TUHH
Technische Universität Hamburg-Harburg

Module Manual

Master of Science

Aircraft Systems Engineering

Cohort: Winter Term 2015

Updated: 31st May 2017

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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, scientifical 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

Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way around selected special areas of management within the scope of business management. • Students are able to explain basic theories, categories, and models in selected special areas of business management. • Students are able to interrelate technical and management knowledge.
Skills	• Students are able to apply basic methods in selected areas of business management. • Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence	
Social Competence	
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	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

Module Responsible	Dagmar Richter
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	**The Non-technical Elective Study Area** 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 **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses. **The Learning Architecture** consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the "non-technical department" follow the specific profiling of TUHH degree courses. 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". 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. **Teaching and Learning Arrangements** 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. **Fields of Teaching** are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication 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. 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. **The Competence Level** 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. 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. **Specialized Competence (Knowledge)** Students can • explain specialized areas in context of the relevant non-technical disciplines, • outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, • different specialist disciplines relate to their own discipline and differentiate it as well as make connections, • 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, • Can communicate in a foreign language in a manner appropriate to the subject.
Skills	**Professional Competence (Skills)** In selected sub-areas students can • apply basic and specific methods of the said scientific disciplines, • aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, • to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner, • justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.
Personal Competence	

Social Competence	**Personal Competences (Social Skills)** Students will be able • to learn to collaborate in different manner, • to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, • to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), • to explain nontechnical items to auditorium with technical background knowledge.
Autonomy	**Personal Competences (Self-reliance)** Students are able in selected areas • to reflect on their own profession and professionalism in the context of real-life fields of application • to organize themselves and their own learning processes • to reflect and decide questions in front of a broad education background • to communicate a nontechnical item in a competent way in writen form or verbaly • to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours	Depends on choice of courses
Credit points	6

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

Module M0763: Aircraft Systems I

Courses

Title	Typ	Hrs/wk	CP
Aircraft Systems I (L0735)	Lecture	3	4
Aircraft Systems I (L0739)	Recitation Section (large)	1	2

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Hydraulics • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • Describe essential components and design points of hydraulic and electrical systems such as high-lift and anti-ice systems • Give an overview of the functionality of air conditioning systems and explain atmospheric conditions for icing such as the functionality of anti-ice systems • Explain the need for high-lift systems such as ist functionality and effects • Assess the challenge during the design of supply systems of an aircraft
Skills	Students are able to: • Design hydraulic supply systems of aircrafts • Design high-lift systems of aircrafts • Analyze the thermodynamic behaviour of air conditioning systems and design anti-ice systems
Personal Competence	
Social Competence	Students are able to: • Perform system design in groups and present and discuss results
Autonomy	Students are able to: • Reflect the contents of lectures autonomously
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	165 Minutes
Assignment for the Following Curricula	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

Course L0735: Aircraft Systems I	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	• 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) • Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis) • High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices) • Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies; cabin pressure control systems) • De- and Anti-Ice Systems: (Atmospheric icing conditions; principles of de- and anti-ice systems)
Literature	• Moir, Seabridge: Aircraft Systems • Green: Aircraft Hydraulic Systems • Torenbek: Synthesis of Subsonic Airplane Design • SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes

Course L0739: Aircraft Systems I	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0771: Flight Physics

Courses

Title	Typ	Hrs/wk	CP
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

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Aviation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 Minutes (WS) + 90 Minutes (SS)
Assignment for the Following Curricula	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

Course L0727: Aerodynamics and Flight Mechanics I

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Klaus-Uwe Hahn, Dr. Ralf Heinrich
Language	DE
Cycle	WiSe
Content	• Aerodynamics (fundamental equations of aerodynamics; compressible and incompressible flows; airfoils and wings; viscous flows) • Flight Mechanics (Equations of motion; flight performance; control surfaces; derivatives; lateral stability and control; trim conditions; flight maneuvers)
Literature	• Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II • Etkin, B.: Dynamics of Atmospheric Flight • Sachs/Hafer: Flugmechanik • Brockhaus: Flugregelung • J.D. Anderson: Introduction to flight

Course L0730: Flight Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Klaus-Uwe Hahn, Dr. Gerko Wende
Language	DE
Cycle	SoSe
Content	• stationary asymmetric flight • dynamics of lateral movement • methods of flight simulation • eyperimental methods of flight mechanics • model validation using system identification • wind tunnel techniques
Literature	• Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II • Etkin, B.: Dynamics of Atmospheric Flight • Sachs/Hafer: Flugmechanik • Brockhaus: Flugregelung • J.D. Anderson: Introduction to flight

Course L0731: Flight Mechanics II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Klaus-Uwe Hahn, Dr. Gerko Wende
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0812: Aircraft Design

Courses

Title	Typ	Hrs/wk	CP
Aircraft Design I (L0820)	Lecture	2	2
Aircraft Design I (L0834)	Recitation Section (large)	1	1
Aircraft Design II (Detailled Design Methods for Aeroynamics and Aircraft Structures, Multidisciplinary Design) (L0844)	Lecture	2	2
Aircraft Design II (Detailled Design Methods for Aeroynamics and Aircraft Structures, Multidisciplinary Design) (L0847)	Project Seminar	1	1

Module Responsible	Prof. Volker Gollnick
Admission Requirements	None
Recommended Previous Knowledge	Bachelor Mech. Eng., Vordiplom Mech. Eng., Module Air Transport Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	1. Principle understanding of integrated aircraft design 2. Understanding of the interactions and contributions of the various disciplines 3. Impact of the relevant design parameter on the aircraft design 4. Introduction of the principle design methods
Skills	Understanding and application of design and calculation methods Understanding of interdisciplinary and integrative interdependencies
Personal Competence	
Social Competence	Working in interdisciplinary teams Communication
Autonomy	Organization of workflows and -strategies
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	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

Course L0820: Aircraft Design I

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	Introduction into the aircraft design process 1. Introduction/process of aircraft design/various aircraft configurations 2. Requirements and design objectives, main design parameter (u.a. payload-range-diagramme) 3. Statistical methods in overall aircraft design/data base methods 4. Principles of aircraft performance design (stability, V-n-diagramme) 5. Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics) 6. Principles of structural fuselage and wing design (mass analysis, beam/tube models, geometry) 7. Principles of engine design and integration 8. Cruise design 9. Design of runway and landing field length 10. Cabin design (fuselage dimensioning, cabin interior, loading systems) 11. System- and equipment aspects 12. Design variations and operating cost calculation
Literature	J. Roskam: "Airplane Design" D.P. Raymer: "Aircraft Design - A Conceptual Approach" J.P. Fielding: "Intorduction to Aircraft Design" Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"

Course L0834: Aircraft Design I	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	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 Manoevre and gust load calculation
Literature	J. Roskam: "Airplane Design" D.P. Raymer: "Aircraft Design - A Conceptual Approach" J.P. Fielding: "Intorduction to Aircraft Design" Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"

Course L0844: Aircraft Design II (Detailled Design Methods for Aeroynamics and Aircraft Structures, Multidisciplinary Design)	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick, Björn Nagel
Language	DE/EN
Cycle	SoSe
Content	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 methodes Numerical wing design
Literature	Horst Kossira: "Grundlagen des Leichtbaus. Einführung in die Theorie dünnwandiger stabförmiger Tragwerke" Johannes Wiedemann: "Leichtbau - Elemente und Konstruktion"

Course L0847: Aircraft Design II (Detailled Design Methods for Aeroynamics and Aircraft Structures, Multidisciplinary Design)	
Typ	Project Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick, Björn Nagel
Language	DE/EN
Cycle	SoSe
Content	Project oriented exercise in detailed aircraft design Setup of numerical models Numerical design optimization Light weight structural design Interdisciplinary model coupling
Literature	Horst Kossira: "Grundlagen des Leichtbaus. Einführung in die Theorie dünnwandiger stabförmiger Tragwerke" Johannes Wiedemann: "Leichtbau - Elemente und Konstruktion"

Module M1041: Systems Engineering Development Project I

Courses

Title	Typ	Hrs/wk	CP
Systems Engineering Development Project I (L1307)	Problem-based Learning	6	6

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Electrical Engineering • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to… • Name and explain all phases of the systems engineering process (V-Model) • Describe tools for systems engineering
Skills	Students are able to… • Define requirements for a system • Document and evaluate the system development process by using suitable tools • Design a system • Plan, execute and interpret system tests
Personal Competence	
Social Competence	Students are able to… • Perform a complete system design in small groups • Develop technical solutions in small groups as well as discuss, prepare and present these solutions to a plenum • Lead team meetings and group work
Autonomy	Students are able to… • Define tasks and tap required knowledge • Choose suitable methods for different systems engineering tasks
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written elaboration
Examination duration and scale	approx. 30 - 150 pages
Assignment for the Following Curricula	Aircraft Systems Engineering: Core qualification: Compulsory

