>Social Competence</i>			
<i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core qualification: 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: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory		

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

Module M0565: Mechatronic Systems				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Electro- and Contromechanics (L0174)		Lecture	2	2
Electro- and Contromechanics (L1300)		Recitation Section (small)	1	2
Mechatronics Laboratory (L0196)		Laboratory	2	2
<b>Module Responsible</b>	Prof. Uwe Weltin			
<b>Admission Requirements</b>	none			
<b>Recommended Previous Knowledge</b>	Fundamentals of mechanics, electromechanics and 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 methods and calculations to design, model, simulate and optimize mechatronic systems and can repeat methods to verify and validate models.			
<i>Skills</i>	Students are able to plan and execute mechatronic experiments. Students are able to model mechatronic systems and derive simulations and optimizations.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task within the team.			
<i>Autonomy</i>	Students are able to solve individually exercises related to this lecture with instructional direction.  Students are able to plan, execute and summarize a mechatronic experiment.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min.			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Core qualification: Compulsory			

Course L0174: Electro- and Contromechanics	
<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. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	Introduction to methodical design of mechatronic systems: <ul style="list-style-type: none"> <li>• Modelling</li> <li>• System identification</li> <li>• Simulation</li> <li>• Optimization</li> </ul>
<b>Literature</b>	Denny Miu: Mechatronics, Springer 1992  Rolf Isermann: Mechatronic systems : fundamentals, Springer 2003

Course L1300: Electro- and Contromechanics	
<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. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L0196: Mechatronics Laboratory	
<b>Typ</b>	Laboratory
<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. Uwe Weltin
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Modeling in MATLAB® und Simulink® Controller Design (Linear, Nonlinear, Observer) Parameter identification Control of a real system with a realtimeboard and Simulink® RTW
<b>Literature</b>	- Abhängig vom Versuchsaufbau - Depends on the experiment



Module M0721 : Air Conditioning				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Air Conditioning (L0594)		Lecture	3	5
Air Conditioning (L0595)		Recitation Section (large)	1	1
<b>Module Responsible</b>	Prof. Gerhard Schmitz			
<b>Admission Requirements</b>	none			
<b>Recommended Previous Knowledge</b>	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a $h_1+x,x$ -diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants.			
<i>Skills</i>	Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air duct network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to discuss in small groups and develop an approach.			
<i>Autonomy</i>	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 min			
<b>Assignment for the Following Curricula</b>	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Course L0594: Air Conditioning	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Gerhard Schmitz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>1. Overview</p> <p>1.1 Kinds of air conditioning systems</p> <p>1.2 Ventilating</p> <p>1.3 Function of an air condition system</p> <p>2. Thermodynamic processes</p> <p>2.1 Psychrometric chart</p> <p>2.2 Mixer preheater, heater</p> <p>2.3 Cooler</p> <p>2.4 Humidifier</p> <p>2.5 Air conditioning process in a Psychrometric chart</p> <p>2.6 Desiccant assisted air conditioning</p> <p>3. Calculation of heating and cooling loads</p> <p>3.1 Heating loads</p> <p>3.2 Cooling loads</p> <p>3.3 Calculation of inner cooling load</p> <p>3.4 Calculation of outer cooling load</p> <p>4. Ventilating systems</p> <p>4.1 Fresh air demand</p> <p>4.2 Air flow in rooms</p> <p>4.3 Calculation of duct systems</p> <p>4.4 Fans</p> <p>4.5 Filters</p> <p>5. Refrigeration systems</p> <p>5.1. compression chillers</p> <p>5.2 Absorption chillers</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung</li> <li>• VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013</li> <li>• Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009</li> <li>• Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013</li> </ul>

Course L0595: Air Conditioning	
<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. Gerhard Schmitz
<b>Language</b>	DE
<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)		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>				
<i>Knowledge</i>	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
<i>Skills</i>	Students are able to apply existing methods and procedures of Nonlinear Dynamics and to develop novel methods and procedures.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can reach working results also in groups.			
<i>Autonomy</i>	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	2 Hours			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Scientific Computing: 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: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

Course L0702: Nonlinear Dynamics	
<b>Typ</b>	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 M0840: Optimal and Robust Control				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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>	Control Systems Theory and Design			
<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>	<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>Knowledge</i>				
<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>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: 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 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: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: 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 H<sub>2</sub> and H<sub>∞</sub> norms</li> <li>• Singular value plots, input and output directions</li> <li>• Mixed sensitivity design, H<sub>∞</sub> loop shaping, choice of weighting filters</li> <li>• Case study: design example flight control</li> <li>• Linear matrix inequalities, design specifications as LMI constraints (H<sub>2</sub>, H<sub>∞</sub> 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 M1043: Aircraft Systems Engineering	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Design Optimization and Probabilistic Approaches in Structural Analysis (L1814)	Seminar 3 3
Fatigue & Damage Tolerance (L0310)	Lecture 2 3
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1514)	Lecture 2 2
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1515)	Recitation Section (large) 1 1
Lightweight Design Practical Course (L1258)	Problem-based Learning 3 3
Aviation Security (L1549)	Lecture 2 2
Aviation Security (L1550)	Recitation Section (small) 1 1
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture 2 2
Metallic Materials for Aircraft Applications (L0514)	Lecture 2 3
Turbo Jet Engines (L0908)	Lecture 2 3
System Analysis in Air Transportation (L0855)	Lecture 3 3
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 avionics assemblies (L1554)	Lecture 2 2
Reliability of avionics assemblies (L1555)	Recitation Section (small) 1 1
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> <i>Knowledge</i>	<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>
<b>Skills</b>	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 choose 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: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1814: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Seminar
<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>	Hausarbeit
<b>Examination duration and scale</b>	ca. 10 Seiten und Diskussion
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. [2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L0310: Fatigue & Damage Tolerance	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	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 L1514: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Marco Schürg
Language	DE
Cycle	WiSe
Content	<p><b>Fundamentals of Anisotropic Elasticity</b></p> <p>Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law</p> <p><b>Behaviour of a single laminate layer</b></p> <p>Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules</p> <p><b>Fundamentals of Micromechanics of a laminate layer</b></p> <p>Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer</p> <p><b>Classical Laminate Plate Theory</b></p> <p>Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties</p> <p><b>Strength of Laminated Plates</b></p> <p>Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin</p> <p><b>Bending of Composite Laminated Plates</b></p> <p>Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions</p> <p><b>Stress Concentration Problems</b></p> <p>Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis</p> <p><b>Stability of Thin-Walled Composite Structures</b></p> <p>Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles</p> <p><b>Written exercise (report required)</b></p> <p>Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account</p>
Literature	<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: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
<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>	Dr. Marco Schürg
<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>	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>	<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 L1550: Aviation Security	
<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 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 L0514: Metallic Materials for Aircraft Applications	
<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. Joachim Albrecht
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties.</p> <p>CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications.</p> <p>Alpha+Beta alloys: Processing and microstructure, properties and applications.</p> <p>Beta alloys: Processing and microstructure, properties and applications</p> <p>Nickel-base Superalloys: Optimization of creep resistance for gas turbine engines, microstructural constituents and influence of alloying elements, thermomechanical treatment and resulting properties, long time stability at high temperatures</p>
<b>Literature</b>	<p>G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397</p> <p>C.T. Sims, W.C. Hagel: The Superalloys, John Wiley &amp; Sons, New York, 1972, ISBN 0-471-79207-1</p>