Course L1307: Systems Engineering Development Project I

Typ	Problem-based Learning
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Module M1155: Aircraft Cabin Systems

Courses

Title	Typ	Hrs/wk	CP
Aircraft Cabin Systems (L1545)	Lecture	3	4
Aircraft Cabin Systems (L1546)	Recitation Section (large)	1	2

Module Responsible	Prof. Ralf God
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe cabin operations, equipment in the cabin and cabin systems • explain the functional and non-functional requirements for cabin systems • elucidate the necessity of cabin operating systems and emergency systems • assess the challenges human factors integration in a cabin environment
Skills	Students are able to: • design a cabin layout for a given business model of an airline • design cabin systems for safe operations • design emergency systems for safe man-machine interaction • solve comfort needs and entertainment requirements in the cabin
Personal Competence	
Social Competence	Students are able to: • understand existing system solutions and discuss their ideas with experts
Autonomy	Students are able to: • Reflect the contents of lectures and expert presentations self-dependent
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	120 Minutes
Assignment for the Following Curricula	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

Course L1545: Aircraft Cabin Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • Materials used in the cabin • Ergonomics and human factors • Cabin interior and non-electrical systems • Cabin electrical systems and lights • Cabin electronics, communication-, information- and IFE-systems • Cabin and passenger process chains • RFID Aircraft Parts Marking • Energy sources and energy conversion
Literature	- Skript zur Vorlesung - Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999 - Rossow, C.-C., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014 - Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008 - Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003 - Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006 - Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006

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

Module M0764: Aircraft Systems II

Courses

Title	Typ	Hrs/wk	CP
Aircraft Systems II (L0736)	Lecture	3	4
Aircraft Systems II (L0740)	Recitation Section (large)	1	2

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	basic knowledge of: • mathematics • mechanics • thermo dynamics • electronics • fluid technology • control technology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to… • 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. • explain different configurations and designs and their origins
Skills	Students are able to… • size primary flight control actuation systems • perform a controller design process for the flight control actuators • design high-lift kinematics • design and analyse landing gear systems
Personal Competence	
Social Competence	Students are able to: • Develop joint solutions in mixed teams
Autonomy	Students are able to: • derive requirements and perform appropriate yet simplified design processes for aircraft systems from complex issues and circumstances in a self-reliant manner
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	165 Minutes
Assignment for the Following Curricula	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

Course L0736: Aircraft Systems II	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	SoSe
Content	• Actuation (Principles of actuators; electro-mechanical actuators; modeling, analysis and sizing of position control systems; hydro-mechanic actuation systems) • 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) • 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-skit systems) • Fuel Systems (Architectures; aviation fuels; system components; fueling system; tank inerting system; fuel management; trim tank)
Literature	• Moir, Seabridge: Aircraft Systems • Torenbek: Synthesis of Subsonic Airplane Design • Curry: Aircraft Landing Gear Design: Principles and Practices

Course L0740: Aircraft Systems II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1042: Systems Engineering Development Project II

Courses

Title	Typ	Hrs/wk	CP
Systems Engineering Development Project II (L1308)	Problem-based Learning	6	6

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Electrical Engineering • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to… • Name and explain all phases of the systems engineering process (V-Model) • Describe tools for systems engineering
Skills	Students are able to… • Define requirements for a system • Document and evaluate the system development process by using suitable tools • Design a system • Plan, execute and interpret system tests
Personal Competence	
Social Competence	Students are able to… • Perform a complete system design in small groups • Develop technical solutions in small groups as well as discuss, prepare and present these solutions to a plenum • Lead team meetings and group work
Autonomy	Students are able to… • Define tasks and tap required knowledge • Choose suitable methods for different systems engineering tasks
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written elaboration
Examination duration and scale	approx. 30 - 150 pages
Assignment for the Following Curricula	Aircraft Systems Engineering: Core qualification: Compulsory

Course L1308: Systems Engineering Development Project II

Typ	Problem-based Learning
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Module M1156: Systems Engineering

Courses

Title	Typ	Hrs/wk	CP
Systems Engineering (L1547)	Lecture	3	4
Systems Engineering (L1548)	Recitation Section (large)	1	2

Module Responsible	Prof. Ralf God
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Aircraft Cabin Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • understand systems engineering process models, methods and tools for the development of complex systems • describe innovation processes and the need for technology management • explain the aircraft development process and the process of type certification for aircraft • explain the system development process, including requirements for systems reliability • identify environmental conditions and test procedures for airborne equipment • value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE)
Skills	Students are able to: • plan the process for the development of complex systems • organize the development phases and development tasks • assign required business activities and technical tasks • apply systems engineering methods and tools
Personal Competence	
Social Competence	Students are able to: • understand their responsibilities within a development team and integrate themselves with their role in the overall process
Autonomy	Students are able to: • interact and communicate in a development team which has distributed tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	120 Minutes
Assignment for the Following Curricula	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: 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	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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. 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: • Innovation processes • IP-protection • Technology management • Systems engineering • Aircraft program • Certification issues • Systems development • Safety objectives and fault tolerance • Environmental and operating conditions • Tools for systems engineering • Requirements-based engineering (RBE) • Model-based requirements engineering (MBRE)
Literature	- Skript zur Vorlesung - diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE) - Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010 - NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007 - Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010 - De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010 - Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008

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

Module Responsible	Prof. Herbert Werner
Admission Requirements	None
Recommended Previous Knowledge	Introduction to Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• 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 • They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively • They can explain the significance of a minimal realisation • They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection • They can extend all of the above to multi-input multi-output systems • They can explain the z-transform and its relationship with the Laplace Transform • They can explain state space models and transfer function models of discrete-time systems • 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 • They can explain how a state space model can be constructed from a discrete-time impulse response
Skills	• Students can transform transfer function models into state space models and vice versa • They can assess controllability and observability and construct minimal realisations • They can design LQG controllers for multivariable plants • 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 • They can identify transfer function models and state space models of dynamic systems from experimental data • They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink)
Personal Competence	
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems. They can assess their knowledge in weekly on-line tests and thereby control their learning progress.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Compulsory Computational Science and Engineering: Specialisation Systems Engineering: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. 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	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	State space methods (single-input single-output) • State space models and transfer functions, state feedback • Coordinate basis, similarity transformations • Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem • Controllability and pole placement • State estimation, observability, Kalman decomposition • Observer-based state feedback control, reference tracking • Transmission zeros • Optimal pole placement, symmetric root locus Multi-input multi-output systems • Transfer function matrices, state space models of multivariable systems, Gilbert realization • Poles and zeros of multivariable systems, minimal realization • Closed-loop stability • Pole placement for multivariable systems, LQR design, Kalman filter Digital Control • Discrete-time systems: difference equations and z-transform • Discrete-time state space models, sampled data systems, poles and zeros • Frequency response of sampled data systems, choice of sampling rate System identification and model order reduction • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction Case study • Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools • Matlab/Simulink
Literature	• Werner, H., Lecture Notes „Control Systems Theory and Design“ • T. Kailath "Linear Systems", Prentice Hall, 1980 • K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 • L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

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

Module M0565: Mechatronic Systems

Courses

Title	Typ	Hrs/wk	CP
Electro- and Contromechanics (L0174)	Lecture	2	2
Electro- and Contromechanics (L1300)	Recitation Section (small)	1	2
Mechatronics Laboratory (L0196)	Laboratory	2	2

Module Responsible	Prof. Uwe Weltin
Admission Requirements	none
Recommended Previous Knowledge	Fundamentals of mechanics, electromechanics and control theory
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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.
Skills	Students are able to plan and execute mechatronic experiments. Students are able to model mechatronic systems and derive simulations and optimizations.
Personal Competence	
Social Competence	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task within the team.
Autonomy	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.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	90 min.
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Mechatronics: Core qualification: Compulsory

Course L0174: Electro- and Contromechanics

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	Introduction to methodical design of mechatronic systems: • Modelling • System identification • Simulation • Optimization
Literature	Denny Miu: Mechatronics, Springer 1992 Rolf Isermann: Mechatronic systems : fundamentals, Springer 2003

Course L1300: Electro- and Contromechanics

Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0196: Mechatronics Laboratory	
Typ	Laboratory
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Uwe Weltin
Language	DE/EN
Cycle	SoSe
Content	Modeling in MATLAB® und Simulink® Controller Design (Linear, Nonlinear, Observer) Parameter identification Control of a real system with a realtimeboard and Simulink® RTW
Literature	- Abhängig vom Versuchsaufbau - Depends on the experiment