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 L0855: System Analysis in Air Transportation	
<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>	60 Minuten
<b>Lecturer</b>	Dr. Marco Weiss
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the Air Transport System</li> <li>2. System analysis methodologies</li> <li>3. Technology management</li> <li>4. Technical analysis methods</li> <li>5. Economical analysis methods</li> <li>6. Ecological analysis methods</li> <li>7. Societal analysis methods</li> <li>8. Research on the future</li> <li>9. Synthesis, overall assessment, decision making</li> <li>10. Case studies - Technology Push</li> <li>11. Case studies - Scenario Pull</li> </ol>
<b>Literature</b>	Hand out

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</p> <p>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>	Prof. Uwe Weltin
<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>	Prof. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1554: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L1555: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L0749: Reliability of Aircraft 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>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
<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 M1145: Automation and Simulation				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Automation and Simulation (L1525)		Lecture	3	3
Automation and Simulation (L1527)		Recitation Section (large)	2	3
<b>Module Responsible</b>	Prof. Günter Ackermann			
<b>Admission Requirements</b>	none			
<b>Recommended Previous Knowledge</b>	<b>BSc Mechanical Engineering or similar</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students can describe the structure and the function of process computers, the corresponding components, the data transfer via bus systems and programmable logic computers .			
	They can describe the basic principle of a numeric simulation and the corresponding parameters.			
	They can explain the usual method to simulate the dynamic behaviour of three-phase machines.			
<i>Skills</i>	Students can describe and design simple controllers using established methods.			
	They are able to assess the basic characteristics of a given automation system and to evaluate, if it is adequate for a given plant.			
	They can model and simulate technical systems with respect to their dynamical behaviour and can use Matlab/Simulink for the simulation.			
	They are able to apply established methods for the calculation of the dynamical behaviour of three-phase machines.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Teamwork in small teams.			
<i>Autonomy</i>	Students are able to identify the need of methodic analyses in the field of automation systems, to do these analyses in an adequate manner and to evaluate the results critically.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	Vorzugsweise in Dreier-Gruppen, etwa 1 Stunde			
<b>Assignment for the Following Curricula</b>	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective 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: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory			

Course L1525: Automation and Simulation	
<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. Günter Ackermann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Structure of automation systems</p> <p>Aufbau von Automationseinrichtungen</p> <p>Structure and function of process computers and corresponding components</p> <p>Data transfer via bus systems</p> <p>Programmable Logic Computers</p> <p>Methods to describe logic sequences</p> <p>Principles of the modelling and the simulation of continuous technical systems</p> <p>Practical work with an established simulation program (Matlab/Simulink)</p> <p>Simulation of the dynamic behaviour of a three-phase machine, simulation of a mixed continuous/discrete system on basis of transition flow diagrams.</p>
<b>Literature</b>	<p>U. Tietze, Ch. Schenk: Halbleiter-Schaltungstechnik; Springer Verlag</p> <p>R. Lauber, P. Göhner: Prozessautomatisierung 2, Springer Verlag</p> <p>Färber: Prozessrechenstechnik (Grundlagen, Hardware, Echtzeitverhalten), Springer Verlag</p> <p>Einführung/Tutorial Matlab/Simulink - verschiedene Autoren</p>

Course L1527: Automation and Simulation	
<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. Günter Ackermann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course



Module M1043: Aircraft Systems Engineering	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Design Optimization and Probabilistic Approaches in Structural Analysis (L1814)	Seminar 3 3
Fatigue & Damage Tolerance (L0310)	Lecture 2 3
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1514)	Lecture 2 2
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1515)	Recitation Section (large) 1 1
Lightweight Design Practical Course (L1258)	Problem-based Learning 3 3
Aviation Security (L1549)	Lecture 2 2
Aviation Security (L1550)	Recitation Section (small) 1 1
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture 2 2
Metallic Materials for Aircraft Applications (L0514)	Lecture 2 3
Turbo Jet Engines (L0908)	Lecture 2 3
System Analysis in Air Transportation (L0855)	Lecture 3 3
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 avionics assemblies (L1554)	Lecture 2 2
Reliability of avionics assemblies (L1555)	Recitation Section (small) 1 1
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> <i>Knowledge</i>	<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>
<b>Skills</b>	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 choose 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: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1814: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Seminar
<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>	Hausarbeit
<b>Examination duration and scale</b>	ca. 10 Seiten und Diskussion
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. [2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L0310: Fatigue & Damage Tolerance	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	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 L1514: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Marco Schürg
Language	DE
Cycle	WiSe
Content	<p><b>Fundamentals of Anisotropic Elasticity</b></p> <p>Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law</p> <p><b>Behaviour of a single laminate layer</b></p> <p>Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules</p> <p><b>Fundamentals of Micromechanics of a laminate layer</b></p> <p>Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer</p> <p><b>Classical Laminate Plate Theory</b></p> <p>Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties</p> <p><b>Strength of Laminated Plates</b></p> <p>Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin</p> <p><b>Bending of Composite Laminated Plates</b></p> <p>Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions</p> <p><b>Stress Concentration Problems</b></p> <p>Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis</p> <p><b>Stability of Thin-Walled Composite Structures</b></p> <p>Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles</p> <p><b>Written exercise (report required)</b></p> <p>Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account</p>
Literature	<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: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
<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>	Dr. Marco Schürg
<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>	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>	<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 L1550: Aviation Security	
<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 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 L0514: Metallic Materials for Aircraft Applications	
<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. Joachim Albrecht
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties.</p> <p>CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications.</p> <p>Alpha+Beta alloys: Processing and microstructure, properties and applications.</p> <p>Beta alloys: Processing and microstructure, properties and applications</p> <p>Nickel-base Superalloys: Optimization of creep resistance for gas turbine engines, microstructural constituents and influence of alloying elements, thermomechanical treatment and resulting properties, long time stability at high temperatures</p>
<b>Literature</b>	<p>G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397</p> <p>C.T. Sims, W.C. Hagel: The Superalloys, John Wiley &amp; Sons, New York, 1972, ISBN 0-471-79207-1</p>