Module M0721: Air Conditioning

Courses

Title	Typ	Hrs/wk	CP
Air Conditioning (L0594)	Lecture	3	5
Air Conditioning (L0595)	Recitation Section (large)	1	1

Module Responsible	Prof. Gerhard Schmitz
Admission Requirements	none
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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 h1+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.
Skills	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.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach.
Autonomy	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.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	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 Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering : Elective Compulsory

Course L0594: Air Conditioning	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	1. Overview 1.1 Kinds of air conditioning systems 1.2 Ventilating 1.3 Function of an air condition system 2. Thermodynamic processes 2.1 Psychrometric chart 2.2 Mixer preheater, heater 2.3 Cooler 2.4 Humidifier 2.5 Air conditioning process in a Psychrometric chart 2.6 Desiccant assisted air conditioning 3. Calculation of heating and cooling loads 3.1 Heating loads 3.2 Cooling loads 3.3 Calculation of inner cooling load 3.4 Calculation of outer cooling load 4. Ventilating systems 4.1 Fresh air demand 4.2 Air flow in rooms 4.3 Calculation of duct systems 4.4 Fans 4.5 Filters 5. Refrigeration systems 5.1. compression chillers 5.2Absorption chillers
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0595: Air Conditioning	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0752: Nonlinear Dynamics

Courses

Title	Typ	Hrs/wk	CP
Nonlinear Dynamics (L0702)	Lecture	3	6

Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.
Skills	Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procedures.
Personal Competence	
Social Competence	Students can reach working results also in groups.
Autonomy	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Credit points	6
Examination	Written exam
Examination duration and scale	2 Hours
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: 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 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 Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0702: Nonlinear Dynamics

Typ	Lecture
Hrs/wk	3
CP	6
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Lecturer	Prof. Norbert Hoffmann
Language	EN
Cycle	SoSe
Content	Fundamentals of Nonlinear Dynamics.
Literature	S. Strogatz: Applied Nonlinear Dynamics

Module M1043: Aircraft Systems Engineering

Courses

Title	Typ	Hrs/wk	CP
Advanced Topics in Control (L0661)	Lecture	2	3
Advanced Topics in Control (L0662)	Recitation Section (small)	1	1
Introduction to Electromagnetic Waveguides and Antennas (L1669)	Lecture	2	2
Design Optimization and Probabilistic Approaches in Structural Analysis (L1817)	Seminar	3	3
Fatigue & Damage Tolerance (L0310)	Lecture	2	3
Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics (L1514)	Lecture	2	2
Lightweight Construction with Fibre Reinforced Rolymers - 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
Metallic Materials for Aircraft Applications (L0514)	Lecture	2	3
Optimal and Robust Control (L0658)	Lecture	2	3
Optimal and Robust Control (L0659)	Recitation Section (small)	1	1
Turbo Jet Engines (L0908)	Lecture	2	3
System Analysis in Air Transportation (L0855)	Lecture	3	3
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

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Hydraulics • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within systems engineering, air transportation system and material science • Students are able to explain basic models and procedures in selected special areas. • Students are able to interrelate scientific and technical knowledge.
Skills	Students are able to apply basic methods in selected areas of engineering.
Personal Competence	
Social Competence	
Autonomy	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L0661: Advanced Topics in Control	
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	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	• Linear Parameter-Varying (LPV) Gain Scheduling - Linearizing gain scheduling, hidden coupling - Jacobian linearization vs. quasi-LPV models - Stability and induced L2 norm of LPV systems - Synthesis of LPV controllers based on the two-sided projection lemma - Simplifications: controller synthesis for polytopic and LFT models - Experimental identification of LPV models - Controller synthesis based on input/output models - Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator • Control of Multi-Agent Systems - Communication graphs - Spectral properties of the graph Laplacian - First and second order consensus protocols - Formation control, stability and performance - LPV models for agents subject to nonholonomic constraints - Application: formation control for a team of quadrotor helicopters • Control of Spatially Interconnected Systems - Multidimensional signals, l2 and L2 signal norm - Multidimensional systems in Roesser state space form - Extension of real-bounded lemma to spatially interconnected systems - LMI-based synthesis of distributed controllers - Spatial LPV control of spatially varying systems - Applications: control of temperature profiles, vibration damping for an actuated beam
Literature	• Werner, H., Lecture Notes "Advanced Topics in Control" • Selection of relevant research papers made available as pdf documents via StudIP

Course L0662: Advanced Topics in Control	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1669: Introduction to Electromagnetic Waveguides and Antennas	
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	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	Introduction to the principles and applications of electromagnetic wave propagation, electromagnetic waveguides and antennas for students without background in electrical engineering.
Literature	- S. Ramo, J. Whinnery, T. Van Duzer, "Fields and Waves in Communication Electronics", Wiley (1994) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - C. A. Balanis, "Antenna Theory: Analysis and Design", Wiley (2005)

Course L1817: Design Optimization and Probabilistic Approaches in Structural Analysis	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Hausarbeit
Examination duration and scale	10 Seiten und Diskussion
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	SoSe
Content	
Literature	

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. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L1514: Lightweight Construction with Fibre Reinforced Rolymers - 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	Christian Mittelstedt
Language	DE
Cycle	WiSe
Content	**Fundamentals of Anisotropic Elasticity** Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law **Behaviour of a single laminate layer** Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules **Fundamentals of Micromechanics of a laminate layer** Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer **Classical Laminate Plate Theory** 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 **Strength of Laminated Plates** Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin **Bending of Composite Laminated Plates** Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions **Stress Concentration Problems** Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis **Stability of Thin-Walled Composite Structures** 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 **Written exercise (report required)** Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1515: Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Christian Mittelstedt
Language	DE
Cycle	WiSe
Content	**Fundamentals of Anisotropic Elasticity** Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law **Behaviour of a single laminate layer** Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules **Fundamentals of Micromechanics of a laminate layer** Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer **Classical Laminate Plate Theory** 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 **Strength of Laminated Plates** Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin **Bending of Composite Laminated Plates** Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions **Stress Concentration Problems** Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis **Stability of Thin-Walled Composite Structures** 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 **Written exercise (report required)** Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1258: Lightweight Design Practical Course	
Typ	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	SoSe
Content	Development of a sandwich structure made of fibre reinforced plastics • getting familiar with fibre reinforced plastics as well as lightweight design • Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA) • Determination of material properties based on sample tests • manufacturing of the structure in the composite lab • Testing of the developed structure • Concept presentation • Self-organised teamwork
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005. • Puck, A., „Festigkeitsanalsyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996. • R&G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009. • VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“ • Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006. • Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989. • Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986. • Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986. • Backmann, B.F., „Composite Structures, Design, Safety and Innovation”, Oxford (UK), Elsevier, 2005. • Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012. • Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005.

Course L1549: Aviation Security	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies
Literature	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L1550: Aviation Security	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies
Literature	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L0514: Metallic Materials for Aircraft Applications	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Joachim Albrecht
Language	EN
Cycle	SoSe
Content	Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties. CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications. Alpha+Beta alloys: Processing and microstructure, properties and applications. Beta alloys: Processing and microstructure, properties and applications 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
Literature	G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397 C.T. Sims, W.C. Hagel: The Superalloys, John Wiley & Sons, New York, 1972, ISBN 0-471-79207-1

Course L0658: Optimal and Robust Control	
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	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	• Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman's identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H2 and H∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	• Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewhaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

Course L0659: Optimal and Robust Control	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0908: Turbo Jet Engines	
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. Burkhard Andrich
Language	DE
Cycle	WiSe
Content	• Cycle of the gas turbine • Thermodynamics of gas turbine components • Wing-, grid- and stage-sizing • Operating characteristics of gas turbine components • Sizing criteria's for jet engines • Development trends of gas turbines and jet engines • Maintenance of jet engines
Literature	• Bräunling: Flugzeugtriebwerke • Engmann: Technologie des Fliegens • Kerrebrock: Aircraft Engines and Gas Turbines

Course L0855: System Analysis in Air Transportation	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 Minuten
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	1. Introduction to the Air Transport System 2. System analysis methodologies 3. Technology management 4. Technical analysis methods 5. Economical analysis methods 6. Ecological analysis methods 7. Societal analysis methods 8. Research on the future 9. Synthesis, overall assessment, decision making 10. Case studies – Technology Push 11. Case studies – Scenario Pull
Literature	Hand out

Course L0176: Reliability in Engineering Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min.
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	Method for calculation and testing of reliability of dynamic machine systems • Modeling • System identification • Simulation • Processing of measurement data • Damage accumulation • Test planning and execution
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

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

Course L1554: Reliability of avionics assemblies	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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: • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F^3I concept • Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L1555: Reliability of avionics assemblies	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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: • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F^3I concept • Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L0749: Reliability of Aircraft Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
Language	DE
Cycle	WiSe
Content	• Functions of reliability and safety (regulations, certification requirements) • Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment) • Reliability analysis of electrical and mechanical systems
Literature	• CS 25.1309 • SAE ARP 4754 • SAE ARP 4761

Module M1145: Automation and Simulation

Courses

Title	Typ	Hrs/wk	CP
Automation and Simulation (L1525)	Lecture	3	3
Automation and Simulation (L1527)	Recitation Section (large)	2	3

Module Responsible	Prof. Günter Ackermann
Admission Requirements	none
Recommended Previous Knowledge	**BSc Mechanical Engineering or similar**
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe the structure an the function of process computers, the corresponding components, the data transfer via bus systems an programmable logic computers . They can describe the basich principle of a numeric simulation and the corresponding parameters. Thy can explain the usual method to simulate the dynamic behaviour of three-phase machines.
Skills	Students can describe and design simple controllers using established methodes. They are able to assess the basic characterisitcs of a given automation system and to evaluate, if it is adequate for a given plant. They can modell and simulate technical systems with respect to their dynamical behaviour and can use Matlab/Simulink for the simulation. They are able to applay established methods for the caclulation of the dynamical behaviour of three-phase machines.
Personal Competence	
Social Competence	Teamwork in small teams.
Autonomy	Students are able to identify the need of methocic analysises in the field of automation systems, to do these analysisis in an adequate manner und to evaluate the results critically.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Oral exam
Examination duration and scale	Vorzugsweise in Dreier-Gruppen, etwa 1 Stunde
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: 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	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	SoSe
Content	Structure of automation systsems Aufbau von Automationseinrichtungen Structure and function of process computers and corresponding componentes Data transfer via bus systems Programmable Logic Computers Methods to describe logic sequences Prionciples of the modelling and the simulation of continous technical systems Practical work with an established simulation program (Matlab/Simulink) Simulation of the dynamic behaviour of a three-phase maschine, simulation of a mixed continous/discrete system on base of tansistion flow diagrams.
Literature	U. Tietze, Ch. Schenk: Halbleiter-Schaltungstechnik; Springer Verlag R. Lauber, P. Göhner: Prozessautomatisierung 2, Springer Verlag Färber: Prozessrechentechnik (Grundlagen, Hardware, Echtzeitverhalten), Springer Verlag Einführung/Tutorial Matlab/Simulink - verschiedene Autoren

Course L1527: Automation and Simulation	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0808: Finite Elements Methods

Courses

Title	Typ	Hrs/wk	CP
Finite Element Methods (L0291)	Lecture	2	3
Finite Element Methods (L0804)	Recitation Section (large)	2	3

Module Responsible	Prof. Otto von Estorff
Admission Requirements	none
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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.
Skills	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.
Personal Competence	
Social Competence	-
Autonomy	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.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	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 Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: 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: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Technomathematics: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	- General overview on modern engineering - Displacement method - Hybrid formulation - Isoparametric elements - Numerical integration - Solving systems of equations (statics, dynamics) - Eigenvalue problems - Non-linear systems - Applications - Programming of elements (Matlab, hands-on sessions) - Applications
Literature	Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

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

Module M1091: Flight Guidance and Airline Operations

Courses

Title	Typ	Hrs/wk	CP
Airline Operations (L1310)	Lecture	3	3
Introduction to Flight Guidance (L0848)	Lecture	3	2
Introduction to Flight Guidance (L0854)	Recitation Section (large)	1	1

Module Responsible	Prof. Volker Gollnick
Admission Requirements	None
Recommended Previous Knowledge	• Bachelor Mech. Eng. • Vordiplom Mech. Eng. • Lecture Air Transportation Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	1. Principles of Air Traffic Management and technologies 2. Design and modelling of traffic flows, avionics and sensor systems, cockpit design 3. Principles of Airline organization and business 4. Fleet setup, fleet operation, aircraft selection, maintenance, repair overhaul technologies and business
Skills	• Understanding and application of different interdisciplinary interdependencies • Integration and assessment of new technologies in the air transportation system • Modelling and assessment of flight guidance systems • Airline fleet planning and fleet operation
Personal Competence	
Social Competence	• Working in interdisciplinary teams • Communication
Autonomy	Organization of workflows and -strategies
Workload in Hours	Independent Study Time 82, Study Time in Lecture 98
Credit points	6
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	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

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Dr. Karl Echtermeyer
Language	DE
Cycle	SoSe
Content	1. Introdution and overview 2. Airline business models 3. Interdependencies in flight planning (network management, slot management, netzwork structures, aircraft circulation) 4. Operative flight preparation (weight & balance, payload/range, etc.) 5. fleet policy 6. Aircraft assessment and fleet planning 7. Airline organisation 8. Aircraft maintenance, repair and overhaul
Literature	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	
Typ	Lecture
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	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) Commuication systems Avionics architectures (computer systems, bus systems) Cockpit systems and displays (cockpit design, cockpit equipment)
Literature	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	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1193: Cabin Systems Engineering

Courses

Title	Typ	Hrs/wk	CP
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

Module Responsible	Prof. Ralf God
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Systems Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe the structure and operation of computer architectures • explain the structure and operation of digital communication Networks • explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraft Data Communication Network (ADCN) • understand the approach of Model-Based Systems Engineering (MBSE) in the design of hardware and software-based cabin systems
Skills	Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate with other network participants • connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network • model system functions by means of formal languages SysML/UML and generate software code from the models • execute software code on a minicomputer
Personal Competence	
Social Competence	Students are able to: • elaborate partial results and merge with others to form a complete solution
Autonomy	Students are able to: • organize and schedule their practical tasks
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	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	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • History of computer and network technology • Layer model in computer technology • Computer architectures (PC, IPC, Embedded Systems) • BIOS, UEFI and operating system (OS) • Programming languages (machine code and high-level languages) • Applications and Application Programming Interfaces • External interfaces (serial, USB, Ethernet) • Layer model in network technology • Network topologies • Network components • Bus access procedures • Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN) • Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004

Course L1558: Computer and communication technology in cabin electronics and avionics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • History of computer and network technology • Layer model in computer technology • Computer architectures (PC, IPC, Embedded Systems) • BIOS, UEFI and operating system (OS) • Programming languages (machine code and high-level languages) • Applications and Application Programming Interfaces • External interfaces (serial, USB, Ethernet) • Layer model in network technology • Network topologies • Network components • Bus access procedures • Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN) • Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML	
Typ	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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®): • What is a model? • What is Systems Engineering? • Survey of MBSE methodologies • The modelling languages SysML /UML • Tools for MBSE • Best practices for MBSE • Requirements specification, functional architecture, specification of a solution • From model to software code • Validation and verification: XiL methods • Accompanying MBSE project
Literature	- Skript zur Vorlesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011

Module M1204: Modelling and Optimization in Dynamics

Courses

Title	Typ	Hrs/wk	CP
Flexible Multibody Systems (L1632)	Lecture	2	3
Optimization of dynamical systems (L1633)	Lecture	2	3

Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I, II, III • Mechanics I, II, III, IV • Simulation of dynamical Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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.
Skills	Students are able + to think holistically + to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems + to describe dynamics problems mathematically + to optimize dynamics problems
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.
Autonomy	Students are able to + assess their knowledge by means of exercises. + acquaint themselves with the necessary knowledge to solve research oriented tasks.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	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

Course L1632: Flexible Multibody Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	1. Basics of Multibody Systems 2. Basics of Continuum Mechanics 3. Linear finite element modelles and modell reduction 4. Nonlinear finite element Modelles: absolute nodal coordinate formulation 5. Kinematics of an elastic body 6. Kinetics of an elastic body 7. System assembly
Literature	Schwertassek, R. und Wallrapp, O.: Dynamik flexibler Mehrkörpersysteme. Braunschweig, Vieweg, 1999. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014. Shabana, A.A.: Dynamics of Multibody Systems. Cambridge Univ. Press, Cambridge, 2004, 3. Auflage.

Course L1633: Optimization of dynamical systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	1. Formulation and classification of optimization problems 2. Scalar Optimization 3. Sensitivity Analysis 4. Unconstrained Parameter Optimization 5. Constrained Parameter Optimization 6. Stochastic optimization 7. Multicriteria Optimization 8. Topology Optimization
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994. Nocedal, J. , Wright , S.J. : Numerical Optimization. New York: Springer, 2006.