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 L0855: System Analysis in Air Transportation	
<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>	60 Minuten
<b>Lecturer</b>	Dr. Marco Weiss
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the Air Transport System</li> <li>2. System analysis methodologies</li> <li>3. Technology management</li> <li>4. Technical analysis methods</li> <li>5. Economical analysis methods</li> <li>6. Ecological analysis methods</li> <li>7. Societal analysis methods</li> <li>8. Research on the future</li> <li>9. Synthesis, overall assessment, decision making</li> <li>10. Case studies - Technology Push</li> <li>11. Case studies - Scenario Pull</li> </ol>
<b>Literature</b>	Hand out

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</p> <p>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>	Prof. Uwe Weltin
<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>	Prof. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1554: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L1555: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>



Course L0749: Reliability of Aircraft 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>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
<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 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>	-		
<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>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 Computational Science and Engineering: Specialisation Scientific Computing: 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 Endoprotheses: 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 Technomathematics: Core qualification: 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 M1091: Flight Guidance and Airline Operations				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>	
Airline Operations (L1310)	Lecture	3	3	
Introduction to Flight Guidance (L0848)	Lecture	3	2	
Introduction to Flight Guidance (L0854)	Recitation Section (large)	1	1	
<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>• Vordiplom Mech. Eng.</li> <li>• Lecture Air Transportation 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. Principles of Air Traffic Management and technologies</li> <li>2. Design and modelling of traffic flows, avionics and sensor systems, cockpit design</li> <li>3. Principles of Airline organization and business</li> <li>4. Fleet setup, fleet operation, aircraft selection, maintenance, repair overhaul technologies and business</li> </ol> <p><i>Skills</i></p> <ul style="list-style-type: none"> <li>• Understanding and application of different interdisciplinary interdependencies</li> <li>• Integration and assessment of new technologies in the air transportation system</li> <li>• Modelling and assessment of flight guidance systems</li> <li>• Airline fleet planning and fleet operation</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <ul style="list-style-type: none"> <li>• Working in interdisciplinary teams</li> <li>• Communication</li> </ul> <p><i>Autonomy</i></p> <p>Organization of workflows and -strategies</p>			
<b>Workload in Hours</b>	Independent Study Time 82, Study Time in Lecture 98			
<b>Credit points</b>	6			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	180 min			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory			

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>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 L0848: Introduction to Flight Guidance	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 18, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.) Navigation Radio navigation Satellite navigation 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 Airspace surveillance (radar systems) Communication systems Avionics architectures (computer systems, bus systems) Cockpit systems and displays (cockpit design, cockpit equipment)
<b>Literature</b>	Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2012 Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013 Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2014

Course L0854: Introduction to 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>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

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)		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>				
<i>Knowledge</i>	Students are able to: <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>			
<i>Skills</i>	Students are able to: <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>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• elaborate partial results and merge with others to form a complete solution</li> </ul>			
<i>Autonomy</i>	Students are able to: <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>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: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: 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 L1557: Computer and communication technology in cabin electronics and avionics	
<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>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003</li> <li>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004</li> <li>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006</li> </ul>

Course L1558: Computer and communication technology in cabin electronics and avionics	
<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>

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML	
<b>Typ</b>	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>- Weilkiens, 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 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>	<p><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.</p> <p><i>Skills</i> Students are able</p> <ul style="list-style-type: none"> <li>+ to think holistically</li> <li>+ to independently, securely and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems</li> <li>+ to describe dynamics problems mathematically</li> <li>+ to optimize dynamics problems</li> </ul>		
<b>Personal Competence</b>	<p><i>Social Competence</i> Students are able to</p> <ul style="list-style-type: none"> <li>+ solve problems in heterogeneous groups and to document the corresponding results.</li> </ul> <p><i>Autonomy</i> Students are able to</p> <ul style="list-style-type: none"> <li>+ assess their knowledge by means of exercises.</li> <li>+ acquaint themselves with the necessary knowledge to solve research oriented tasks.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<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: 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 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
<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, Dr. Alexander Held
<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 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)		Laboratory Course	1	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>• 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>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering; Specialisation Aircraft Systems: 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 History</li> <li>2. Flight Control</li> <li>3. Hardware</li> <li>4. I/O und Bus Systems</li> <li>5. Software</li> <li>6. Process und Certification</li> <li>7. Cockpit und Displays</li> <li>8. Integrated Modular Avionics I</li> <li>9. Integrated Modular Avionics II</li> <li>10. Design of IMA Systems</li> <li>11. Configuration of IMA Systems</li> <li>12. Verification and Test</li> <li>13. Integration</li> <li>14. Space avionics</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>	Laboratory 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 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>	Optimal and Robust Control		
<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>	<p><i>Knowledge</i></p> <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> <p><i>Skills</i></p> <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> <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> <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> <li>Students are able to design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided</li> <li>Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox</li> </ul>		
<b>Personal Competence</b>	<p><i>Social Competence</i></p> <p>Students can work in small groups and arrive at joint results.</p> <p><i>Autonomy</i></p> <p>Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: 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 Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: 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>• Control of Spatially Interconnected Systems               <ul style="list-style-type: none"> <li>- Multidimensional signals, l2 and L2 signal norm</li> <li>- Multidimensional systems in Roesser state space form</li> <li>- Extension of real-bounded lemma to spatially interconnected systems</li> <li>- LMI-based synthesis of distributed controllers</li> <li>- Spatial LPV control of spatially varying systems</li> <li>- Applications: control of temperature profiles, vibration damping for an actuated beam</li> </ul> </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 M0563: Robotics			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Robotics: Modelling and Control (L0168)	Lecture	3	3
Robotics: Modelling and Control (L1305)	Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Uwe Weltin		
<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 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Production Management: Specialisation Production Technology: 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: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Course L0168: Robotics: Modelling and Control	
<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. Uwe Weltin
<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

Course L1305: Robotics: Modelling and 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. Uwe Wetlin
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course





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>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 strucutres around airports</li> <li>4. Airfield lightings, marking and information</li> <li>5. Airfield and terminal configuration</li> </ol>
<b>Literature</b>	N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley & Sons, 1991  Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003

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>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

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)		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>				
<i>Knowledge</i>	Students are able to: <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>			
<i>Skills</i>	Students are able to: <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>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• elaborate partial results and merge with others to form a complete solution</li> </ul>			
<i>Autonomy</i>	Students are able to: <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>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: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: 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			

Course L1557: Computer and communication technology in cabin electronics and avionics	
<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>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003</li> <li>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004</li> <li>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006</li> </ul>

Course L1558: Computer and communication technology in cabin electronics and avionics	
<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>

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML	
<b>Typ</b>	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>- Weilkiens, 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 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>				
<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>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	20-30 Minuten			
<b>Assignment for the Following Curricula</b>	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: 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: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: 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