Module M1213: Avionics for safety-critical Systems

Courses

Title	Typ	Hrs/wk	CP
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

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Electrical Engineering • Informatics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can: • describe the most important principles and components of safety-critical avionics • denote processes and standards of safety-critical software development • depict the principles of Integrated Modular Avionics (IMA) • can compare hardware and bus systems used in avionics • assess the difficulties of developing a safety-critical avionics system correctly
Skills	Students can … • operate real-time hardware and simulations • program A653 applications • plan avionics architectures up to a certain extend • create test scripts and assess test results
Personal Competence	
Social Competence	Students can: • jointly develop solutions in inhomogeneous teams • exchange information formally with other teams • present development results in a convenient way
Autonomy	Students can: • understand the requirements for an avionics system • autonomously derive concepts for systems based on safety-critical avionics
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory

Course L1640: Avionics of Safty Critical Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Björn Annighöfer
Language	DE
Cycle	WiSe
Content	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. Content: 1. Introduction and History 2. Flight Control 3. Hardware 4. I/O und Bus Systems 5. Software 6. Process und Certification 7. Cockpit und Displays 8. Integrated Modular Avionics I 9. Integrated Modular Avionics II 10. Design of IMA Systems 11. Configuration of IMA Systems 12. Verification and Test 13. Integration 14. Space avionics
Literature	• Moir, I.; Seabridge, A. & Jukes, M., Civil Avionics Systems Civil Avionics Systems, John Wiley & Sons, Ltd, 2013 • Spitzer, C. R. Spitzer, Digital Avionics Handbook, CRC Press, 2007 • FAA, Advanced Avionics Handbook U.S. Department of Transportation Federal Aviation Administration, 2009 • Moir, I. & Seabridge, A. Aircraft Systems, Wiley, 2008, 3

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

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

Specialization Cabin Systems

In the specialization in cabin systems, students learn to systematically deal with issues related to the development of aircraft cabin systems, the use of these systems and their application in an operational environment. The aircraft cabin with the cabin management system represents the central working system of an airline during passenger transport. The focus of the specialization is the design of electronic cabin and communication systems using the methodology of Model-Based Systems Engineering (MBSE). Environmental control systems, acoustics, design methods related to composite materials and for integrated product development are further important aspects in the specialization for aircraft cabin development. Airport operations and operations of an airline with respective procedures and systems round off the context of the aircraft cabin. Students have broad knowledge on development methods for complex systems. The can draft requirements, functions and architectures for hardware- and software-based systems, and model and simulate solutions. They know about appropriate tools and methods and master the overall system development process from system design via system implementation and system integration, right up to validation and verification.

Module M1032: Airport Planning and Operations

Courses

Title	Typ	Hrs/wk	CP
Airport Operations (L1276)	Lecture	3	3
Airport Planning (L1275)	Lecture	2	2
Airport Planning (L1469)	Recitation Section (small)	1	1

Module Responsible	Prof. Volker Gollnick
Admission Requirements	
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	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

Course L1276: Airport Operations

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Axel Christian Husfeldt
Language	DE
Cycle	WiSe
Content	FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground handling Terminal operations
Literature	Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003

Course L1275: Airport Planning	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	1. Introduction, definitions, overviewg 2. Runway systems 3. Air space strucutres around airports 4. Airfield lightings, marking and information 5. Airfield and terminal configuration
Literature	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	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1193: Cabin Systems Engineering

Courses

Title	Typ	Hrs/wk	CP
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

Module Responsible	Prof. Ralf God
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Systems Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe the structure and operation of computer architectures • explain the structure and operation of digital communication networks • explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraft Data Communication Network (ADCN) • understand the approach of Model-Based Systems Engineering (MBSE) in the design of hardware and software-based cabin systems
Skills	Students are able to: • understand, operate and maintain a minicomputer • build up a network communication and communicate with other network participants • connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network • model system functions by means of formal languages SysML/UML and generate software code from the models • execute software code on a minicomputer
Personal Competence	
Social Competence	Students are able to: • elaborate partial results and merge with others to form a complete solution
Autonomy	Students are able to: • organize and schedule their practical tasks
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Project
Examination duration and scale	
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Compulsory

Course L1557: Computer and communication technology in cabin electronics and avionics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • History of computer and network technology • Layer model in computer technology • Computer architectures (PC, IPC, Embedded Systems) • BIOS, UEFI and operating system (OS) • Programming languages (machine code and high-level languages) • Applications and Application Programming Interfaces • External interfaces (serial, USB, Ethernet) • Layer model in network technology • Network topologies • Network components • Bus access procedures • Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN) • Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004

Course L1558: Computer and communication technology in cabin electronics and avionics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • History of computer and network technology • Layer model in computer technology • Computer architectures (PC, IPC, Embedded Systems) • BIOS, UEFI and operating system (OS) • Programming languages (machine code and high-level languages) • Applications and Application Programming Interfaces • External interfaces (serial, USB, Ethernet) • Layer model in network technology • Network topologies • Network components • Bus access procedures • Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN) • Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML	
Typ	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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®): • What is a model? • What is Systems Engineering? • Survey of MBSE methodologies • The modelling languages SysML /UML • Tools for MBSE • Best practices for MBSE • Requirements specification, functional architecture, specification of a solution • From model to software code • Validation and verification: XiL methods • Accompanying MBSE project
Literature	- Skript zur Vorlesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011

Module M0721: Air Conditioning

Courses

Title	Typ	Hrs/wk	CP
Air Conditioning (L0594)	Lecture	3	5
Air Conditioning (L0595)	Recitation Section (large)	1	1

Module Responsible	Prof. Gerhard Schmitz
Admission Requirements	none
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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 h1+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.
Skills	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.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach.
Autonomy	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.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	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 Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering : Elective Compulsory

Course L0594: Air Conditioning	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	1. Overview 1.1 Kinds of air conditioning systems 1.2 Ventilating 1.3 Function of an air condition system 2. Thermodynamic processes 2.1 Psychrometric chart 2.2 Mixer preheater, heater 2.3 Cooler 2.4 Humidifier 2.5 Air conditioning process in a Psychrometric chart 2.6 Desiccant assisted air conditioning 3. Calculation of heating and cooling loads 3.1 Heating loads 3.2 Cooling loads 3.3 Calculation of inner cooling load 3.4 Calculation of outer cooling load 4. Ventilating systems 4.1 Fresh air demand 4.2 Air flow in rooms 4.3 Calculation of duct systems 4.4 Fans 4.5 Filters 5. Refrigeration systems 5.1. compression chillers 5.2Absorption chillers
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0595: Air Conditioning	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)

Courses

Title	Typ	Hrs/wk	CP
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

Module Responsible	Prof. Otto von Estorff
Admission Requirements	none
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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.
Skills	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.
Personal Competence	
Social Competence	
Autonomy	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.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Oral exam
Examination duration and scale	20-30 Minuten
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	SoSe
Content	- Introduction and Motivation - Acoustic quantities - Acoustic waves - Sound sources, sound radiation - Sound engergy and intensity - Sound propagation - Signal processing - Psycho acoustics - Noise - Measurements in acoustics
Literature	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)

Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1043: Aircraft Systems Engineering

Courses

Title	Typ	Hrs/wk	CP
Advanced Topics in Control (L0661)	Lecture	2	3
Advanced Topics in Control (L0662)	Recitation Section (small)	1	1
Introduction to Electromagnetic Waveguides and Antennas (L1669)	Lecture	2	2
Design Optimization and Probabilistic Approaches in Structural Analysis (L1817)	Seminar	3	3
Fatigue & Damage Tolerance (L0310)	Lecture	2	3
Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics (L1514)	Lecture	2	2
Lightweight Construction with Fibre Reinforced Rolymers - 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
Metallic Materials for Aircraft Applications (L0514)	Lecture	2	3
Optimal and Robust Control (L0658)	Lecture	2	3
Optimal and Robust Control (L0659)	Recitation Section (small)	1	1
Turbo Jet Engines (L0908)	Lecture	2	3
System Analysis in Air Transportation (L0855)	Lecture	3	3
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

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Hydraulics • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within systems engineering, air transportation system and material science • Students are able to explain basic models and procedures in selected special areas. • Students are able to interrelate scientific and technical knowledge.
Skills	Students are able to apply basic methods in selected areas of engineering.
Personal Competence	
Social Competence	
Autonomy	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L0661: Advanced Topics in Control	
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	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	• Linear Parameter-Varying (LPV) Gain Scheduling - Linearizing gain scheduling, hidden coupling - Jacobian linearization vs. quasi-LPV models - Stability and induced L2 norm of LPV systems - Synthesis of LPV controllers based on the two-sided projection lemma - Simplifications: controller synthesis for polytopic and LFT models - Experimental identification of LPV models - Controller synthesis based on input/output models - Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator • Control of Multi-Agent Systems - Communication graphs - Spectral properties of the graph Laplacian - First and second order consensus protocols - Formation control, stability and performance - LPV models for agents subject to nonholonomic constraints - Application: formation control for a team of quadrotor helicopters • Control of Spatially Interconnected Systems - Multidimensional signals, l2 and L2 signal norm - Multidimensional systems in Roesser state space form - Extension of real-bounded lemma to spatially interconnected systems - LMI-based synthesis of distributed controllers - Spatial LPV control of spatially varying systems - Applications: control of temperature profiles, vibration damping for an actuated beam
Literature	• Werner, H., Lecture Notes "Advanced Topics in Control" • Selection of relevant research papers made available as pdf documents via StudIP

Course L0662: Advanced Topics in Control	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1669: Introduction to Electromagnetic Waveguides and Antennas	
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	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	Introduction to the principles and applications of electromagnetic wave propagation, electromagnetic waveguides and antennas for students without background in electrical engineering.
Literature	- S. Ramo, J. Whinnery, T. Van Duzer, "Fields and Waves in Communication Electronics", Wiley (1994) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - C. A. Balanis, "Antenna Theory: Analysis and Design", Wiley (2005)

Course L1817: Design Optimization and Probabilistic Approaches in Structural Analysis	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Hausarbeit
Examination duration and scale	10 Seiten und Diskussion
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	SoSe
Content	
Literature	

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. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L1514: Lightweight Construction with Fibre Reinforced Rolymers - 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	Christian Mittelstedt
Language	DE
Cycle	WiSe
Content	**Fundamentals of Anisotropic Elasticity** Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law **Behaviour of a single laminate layer** Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules **Fundamentals of Micromechanics of a laminate layer** Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer **Classical Laminate Plate Theory** 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 **Strength of Laminated Plates** Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin **Bending of Composite Laminated Plates** Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions **Stress Concentration Problems** Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis **Stability of Thin-Walled Composite Structures** 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 **Written exercise (report required)** Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1515: Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Christian Mittelstedt
Language	DE
Cycle	WiSe
Content	**Fundamentals of Anisotropic Elasticity** Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law **Behaviour of a single laminate layer** Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules **Fundamentals of Micromechanics of a laminate layer** Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer **Classical Laminate Plate Theory** 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 **Strength of Laminated Plates** Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin **Bending of Composite Laminated Plates** Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions **Stress Concentration Problems** Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis **Stability of Thin-Walled Composite Structures** 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 **Written exercise (report required)** Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1258: Lightweight Design Practical Course	
Typ	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	SoSe
Content	Development of a sandwich structure made of fibre reinforced plastics • getting familiar with fibre reinforced plastics as well as lightweight design • Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA) • Determination of material properties based on sample tests • manufacturing of the structure in the composite lab • Testing of the developed structure • Concept presentation • Self-organised teamwork
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005. • Puck, A., „Festigkeitsanalsyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996. • R&G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009. • VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“ • Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006. • Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989. • Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986. • Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986. • Backmann, B.F., „Composite Structures, Design, Safety and Innovation”, Oxford (UK), Elsevier, 2005. • Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012. • Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005.

Course L1549: Aviation Security	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies
Literature	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L1550: Aviation Security	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies
Literature	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L0514: Metallic Materials for Aircraft Applications	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Joachim Albrecht
Language	EN
Cycle	SoSe
Content	Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties. CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications. Alpha+Beta alloys: Processing and microstructure, properties and applications. Beta alloys: Processing and microstructure, properties and applications 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
Literature	G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397 C.T. Sims, W.C. Hagel: The Superalloys, John Wiley & Sons, New York, 1972, ISBN 0-471-79207-1

Course L0658: Optimal and Robust Control	
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	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	• Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman's identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H2 and H∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	• Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewhaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

Course L0659: Optimal and Robust Control	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0908: Turbo Jet Engines	
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. Burkhard Andrich
Language	DE
Cycle	WiSe
Content	• Cycle of the gas turbine • Thermodynamics of gas turbine components • Wing-, grid- and stage-sizing • Operating characteristics of gas turbine components • Sizing criteria's for jet engines • Development trends of gas turbines and jet engines • Maintenance of jet engines
Literature	• Bräunling: Flugzeugtriebwerke • Engmann: Technologie des Fliegens • Kerrebrock: Aircraft Engines and Gas Turbines

Course L0855: System Analysis in Air Transportation	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 Minuten
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	1. Introduction to the Air Transport System 2. System analysis methodologies 3. Technology management 4. Technical analysis methods 5. Economical analysis methods 6. Ecological analysis methods 7. Societal analysis methods 8. Research on the future 9. Synthesis, overall assessment, decision making 10. Case studies – Technology Push 11. Case studies – Scenario Pull
Literature	Hand out

Course L0176: Reliability in Engineering Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min.
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	Method for calculation and testing of reliability of dynamic machine systems • Modeling • System identification • Simulation • Processing of measurement data • Damage accumulation • Test planning and execution
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

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

Course L1554: Reliability of avionics assemblies	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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: • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F^3I concept • Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L1555: Reliability of avionics assemblies	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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: • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F^3I concept • Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L0749: Reliability of Aircraft Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
Language	DE
Cycle	WiSe
Content	• Functions of reliability and safety (regulations, certification requirements) • Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment) • Reliability analysis of electrical and mechanical systems
Literature	• CS 25.1309 • SAE ARP 4754 • SAE ARP 4761

Module M1145: Automation and Simulation

Courses

Title	Typ	Hrs/wk	CP
Automation and Simulation (L1525)	Lecture	3	3
Automation and Simulation (L1527)	Recitation Section (large)	2	3

Module Responsible	Prof. Günter Ackermann
Admission Requirements	none
Recommended Previous Knowledge	**BSc Mechanical Engineering or similar**
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe the structure an the function of process computers, the corresponding components, the data transfer via bus systems an programmable logic computers . They can describe the basich principle of a numeric simulation and the corresponding parameters. Thy can explain the usual method to simulate the dynamic behaviour of three-phase machines.
Skills	Students can describe and design simple controllers using established methodes. They are able to assess the basic characterisitcs of a given automation system and to evaluate, if it is adequate for a given plant. They can modell and simulate technical systems with respect to their dynamical behaviour and can use Matlab/Simulink for the simulation. They are able to applay established methods for the caclulation of the dynamical behaviour of three-phase machines.
Personal Competence	
Social Competence	Teamwork in small teams.
Autonomy	Students are able to identify the need of methocic analysises in the field of automation systems, to do these analysisis in an adequate manner und to evaluate the results critically.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Oral exam
Examination duration and scale	Vorzugsweise in Dreier-Gruppen, etwa 1 Stunde
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: 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	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	SoSe
Content	Structure of automation systsems Aufbau von Automationseinrichtungen Structure and function of process computers and corresponding componentes Data transfer via bus systems Programmable Logic Computers Methods to describe logic sequences Prionciples of the modelling and the simulation of continous technical systems Practical work with an established simulation program (Matlab/Simulink) Simulation of the dynamic behaviour of a three-phase maschine, simulation of a mixed continous/discrete system on base of tansistion flow diagrams.
Literature	U. Tietze, Ch. Schenk: Halbleiter-Schaltungstechnik; Springer Verlag R. Lauber, P. Göhner: Prozessautomatisierung 2, Springer Verlag Färber: Prozessrechentechnik (Grundlagen, Hardware, Echtzeitverhalten), Springer Verlag Einführung/Tutorial Matlab/Simulink - verschiedene Autoren

Course L1527: Automation and Simulation	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0806: Technical Acoustics II (Room Acoustics, Computational Methods)

Courses

Title	Typ	Hrs/wk	CP
Technical Acoustics II (Room Acoustics, Computational Methods) (L0519)	Lecture	2	3
Technical Acoustics II (Room Acoustics, Computational Methods) (L0521)	Recitation Section (large)	2	3

Module Responsible	Prof. Otto von Estorff
Admission Requirements	none
Recommended Previous Knowledge	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)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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.
Skills	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.
Personal Competence	
Social Competence	
Autonomy	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.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Oral exam
Examination duration and scale	20-30 Minuten
Assignment for the Following Curricula	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: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0519: Technical Acoustics II (Room Acoustics, Computational Methods)

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	- Room acoustics - Sound absorber - Standard computations - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Geometrical acoustics - Special formulations - Practical applications - Hands-on Sessions: Programming of elements (Matlab)
Literature	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

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

Module M1024: Methods of Integrated Product Development

Courses

Title	Typ	Hrs/wk	CP
Integrated Product Development II (L1254)	Lecture	3	3
Integrated Product Development II (L1255)	Problem-based Learning	2	3