Course L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )	
<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 M1145: Automation and Simulation				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Automation and Simulation (L1525)		Lecture	3	3
Automation and Simulation (L1527)		Recitation Section (large)	2	3
<b>Module Responsible</b>	Prof. Günter Ackermann			
<b>Admission Requirements</b>	none			
<b>Recommended Previous Knowledge</b>	<b>BSc Mechanical Engineering or similar</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	<p>Students can describe the structure and the function of process computers, the corresponding components, the data transfer via bus systems and programmable logic computers .</p> <p>They can describe the basic principle of a numeric simulation and the corresponding parameters.</p> <p>They can explain the usual method to simulate the dynamic behaviour of three-phase machines.</p>			
<i>Skills</i>	<p>Students can describe and design simple controllers using established methods.</p> <p>They are able to assess the basic characteristics of a given automation system and to evaluate, if it is adequate for a given plant.</p> <p>They can model and simulate technical systems with respect to their dynamical behaviour and can use Matlab/Simulink for the simulation.</p> <p>They are able to apply established methods for the calculation of the dynamical behaviour of three-phase machines.</p>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Teamwork in small teams.			
<i>Autonomy</i>	Students are able to identify the need of methodic analyses in the field of automation systems, to do these analyses in an adequate manner and to evaluate the results critically.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	Vorzugsweise in Dreier-Gruppen, etwa 1 Stunde			
<b>Assignment for the Following Curricula</b>	<p>Energy Systems: Core qualification: Elective Compulsory</p> <p>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory</p> <p>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory</p> <p>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory</p> <p>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory</p> <p>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory</p> <p>Mechatronics: Specialisation System Design: Elective Compulsory</p> <p>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory</p> <p>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory</p> <p>Product Development, Materials and Production: Specialisation Production: Elective Compulsory</p> <p>Product Development, Materials and Production: Specialisation Materials: Elective Compulsory</p>			



Course L1525: Automation and Simulation	
<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. Günter Ackermann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Structure of automation systems</p> <p>Aufbau von Automationseinrichtungen</p> <p>Structure and function of process computers and corresponding components</p> <p>Data transfer via bus systems</p> <p>Programmable Logic Computers</p> <p>Methods to describe logic sequences</p> <p>Principles of the modelling and the simulation of continuous technical systems</p> <p>Practical work with an established simulation program (Matlab/Simulink)</p> <p>Simulation of the dynamic behaviour of a three-phase machine, simulation of a mixed continuous/discrete system on base of transition flow diagrams.</p>
<b>Literature</b>	<p>U. Tietze, Ch. Schenk: Halbleiter-Schaltungstechnik; Springer Verlag</p> <p>R. Lauber, P. Göhner: Prozessautomatisierung 2, Springer Verlag</p> <p>Färber: Prozessrechenstechnik (Grundlagen, Hardware, Echtzeitverhalten), Springer Verlag</p> <p>Einführung/Tutorial Matlab/Simulink - verschiedene Autoren</p>

Course L1527: Automation and Simulation	
<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. Günter Ackermann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1043: Aircraft Systems Engineering	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Design Optimization and Probabilistic Approaches in Structural Analysis (L1814)	Seminar 3 3
Fatigue & Damage Tolerance (L0310)	Lecture 2 3
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1514)	Lecture 2 2
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1515)	Recitation Section (large) 1 1
Lightweight Design Practical Course (L1258)	Problem-based Learning 3 3
Aviation Security (L1549)	Lecture 2 2
Aviation Security (L1550)	Recitation Section (small) 1 1
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture 2 2
Metallic Materials for Aircraft Applications (L0514)	Lecture 2 3
Turbo Jet Engines (L0908)	Lecture 2 3
System Analysis in Air Transportation (L0855)	Lecture 3 3
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 avionics assemblies (L1554)	Lecture 2 2
Reliability of avionics assemblies (L1555)	Recitation Section (small) 1 1
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> <i>Knowledge</i>	<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>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 choose 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: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1814: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Seminar
<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>	Hausarbeit
<b>Examination duration and scale</b>	ca. 10 Seiten und Diskussion
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. [2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L0310: Fatigue & Damage Tolerance	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	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 L1514: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Marco Schürg
Language	DE
Cycle	WiSe
Content	<p><b>Fundamentals of Anisotropic Elasticity</b></p> <p>Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law</p> <p><b>Behaviour of a single laminate layer</b></p> <p>Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules</p> <p><b>Fundamentals of Micromechanics of a laminate layer</b></p> <p>Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer</p> <p><b>Classical Laminate Plate Theory</b></p> <p>Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties</p> <p><b>Strength of Laminated Plates</b></p> <p>Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin</p> <p><b>Bending of Composite Laminated Plates</b></p> <p>Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions</p> <p><b>Stress Concentration Problems</b></p> <p>Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis</p> <p><b>Stability of Thin-Walled Composite Structures</b></p> <p>Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles</p> <p><b>Written exercise (report required)</b></p> <p>Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account</p>
Literature	<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: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
<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>	Dr. Marco Schürg
<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>	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>	<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 L1550: Aviation Security	
<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 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 L0514: Metallic Materials for Aircraft Applications	
<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. Joachim Albrecht
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties.</p> <p>CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications.</p> <p>Alpha+Beta alloys: Processing and microstructure, properties and applications.</p> <p>Beta alloys: Processing and microstructure, properties and applications</p> <p>Nickel-base Superalloys: Optimization of creep resistance for gas turbine engines, microstructural constituents and influence of alloying elements, thermomechanical treatment and resulting properties, long time stability at high temperatures</p>
<b>Literature</b>	<p>G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397</p> <p>C.T. Sims, W.C. Hagel: The Superalloys, John Wiley &amp; Sons, New York, 1972, ISBN 0-471-79207-1</p>

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 L0855: System Analysis in Air Transportation	
<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>	60 Minuten
<b>Lecturer</b>	Dr. Marco Weiss
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the Air Transport System</li> <li>2. System analysis methodologies</li> <li>3. Technology management</li> <li>4. Technical analysis methods</li> <li>5. Economical analysis methods</li> <li>6. Ecological analysis methods</li> <li>7. Societal analysis methods</li> <li>8. Research on the future</li> <li>9. Synthesis, overall assessment, decision making</li> <li>10. Case studies - Technology Push</li> <li>11. Case studies - Scenario Pull</li> </ol>
<b>Literature</b>	Hand out

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>	Prof. Uwe Weltin
<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>	Prof. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course