Module Responsible	Prof. Dieter Krause
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of Integrated product development and applying CAE systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After passing the module students are able to: • explain technical terms of design methodology, • describe essential elements of construction management, • describe current problems and the current state of research of integrated product development.
Skills	After passing the module students are able to: • select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundary conditions, • solve product development problems with the assistance of a workshop based approach, • choose and execute appropriate moderation techniques.
Personal Competence	
Social Competence	After passing the module students are able to: • prepare and lead team meetings and moderation processes, • work in teams on complex tasks, • represent problems and solutions and advance ideas.
Autonomy	After passing the module students are able to: • give a structured feedback and accept a critical feedback, • implement the accepted feedback autonomous.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Oral exam
Examination duration and scale	30 Minuten
Assignment for the Following Curricula	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: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1254: Integrated Product Development II	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe
Content	**Lecture** 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. Topics of the course include in particular: • Methods of product development, • Presentation techniques, • Industrial Design, • Design for variety • Modularization methods, • Design catalogs, • Adapted QFD matrix, • Systematic material selection, • Assembly oriented design, Construction management • CE mark, declaration of conformity including risk assessment, • Patents, patent rights, patent monitoring • Project management (cost, time, quality) and escalation principles, • Development management for mechatronics, • Technical Supply Chain Management. **Exercise (PBL)** In the exercise the content presented in the lecture “Integrated Product Development II” and methods of product development and design management will be enhanced. 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.
Literature	• Andreasen, M.M., Design for Assembly, Berlin, Springer 1985. • Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007. • Beckmann, H.: Supply Chain Management, Berlin, Springer 2004. • Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und Trainer, Weinheim, Beltz 2007. • Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006. • Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000. • Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York, Springer 2013.

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

Module M1202: Design with Polymers and Composites

Courses

Title	Typ	Hrs/wk	CP
Joining of Polymer-Metal Lightweight Structures (L0500)	Lecture	2	2
Joining of Polymer-Metal Lightweight Structures (L0501)	Laboratory Course	1	1
Design with Polymers and Composites (L0057)	Lecture	2	3

Module Responsible	Prof. Bodo Fiedler
Admission Requirements	Non
Recommended Previous Knowledge	Structure and Properties of Polymers Structure and Properties of Composites
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can reflect the fundamentals of design elements of fiber composites and plastics. They can explain the complex relationships of loads on Polymer- and fiber composite structures. The interactions of processing technologies, design and strength (calculation), including to explain contexts (e.g. sustainability, environment).
Skills	Students are capable of using standardized calculation methods in a given context to solve - Problem such as Layer design and to solve manufacturing technology for which non-standard solutions exist. - Approximate sizing using the network theory of the structural elements implement and evaluate. - For their constructive problem select appropriate design elements and dimensioning example Connection technology, sandwich technology. - In the field of thermoplastic construction elements such as Film hinge to assess snap with manufacturing technologies, costs, performance appropriate.
Personal Competence	
Social Competence	Students can, - arrive at work results in groups and document them. - provide appropriate feedback and handle feedback on their own performance constructively.
Autonomy	Students are able to, - assess their own strengths and weaknesses - assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers. - assess possible consequences of their professional activity.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	3 h
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory

Course L0500: Joining of Polymer-Metal Lightweight Structures	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Sergio Amancio Filho
Language	EN
Cycle	WiSe
Content	**Recommended Previous Knowledge:** Fundamentals of Materials Science and Engineering Basic Knowledge of Science and Technology of Welding and Joining **Contents:** The lecture and the related laboratory exercises intend to provide an insight on advanced joining technologies for polymer-metal lightweight structures used in engineering applications. A general understanding of the principles of the consolidated and new technologies and its main fields of applications is to be accomplished through theoretical and practical lectures: Theoretical Lectures: - Review of the relevant properties of Lightweight Alloys, Engineering Plastics and Composites in Joining Technology - Introduction to Welding of Lightweight Alloys, Thermoplastics and Fiber Reinforced Plastics - Mechanical Fastening of Polymer-Metal Hybrid Structures - Adhesive Bonding of Polymer-Metal Hybrid Structures - Fusion and Solid State Joining Processes of Polymer-Metal Hybrid Structures - Hybrid Joining Methods and Direct Assembly of Polymer-Metal Hybrid Structures Laboratory Exercises (will be offered at Helmholtz-Zentrum Geesthacht as a 2-3 days compact course) - Joining Processes: Introduction to state-of-the-art friction-based spot welding and joining technologies (Friction Riveting, Friction Spot Joining and Injection Clinching Joining) - Introduction to metallographic specimen preparation, optical microscopy and mechanical testing of polymer-metal joints **Learning Outcomes:** After successful completion of this unit, students should be able to understand the principles of welding and joining of polymer-metal lightweight structures as well as their application fields.
Literature	• Lecture Notes and selected papers • J.F. Shackelford, Introduction to materials science for engineers, Prentice-Hall International • J. Rotheiser, Joining of Plastics, Handbook for designers and engineers, Hanser Publishers • D.A. Grewell, A. Benatar, J.B. Park, Plastics and Composites Welding Handbook • D. Lohwasser, Z. Chen, Friction Stir Welding, From basics to applications, Woodhead Publishing Limited

Course L0501: Joining of Polymer-Metal Lightweight Structures	
Typ	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Sergio Amancio Filho
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0057: Design with Polymers and Composites	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	DE
Cycle	WiSe
Content	Designing with Polymers: Materials Selection; Structural Design; Dimensioning Designing with Composites: Laminate Theory; Failure Criteria; Design of Pipes and Shafts; Sandwich Structures; Notches; Joining Techniques; Compression Loading; Examples
Literature	Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag

Module M1231: High Frequency and Communication Theory in Avionics for Aircraft Systems Engineers

Courses

Title	Typ	Hrs/wk	CP
Introduction to Electromagnetic Waveguides and Antennas (L1669)	Lecture	2	2
High Frequency and Communication Engineering in Avionics (L0750)	Lecture	2	2
High Frequency and Communication Engineering in Avionics (L0751)	Recitation Section (small)	1	2

Module Responsible	Prof. Frank Gronwald
Admission Requirements	None
Recommended Previous Knowledge	Electrical Engineering Fundamentals
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain the fundamental principles, inter-dependencies, and methods of avionics and the integration of avionic systems in aircraft. This includes • concepts of electromagnetic field theory and wave propagation • concepts of antenna theory • classical and satellite based navigation system • identification systems and radar applications • communication systems • lightning protection of aircraft • analysis and integration of avionic components with respect to Electromagnetic Compatibility
Skills	Students are able to apply a series of modeling methods to avionic systems. They are able to determine the most important effects that these models are predicting for the application of avionic systems. They can classify these effects and they can quantitatively analyze them. They are capable of deriving problem solving strategies from these predictions and they can adapt them to applications in avionic practice. They can evaluate their problem solving strategies against each other.
Personal Competence	
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English, during exercises, e.g..
Autonomy	Students are capable to gather necessary information from the references provided 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. Theoretical Electrical Engineering and Communication Theory). They can communicate problems and solutions in the field of Avionics in english language.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Oral exam
Examination duration and scale	2 x (30 to 60 minutes)
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory

Course L1669: Introduction to Electromagnetic Waveguides and Antennas	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction into the topics of electromagnetic wave propagation, guiding, sending, and receiving for graduate engineering students that do not have a specific 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 electromagnetic wave propagation will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)

Course L0750: High Frequency and Communication Engineering in Avionics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Gronwald
Language	DE/EN
Cycle	WiSe
Content	In avionics several electrical engineering disciplines are combined within aeronautic systems. In this lecture the concepts of high frequency theory and communication theory in avionics are explained and combined. These concepts also are of importance for the design of other complex systems, such as those of the automotive industry, e.g.. The following topics are discussed in the lecture: • Basics of electromagnetic theory • Basics of antenna theory • Wave propagation in real environments • Classical navigation systems • Satellite-based navigation systems • Radar and other identification systems • Communication Systems • Electromagnetic Compatibility in aerospace
Literature	• H. Flühr: „Avionik und Flugsicherungstechnik – Einführung in Kommunikationstechnik, Navigation und Surveillance“, 2. Auflage, (Springer, Berlin, 2012). • R.P.G. Collinson: „Introduction to Avionics Systems“, 3rd ed. (Springer, Dordrecht, 2011). • A. Helfrick: „Principles of Avionics“, 6th ed., (Avionics Communivarion Inc., Leesburg, 2010). • Standards and Documents used by the aerospace industry

Course L0751: High Frequency and Communication Engineering in Avionics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Gronwald
Language	DE/EN
Cycle	WiSe
Content	The exercises provide a deeper understanding of the content and concepts of the lecture
Literature	• H. Flühr: „Avionik und Flugsicherungstechnik – Einführung in Kommunikationstechnik, Navigation und Surveillance“, 2. Auflage, (Springer, Berlin, 2012). • R.P.G. Collinson: „Introduction to Avionics Systems“, 3rd ed. (Springer, Dordrecht, 2011). • A. Helfrick: „Principles of Avionics“, 6th ed., (Avionics Communivarion Inc., Leesburg, 2010). • Standards and Documents used by the aerospace industry • Scientific articles and papers