Course L1554: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L1555: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L0749: Reliability of Aircraft 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>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
<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 M0721: Air Conditioning				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Air Conditioning (L0594)		Lecture	3	5
Air Conditioning (L0595)		Recitation Section (large)	1	1
<b>Module Responsible</b>	Prof. Gerhard Schmitz			
<b>Admission Requirements</b>	none			
<b>Recommended Previous Knowledge</b>	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a $h_1+x,x$ -diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants.			
<i>Skills</i>	Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air duct network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to discuss in small groups and develop an approach.			
<i>Autonomy</i>	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 min			
<b>Assignment for the Following Curricula</b>	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Course L0594: Air Conditioning	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Gerhard Schmitz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>1. Overview</p> <p>1.1 Kinds of air conditioning systems</p> <p>1.2 Ventilating</p> <p>1.3 Function of an air condition system</p> <p>2. Thermodynamic processes</p> <p>2.1 Psychrometric chart</p> <p>2.2 Mixer preheater, heater</p> <p>2.3 Cooler</p> <p>2.4 Humidifier</p> <p>2.5 Air conditioning process in a Psychrometric chart</p> <p>2.6 Desiccant assisted air conditioning</p> <p>3. Calculation of heating and cooling loads</p> <p>3.1 Heating loads</p> <p>3.2 Cooling loads</p> <p>3.3 Calculation of inner cooling load</p> <p>3.4 Calculation of outer cooling load</p> <p>4. Ventilating systems</p> <p>4.1 Fresh air demand</p> <p>4.2 Air flow in rooms</p> <p>4.3 Calculation of duct systems</p> <p>4.4 Fans</p> <p>4.5 Filters</p> <p>5. Refrigeration systems</p> <p>5.1. compression chillers</p> <p>5.2 Absorption chillers</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schmitz, G.: Klimaanlageanlagen, Skript zur Vorlesung</li> <li>• VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013</li> <li>• Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009</li> <li>• Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013</li> </ul>

Course L0595: Air Conditioning	
<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. Gerhard Schmitz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1043: Aircraft Systems Engineering	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Design Optimization and Probabilistic Approaches in Structural Analysis (L1814)	Seminar 3 3
Fatigue & Damage Tolerance (L0310)	Lecture 2 3
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1514)	Lecture 2 2
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1515)	Recitation Section (large) 1 1
Lightweight Design Practical Course (L1258)	Problem-based Learning 3 3
Aviation Security (L1549)	Lecture 2 2
Aviation Security (L1550)	Recitation Section (small) 1 1
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture 2 2
Metallic Materials for Aircraft Applications (L0514)	Lecture 2 3
Turbo Jet Engines (L0908)	Lecture 2 3
System Analysis in Air Transportation (L0855)	Lecture 3 3
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 avionics assemblies (L1554)	Lecture 2 2
Reliability of avionics assemblies (L1555)	Recitation Section (small) 1 1
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> <i>Knowledge</i>	<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>
<b>Skills</b>	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 choose 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: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1814: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Seminar
<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>	Hausarbeit
<b>Examination duration and scale</b>	ca. 10 Seiten und Diskussion
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. [2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L0310: Fatigue & Damage Tolerance	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	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 L1514: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Marco Schürg
Language	DE
Cycle	WiSe
Content	<p><b>Fundamentals of Anisotropic Elasticity</b></p> <p>Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law</p> <p><b>Behaviour of a single laminate layer</b></p> <p>Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules</p> <p><b>Fundamentals of Micromechanics of a laminate layer</b></p> <p>Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer</p> <p><b>Classical Laminate Plate Theory</b></p> <p>Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties</p> <p><b>Strength of Laminated Plates</b></p> <p>Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin</p> <p><b>Bending of Composite Laminated Plates</b></p> <p>Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions</p> <p><b>Stress Concentration Problems</b></p> <p>Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis</p> <p><b>Stability of Thin-Walled Composite Structures</b></p> <p>Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles</p> <p><b>Written exercise (report required)</b></p> <p>Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account</p>
Literature	<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: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
<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>	Dr. Marco Schürg
<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>	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>	<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 L1550: Aviation Security	
<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 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 L0514: Metallic Materials for Aircraft Applications	
<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. Joachim Albrecht
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties.</p> <p>CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications.</p> <p>Alpha+Beta alloys: Processing and microstructure, properties and applications.</p> <p>Beta alloys: Processing and microstructure, properties and applications</p> <p>Nickel-base Superalloys: Optimization of creep resistance for gas turbine engines, microstructural constituents and influence of alloying elements, thermomechanical treatment and resulting properties, long time stability at high temperatures</p>
<b>Literature</b>	<p>G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397</p> <p>C.T. Sims, W.C. Hagel: The Superalloys, John Wiley &amp; Sons, New York, 1972, ISBN 0-471-79207-1</p>

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 L0855: System Analysis in Air Transportation	
<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>	60 Minuten
<b>Lecturer</b>	Dr. Marco Weiss
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the Air Transport System</li> <li>2. System analysis methodologies</li> <li>3. Technology management</li> <li>4. Technical analysis methods</li> <li>5. Economical analysis methods</li> <li>6. Ecological analysis methods</li> <li>7. Societal analysis methods</li> <li>8. Research on the future</li> <li>9. Synthesis, overall assessment, decision making</li> <li>10. Case studies - Technology Push</li> <li>11. Case studies - Scenario Pull</li> </ol>
<b>Literature</b>	Hand out

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</p> <p>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>	Prof. Uwe Weltin
<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>	Prof. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1554: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L1555: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L0749: Reliability of Aircraft 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>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
<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 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> <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>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	20-30 Minuten		
<b>Assignment for the Following Curricula</b>	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>	<ul style="list-style-type: none"> <li>- Room acoustics</li> <li>- Sound absorber</li> <li>- Standard computations</li> <li>- Statistical Energy Approaches</li> <li>- Finite Element Methods</li> <li>- Boundary Element Methods</li> <li>- Geometrical acoustics</li> <li>- Special formulations</li> <li>- Practical applications</li> <li>- Hands-on Sessions: Programming of elements (Matlab)</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 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 M1024: Methods of Integrated Product Development				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Integrated Product Development II (L1254)		Lecture	3	3
Integrated Product Development II (L1255)		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>				
<i>Knowledge</i>	After passing the module students are able to: <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>			
<i>Skills</i>	After passing the module students are able to: <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>			
<b>Personal Competence</b>				
<i>Social Competence</i>	After passing the module students are able to: <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>			
<i>Autonomy</i>	After passing the module students are able to: <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>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 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>	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 M1091: Flight Guidance and Airline Operations	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Airline Operations (L1310)	Lecture 3 3
Introduction to Flight Guidance (L0848)	Lecture 3 2
Introduction to Flight Guidance (L0854)	Recitation Section (large) 1 1
<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>• Vordiplom Mech. Eng.</li> <li>• Lecture Air Transportation 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>	<ol style="list-style-type: none"> <li>1. Principles of Air Traffic Management and technologies</li> <li>2. Design and modelling of traffic flows, avionics and sensor systems, cockpit design</li> <li>3. Principles of Airline organization and business</li> <li>4. Fleet setup, fleet operation, aircraft selection, maintenance, repair overhaul technologies and business</li> </ol>
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Understanding and application of different interdisciplinary interdependencies</li> <li>• Integration and assessment of new technologies in the air transportation system</li> <li>• Modelling and assessment of flight guidance systems</li> <li>• Airline fleet planning and fleet operation</li> </ul>
<b>Personal Competence</b>	
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Working in interdisciplinary teams</li> <li>• Communication</li> </ul>
<i>Autonomy</i>	Organization of workflows and -strategies
<b>Workload in Hours</b>	Independent Study Time 82, Study Time in Lecture 98
<b>Credit points</b>	6
<b>Examination</b>	Written exam
<b>Examination duration and scale</b>	180 min
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory

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>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 L0848: Introduction to Flight Guidance	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 18, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.) Navigation Radio navigation Satellite navigation 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 Airspace surveillance (radar systems) Communication systems Avionics architectures (computer systems, bus systems) Cockpit systems and displays (cockpit design, cockpit equipment)
<b>Literature</b>	Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2012 Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013 Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2014

Course L0854: Introduction to 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>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

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.			
<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>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 Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Production Management: Specialisation Production Technology: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Course L0344: Industrial Process Automation	
<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>	J. Lunze: „Automatisierungstechnik“, Oldenbourg Verlag, 2012 Reisig: Petrinetze: Modellierungstechnik, Analysemethoden, Fallstudien; Vieweg+Teubner 2010 Hruz, Zhou: Modeling and Control of Discrete-event Dynamic Systems; Springer 2007 Li, Zhou: Deadlock Resolution in Automated Manufacturing Systems, Springer 2009 Pinedo: Planning and Scheduling in Manufacturing and Services, Springer 2009

Course L0345: Industrial Process Automation	
<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 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> <p><b>Personal Competence</b></p> <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>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	45 min			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory			

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
<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>	WiSe
<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) for graduate engineering students that do not have a formal background in electrical engineering. 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>

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
<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>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

## Specialization Air Transportation Systems

The degree programme „Air Transportation Systems and Preliminary Aircraft Design“ provides a comprehensive understanding of operational aspects of air transport. Further students are educated in aircraft design methods based on operational requirements. The programme competences will extend and intensify the basic competencies of the bachelor studies by specific methods in design and modelling of air transport systems and aircraft a part of it.

As a result graduates will be system analysts being able to design, integrate, model and assess complex systems like air transport including the related technologies.

Module M1091: Flight Guidance and Airline Operations	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b>
Airline Operations (L1310)	Lecture
Introduction to Flight Guidance (L0848)	Lecture
Introduction to Flight Guidance (L0854)	Recitation Section (large)
	<b>Hrs/wk</b>
	<b>CP</b>
	3
	3
	1
	3
	2
	1
	1
<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>• Vordiplom Mech. Eng.</li> <li>• Lecture Air Transportation 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>	<ol style="list-style-type: none"> <li>1. Principles of Air Traffic Management and technologies</li> <li>2. Design and modelling of traffic flows, avionics and sensor systems, cockpit design</li> <li>3. Principles of Airline organization and business</li> <li>4. Fleet setup, fleet operation, aircraft selection, maintenance, repair overhaul technologies and business</li> </ol>
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Understanding and application of different interdisciplinary interdependencies</li> <li>• Integration and assessment of new technologies in the air transportation system</li> <li>• Modelling and assessment of flight guidance systems</li> <li>• Airline fleet planning and fleet operation</li> </ul>
<b>Personal Competence</b>	
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Working in interdisciplinary teams</li> <li>• Communication</li> </ul>
<i>Autonomy</i>	Organization of workflows and -strategies
<b>Workload in Hours</b>	Independent Study Time 82, Study Time in Lecture 98
<b>Credit points</b>	6
<b>Examination</b>	Written exam
<b>Examination duration and scale</b>	180 min
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory



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>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 L0848: Introduction to Flight Guidance	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 18, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Volker Gollnick
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.) Navigation Radio navigation Satellite navigation 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 Airspace surveillance (radar systems) Communication systems Avionics architectures (computer systems, bus systems) Cockpit systems and displays (cockpit design, cockpit equipment)
<b>Literature</b>	Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2012 Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013 Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2014

Course L0854: Introduction to 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>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

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)		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>				
<i>Knowledge</i>	Students are able to: <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>			
<i>Skills</i>	Students are able to: <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>			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• elaborate partial results and merge with others to form a complete solution</li> </ul>			
<i>Autonomy</i>	Students are able to: <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>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: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: 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			

Course L1557: Computer and communication technology in cabin electronics and avionics	
<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>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003</li> <li>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004</li> <li>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006</li> </ul>

Course L1558: Computer and communication technology in cabin electronics and avionics	
<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>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003</li> <li>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004</li> <li>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006</li> </ul>

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML	
<b>Typ</b>	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>	<ul style="list-style-type: none"> <li>- Skript zur Vorlesung</li> <li>- Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008</li> <li>- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering &amp; Tech, 2011</li> </ul>

Module M0982: Transportation Modelling			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Transportation Modelling (L1180)		Problem-based Learning	4                  6
<b>Module Responsible</b>	Prof. Carsten Gertz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“		
<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 understand the operation and potential applications of transport models.		
<i>Skills</i>	Students are able to:		
	<ul style="list-style-type: none"> <li>• use travel demand modelling software packages for solving practical problems.</li> <li>• design a database structure for travel demand models.</li> <li>• assess modelling results.</li> <li>• appraise potential applications and limitations of such models.</li> </ul>		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to independently develop and document solutions.		
<i>Autonomy</i>	Students are able to:		
	<ul style="list-style-type: none"> <li>• independently organise, manage and solve set tasks.</li> <li>• independently prepare written reports.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Examination</b>	Project		
<b>Examination duration and scale</b>			
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory		

Course L1180: Transportation Modelling	
<b>Typ</b>	Problem-based Learning
<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. Carsten Gertz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Principles of transport modelling</li> <li>• Role of transport modelling in the planning process</li> <li>• Fundamentals of mobility behaviour</li> <li>• Design and evaluation of transport/mobility surveys</li> <li>• mode of operation and data requirements for different stages of modelling</li> <li>• Forecasting and scenarios in the transport planning</li> <li>• The range of model applications (from transport infrastructure planning over simulation of traffic flows to integrated land-use and transport models as well as the use of models for evaluating locations)</li> <li>• Practice-oriented project for assessing consequences of infrastructure projects and changes in land-use</li> </ul>
<b>Literature</b>	Lohse, Dieter und Schnabel, Werner (2011): Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung – Band 2. 3. Auflage. Beuth.  Ortúzar, Juan de Dios und Willumsen, Luis G. (2011): Modelling Transport. 4. Auflage. John Wiley & Sons.

Module M0992: Transportation Economics			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Transportation Economics (L1194)		Lecture	2                  4
Transportation Economics (L1195)		Recitation Section (large)	2                  2
<b>Module Responsible</b>	Prof. Carsten Gertz		
<b>Admission Requirements</b>	none		
<b>Recommended Previous Knowledge</b>	Fundamentals of Transportation Economics		
<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>• Specify the different functions of transportation</li> <li>• Describe macroeconomic developments in transportation</li> <li>• Explain the tasks of national and international transport policy</li> <li>• Assess evaluation and decision problems of transport infrastructure policy</li> <li>• Compare different financing models and instruments for transport infrastructure</li> </ul>		
<i>Skills</i>	Students can... <ul style="list-style-type: none"> <li>• Use analysis methods for the evaluation of transport infrastructure appropriately</li> <li>• Choose the appropriate instrument for financing transport infrastructure from a set of alternatives</li> </ul>		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students can... <ul style="list-style-type: none"> <li>• Prepare, document and present results individually or in a group</li> <li>• Assess your own performance and enhance it constructively</li> </ul>		
<i>Autonomy</i>	Students can... <ul style="list-style-type: none"> <li>• Assess your own learning progress and state of knowledge</li> <li>• Carry out literature research and analyses</li> <li>• Perform assigned tasks on your own, structure them with regard to contents and finish them on time</li> <li>• Create written works on your own</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	60 minutes		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Logistics, Infrastructure and Mobility: Core qualification: Compulsory		

Course L1194: Transportation Economics	
<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>	Martin Makait
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>The course transfers knowledge on the principles of transport policy in the following areas</p> <ul style="list-style-type: none"> <li>• Functions and macroeconomic developments in transportation</li> <li>• National und international transport policy</li> <li>• Transport infrastructure policy and economic evaluation problems of infrastructure</li> <li>• Financing models and instruments for transport infrastructure</li> </ul> <p>Key contents of the course are further explored and discussed in the tutorial</p>
<b>Literature</b>	<p>Aberle, G. (2009): Transportwirtschaft, 5. Auflage, Oldenbourg Verlag, München.</p> <p>Button, K. (2010): Transport Economics, 3rd Edition, Edw. Elgar Publishing Cheltenham UK.</p> <p>Daehre-Kommission (2012): Zukunft der Verkehrsinfrastruktur-finanzierung, Berlin.</p> <p>Ferich, J. u. Müller, G. (2004): Europäische Verkehrspolitik, Band 1 - 3, München.</p> <p>Grandjot, H.-H. (2002): Verkehrspolitik - Grundlagen, Funktionen und Perspektiven für Wissenschaft und Praxis, Deutscher Verkehrs-Verlag, Hamburg.</p> <p>Kummer, S. (2006): Einführung in die Verkehrswirtschaft. Facultas Verlag, Wien</p>

Course L1195: Transportation Economics	
<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>	Martin Makait
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1043: Aircraft Systems Engineering	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Design Optimization and Probabilistic Approaches in Structural Analysis (L1814)	Seminar 3 3
Fatigue & Damage Tolerance (L0310)	Lecture 2 3
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1514)	Lecture 2 2
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1515)	Recitation Section (large) 1 1
Lightweight Design Practical Course (L1258)	Problem-based Learning 3 3
Aviation Security (L1549)	Lecture 2 2
Aviation Security (L1550)	Recitation Section (small) 1 1
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture 2 2
Metallic Materials for Aircraft Applications (L0514)	Lecture 2 3
Turbo Jet Engines (L0908)	Lecture 2 3
System Analysis in Air Transportation (L0855)	Lecture 3 3
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 avionics assemblies (L1554)	Lecture 2 2
Reliability of avionics assemblies (L1555)	Recitation Section (small) 1 1
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> <i>Knowledge</i>	<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>
<b>Skills</b>	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 choose 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: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1814: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Seminar
<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>	Hausarbeit
<b>Examination duration and scale</b>	ca. 10 Seiten und Diskussion
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. [2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.



Course L0310: Fatigue & Damage Tolerance	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	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 L1514: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Marco Schürg
Language	DE
Cycle	WiSe
Content	<p><b>Fundamentals of Anisotropic Elasticity</b></p> <p>Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law</p> <p><b>Behaviour of a single laminate layer</b></p> <p>Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules</p> <p><b>Fundamentals of Micromechanics of a laminate layer</b></p> <p>Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer</p> <p><b>Classical Laminate Plate Theory</b></p> <p>Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties</p> <p><b>Strength of Laminated Plates</b></p> <p>Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin</p> <p><b>Bending of Composite Laminated Plates</b></p> <p>Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions</p> <p><b>Stress Concentration Problems</b></p> <p>Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis</p> <p><b>Stability of Thin-Walled Composite Structures</b></p> <p>Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles</p> <p><b>Written exercise (report required)</b></p> <p>Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account</p>
Literature	<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: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
<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>	Dr. Marco Schürg
<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>	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>	<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 L1550: Aviation Security	
<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 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 L0514: Metallic Materials for Aircraft Applications	
<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. Joachim Albrecht
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties.</p> <p>CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications.</p> <p>Alpha+Beta alloys: Processing and microstructure, properties and applications.</p> <p>Beta alloys: Processing and microstructure, properties and applications</p> <p>Nickel-base Superalloys: Optimization of creep resistance for gas turbine engines, microstructural constituents and influence of alloying elements, thermomechanical treatment and resulting properties, long time stability at high temperatures</p>
<b>Literature</b>	<p>G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397</p> <p>C.T. Sims, W.C. Hagel: The Superalloys, John Wiley &amp; Sons, New York, 1972, ISBN 0-471-79207-1</p>

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 L0855: System Analysis in Air Transportation	
<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>	60 Minuten
<b>Lecturer</b>	Dr. Marco Weiss
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the Air Transport System</li> <li>2. System analysis methodologies</li> <li>3. Technology management</li> <li>4. Technical analysis methods</li> <li>5. Economical analysis methods</li> <li>6. Ecological analysis methods</li> <li>7. Societal analysis methods</li> <li>8. Research on the future</li> <li>9. Synthesis, overall assessment, decision making</li> <li>10. Case studies - Technology Push</li> <li>11. Case studies - Scenario Pull</li> </ol>
<b>Literature</b>	Hand out

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</p> <p>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>	Prof. Uwe Weltin
<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>	Prof. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1554: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L1555: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppentechologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppentechologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L0749: Reliability of Aircraft 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>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
<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 M1043: Aircraft Systems Engineering	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Design Optimization and Probabilistic Approaches in Structural Analysis (L1814)	Seminar 3 3
Fatigue & Damage Tolerance (L0310)	Lecture 2 3
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1514)	Lecture 2 2
Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics (L1515)	Recitation Section (large) 1 1
Lightweight Design Practical Course (L1258)	Problem-based Learning 3 3
Aviation Security (L1549)	Lecture 2 2
Aviation Security (L1550)	Recitation Section (small) 1 1
Mechanisms, Systems and Processes of Materials Testing (L0950)	Lecture 2 2
Metallic Materials for Aircraft Applications (L0514)	Lecture 2 3
Turbo Jet Engines (L0908)	Lecture 2 3
System Analysis in Air Transportation (L0855)	Lecture 3 3
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 avionics assemblies (L1554)	Lecture 2 2
Reliability of avionics assemblies (L1555)	Recitation Section (small) 1 1
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> <i>Knowledge</i>	<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>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 choose 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: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1814: Design Optimization and Probabilistic Approaches in Structural Analysis	
<b>Typ</b>	Seminar
<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>	Hausarbeit
<b>Examination duration and scale</b>	ca. 10 Seiten und Diskussion
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. [2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L0310: Fatigue & Damage Tolerance	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	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 L1514: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Marco Schürg
Language	DE
Cycle	WiSe
Content	<p><b>Fundamentals of Anisotropic Elasticity</b></p> <p>Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law</p> <p><b>Behaviour of a single laminate layer</b></p> <p>Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules</p> <p><b>Fundamentals of Micromechanics of a laminate layer</b></p> <p>Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer</p> <p><b>Classical Laminate Plate Theory</b></p> <p>Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties</p> <p><b>Strength of Laminated Plates</b></p> <p>Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin</p> <p><b>Bending of Composite Laminated Plates</b></p> <p>Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions</p> <p><b>Stress Concentration Problems</b></p> <p>Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis</p> <p><b>Stability of Thin-Walled Composite Structures</b></p> <p>Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles</p> <p><b>Written exercise (report required)</b></p> <p>Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account</p>
Literature	<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: Lightweight Construction with Fibre Reinforced Polymers - Structural Mechanics	
<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>	Dr. Marco Schürg
<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>	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>	<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 L1550: Aviation Security	
<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 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 L0514: Metallic Materials for Aircraft Applications	
<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. Joachim Albrecht
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties.</p> <p>CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications.</p> <p>Alpha+Beta alloys: Processing and microstructure, properties and applications.</p> <p>Beta alloys: Processing and microstructure, properties and applications</p> <p>Nickel-base Superalloys: Optimization of creep resistance for gas turbine engines, microstructural constituents and influence of alloying elements, thermomechanical treatment and resulting properties, long time stability at high temperatures</p>
<b>Literature</b>	<p>G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397</p> <p>C.T. Sims, W.C. Hagel: The Superalloys, John Wiley &amp; Sons, New York, 1972, ISBN 0-471-79207-1</p>

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 L0855: System Analysis in Air Transportation	
<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>	60 Minuten
<b>Lecturer</b>	Dr. Marco Weiss
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the Air Transport System</li> <li>2. System analysis methodologies</li> <li>3. Technology management</li> <li>4. Technical analysis methods</li> <li>5. Economical analysis methods</li> <li>6. Ecological analysis methods</li> <li>7. Societal analysis methods</li> <li>8. Research on the future</li> <li>9. Synthesis, overall assessment, decision making</li> <li>10. Case studies - Technology Push</li> <li>11. Case studies - Scenario Pull</li> </ol>
<b>Literature</b>	Hand out

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</p> <p>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>	Prof. Uwe Weltin
<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>	Prof. Uwe Weltin
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1554: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppenttechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppenttechnologie der Elektronik. Montage. Verlag Technik, 1999</p>

Course L1555: Reliability of avionics assemblies	
<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>	SoSe
<b>Content</b>	<p>The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:</p> <ul style="list-style-type: none"> <li>• Survey of the role of electronics in aviation</li> <li>• System levels: From silicon to mechatronic systems</li> <li>• Semiconductor components, assemblies, systems</li> <li>• Challenges of electronic packaging technology (AVT)</li> <li>• System integration in electronics: Requirements for AVT</li> <li>• Methods and techniques of AVT</li> <li>• Error patterns for assemblies and avoidance of errors</li> <li>• Reliability analysis for printed circuit boards (PCBs)</li> <li>• Reliability of Avionics</li> <li>• COTS, ROTS, MOTS and the F<sup>3</sup>I concept</li> <li>• Future challenges for electronics</li> </ul>
<b>Literature</b>	<p>- Skript zur Vorlesung</p> <p>Hanke, H.-J.: Baugruppenttechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994</p> <p>Scheel, W.: Baugruppenttechnologie der Elektronik. Montage. Verlag Technik, 1999</p>



Course L0749: Reliability of Aircraft 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>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	90 Minuten
<b>Lecturer</b>	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
<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 M1032: Airport Planning and Operations	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Airport Operations (L1276)	Lecture 3 3
Airport Planning (L1275)	Lecture 2 2
Airport Planning (L1469)	Recitation Section (small) 1 1
<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>• Vordiplom Mech. Eng.</li> <li>• Lecture Air Transportation 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>	<ol style="list-style-type: none"> <li>1. Regulatory principles of airport planning and operations</li> <li>2. Design of an airport incl. Regulatory baselines</li> <li>3. Airport operation in the terminal and at the airfield</li> </ol>
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Understanding of different interdisciplinary interdependencies</li> <li>• Planning and design of an airport</li> <li>• Modelling and assessment of airport operation</li> </ul>
<b>Personal Competence</b>	
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Working in interdisciplinary teams</li> <li>• Communication</li> </ul>
<i>Autonomy</i>	Organization of workflows and -strategies
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Credit points</b>	6
<b>Examination</b>	Written exam
<b>Examination duration and scale</b>	120 min
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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>Lecturer</b>	Prof. Volker Gollnick, Axel Christian Husfeldt
<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>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 strucutres around airports</li> <li>4. Airfield lightings, marking and information</li> <li>5. Airfield and terminal configuration</li> </ol>
<b>Literature</b>	N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley & Sons, 1991  Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003

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>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

Module M1024: Methods of Integrated Product Development				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Integrated Product Development II (L1254)		Lecture	3	3
Integrated Product Development II (L1255)		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>				
<i>Knowledge</i>	After passing the module students are able to: <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>			
<i>Skills</i>	After passing the module students are able to: <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>			
<b>Personal Competence</b>				
<i>Social Competence</i>	After passing the module students are able to: <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>			
<i>Autonomy</i>	After passing the module students are able to: <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>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 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>	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 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>	-		
<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>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 Computational Science and Engineering: Specialisation Scientific Computing: 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 Endoprotheses: 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 Technomathematics: Core qualification: 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 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> <p><b>Personal Competence</b></p> <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>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	45 min		
<b>Assignment for the Following Curricula</b>	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory		



Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
<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>	WiSe
<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) for graduate engineering students that do not have a formal background in electrical engineering. 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>

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
<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>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

## 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.

Module M-002: Master Thesis	
Courses	
Title	Typ Hrs/wk CP
<b>Module Responsible</b>	Professoren der TUHH
<b>Admission Requirements</b>	<ul style="list-style-type: none"> <li>According to General Regulations §24 (1):</li> </ul> <p>At least 78 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>	
<b>Skills</b>	<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>	
<i>Social Competence</i>	<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>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>Examination</b>	according to Subject Specific Regulations
<b>Examination duration and scale</b>	see FSPO
<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 International Production Management: 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  
Theoretical Mechanical Engineering: Thesis: Compulsory  
Process Engineering: Thesis: Compulsory  
~~Water and Environmental Engineering: Thesis: Compulsory~~