Module M1091: Flight Guidance and Airline Operations

Courses

Title	Typ	Hrs/wk	CP
Airline Operations (L1310)	Lecture	3	3
Introduction to Flight Guidance (L0848)	Lecture	3	2
Introduction to Flight Guidance (L0854)	Recitation Section (large)	1	1

Module Responsible	Prof. Volker Gollnick
Admission Requirements	None
Recommended Previous Knowledge	• Bachelor Mech. Eng. • Vordiplom Mech. Eng. • Lecture Air Transportation Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	1. Principles of Air Traffic Management and technologies 2. Design and modelling of traffic flows, avionics and sensor systems, cockpit design 3. Principles of Airline organization and business 4. Fleet setup, fleet operation, aircraft selection, maintenance, repair overhaul technologies and business
Skills	• Understanding and application of different interdisciplinary interdependencies • Integration and assessment of new technologies in the air transportation system • Modelling and assessment of flight guidance systems • Airline fleet planning and fleet operation
Personal Competence	
Social Competence	• Working in interdisciplinary teams • Communication
Autonomy	Organization of workflows and -strategies
Workload in Hours	Independent Study Time 82, Study Time in Lecture 98
Credit points	6
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	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

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Dr. Karl Echtermeyer
Language	DE
Cycle	SoSe
Content	1. Introdution and overview 2. Airline business models 3. Interdependencies in flight planning (network management, slot management, netzwork structures, aircraft circulation) 4. Operative flight preparation (weight & balance, payload/range, etc.) 5. fleet policy 6. Aircraft assessment and fleet planning 7. Airline organisation 8. Aircraft maintenance, repair and overhaul
Literature	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	
Typ	Lecture
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	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) Commuication systems Avionics architectures (computer systems, bus systems) Cockpit systems and displays (cockpit design, cockpit equipment)
Literature	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	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	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 compentencies of the bachelor studies by specific methods in design and modelling of air transport systems and and aircraft a spart 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

Courses

Title	Typ	Hrs/wk	CP
Airline Operations (L1310)	Lecture	3	3
Introduction to Flight Guidance (L0848)	Lecture	3	2
Introduction to Flight Guidance (L0854)	Recitation Section (large)	1	1

Module Responsible	Prof. Volker Gollnick
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 82, Study Time in Lecture 98
Credit points	6
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: 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

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Dr. Karl Echtermeyer
Language	DE
Cycle	SoSe
Content	1. Introdution and overview 2. Airline business models 3. Interdependencies in flight planning (network management, slot management, netzwork structures, aircraft circulation) 4. Operative flight preparation (weight & balance, payload/range, etc.) 5. fleet policy 6. Aircraft assessment and fleet planning 7. Airline organisation 8. Aircraft maintenance, repair and overhaul
Literature	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	
Typ	Lecture
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	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) Commuication systems Avionics architectures (computer systems, bus systems) Cockpit systems and displays (cockpit design, cockpit equipment)
Literature	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	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1193: Cabin Systems Engineering

Courses

Title	Typ	Hrs/wk	CP
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

Module Responsible	Prof. Ralf God
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Systems Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe the structure and operation of computer architectures • explain the structure and operation of digital communication networks • explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraft Data Communication Network (ADCN) • understand the approach of Model-Based Systems Engineering (MBSE) in the design of hardware and software-based cabin systems
Skills	Students are able to: • understand, operate and maintain a minicomputer • build up a network communication and communicate with other network participants • connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network • model system functions by means of formal languages SysML/UML and generate software code from the models • execute software code on a minicomputer
Personal Competence	
Social Competence	Students are able to: • elaborate partial results and merge with others to form a complete solution
Autonomy	Students are able to: • organize and schedule their practical tasks
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Project
Examination duration and scale	
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Compulsory

Course L1557: Computer and communication technology in cabin electronics and avionics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • History of computer and network technology • Layer model in computer technology • Computer architectures (PC, IPC, Embedded Systems) • BIOS, UEFI and operating system (OS) • Programming languages (machine code and high-level languages) • Applications and Application Programming Interfaces • External interfaces (serial, USB, Ethernet) • Layer model in network technology • Network topologies • Network components • Bus access procedures • Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN) • Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004

Course L1558: Computer and communication technology in cabin electronics and avionics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • History of computer and network technology • Layer model in computer technology • Computer architectures (PC, IPC, Embedded Systems) • BIOS, UEFI and operating system (OS) • Programming languages (machine code and high-level languages) • Applications and Application Programming Interfaces • External interfaces (serial, USB, Ethernet) • Layer model in network technology • Network topologies • Network components • Bus access procedures • Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN) • Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML	
Typ	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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®): • What is a model? • What is Systems Engineering? • Survey of MBSE methodologies • The modelling languages SysML /UML • Tools for MBSE • Best practices for MBSE • Requirements specification, functional architecture, specification of a solution • From model to software code • Validation and verification: XiL methods • Accompanying MBSE project
Literature	- Skript zur Vorlesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011

Module M0982: Transportation Modelling

Courses

Title	Typ	Hrs/wk	CP
Transportation Modelling (L1180)	Problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to understand the operation and potential applications of transport models.
Skills	Students are able to: • use travel demand modelling software packages for solving practical problems. • design a database structure for travel demand models. • assess modelling results. • appraise potential applications and limitations of such models.
Personal Competence	
Social Competence	Students are able to independently develop and document solutions.
Autonomy	Students are able to: • independently organise, manage and solve set tasks. • independently prepare written reports.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Project
Examination duration and scale	
Assignment for the Following Curricula	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

Typ	Problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	• Principles of transport modelling • Role of transport modelling in the planning process • Fundamentals of mobility behaviour • Design and evaluation of transport/mobility surveys • mode of operation and data requirements for different stages of modelling • Forecasting and scenarios in the transport planning • 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) • Practice-oriented project for assessing consequences of infrastructure projects and changes in land-use
Literature	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

Courses

Title	Typ	Hrs/wk	CP
Transportation Economics (L1194)	Lecture	2	4
Transportation Economics (L1195)	Recitation Section (large)	2	2

Module Responsible	Prof. Carsten Gertz
Admission Requirements	none
Recommended Previous Knowledge	Fundamentals of Transportation Economics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can... • Specify the different functions of transportation • Describe macroeconomic developments in transportation • Explain the tasks of national and international transport policy • Assess evaluation and decision problems of transport infrastructure policy • Compare different financing models and instruments for transport infrastructure
Skills	Students can... • Use analysis methods for the evaluation of transport infrastructure appropriately • Choose the appropriate instrument for financing transport infrastructure from a set of alternatives
Personal Competence	
Social Competence	Students can... • Prepare, document and present results individually or in a group • Assess your own performance and enhance it constructively
Autonomy	Students can... • Assess your own learning progress and state of knowledge • Carry out literature research and analyses • Perform assigned tasks on your own, structure them with regard to contents and finish them on time • Create written works on your own
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	60 minutes
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Logistics, Infrastructure and Mobility: Core qualification: Compulsory

Course L1194: Transportation Economics	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Heiner Hautau, Dr. Barbara Hüttmann
Language	DE
Cycle	SoSe
Content	The course transfers knowledge on the principles of transport policy in the following areas • Functions and macroeconomic developments in transportation • National und international transport policy • Transport infrastructure policy and economic evaluation problems of infrastructure • Financing models and instruments for transport infrastructure Key contents of the course are further explored and discussed in the tutorial
Literature	Aberle, G. (2009): Transportwirtschaft, 5. Auflage, Oldenbourg Verlag, München. Button, K. (2010): Transport Economics, 3rd Edition, Edw. Elgar Publishing Cheltenham UK. Daehre-Kommission (2012): Zukunft der Verkehrsinfrastruktur-finanzierung, Berlin. Frerich, J. u. Müller, G. (2004): Europäische Verkehrspolitik, Band 1 – 3, München. Grandjot, H.-H. (2002): Verkehrspolitik – Grundlagen, Funktionen und Perspektiven für Wissenschaft und Praxis, Deutscher Verkehrs-Verlag, Hamburg. Kummer, S. (2006): Einführung in die Verkehrswirtschaft. Facultas Verlag, Wien

Course L1195: Transportation Economics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Barbara Hüttmann
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1043: Aircraft Systems Engineering

Courses

Title	Typ	Hrs/wk	CP
Advanced Topics in Control (L0661)	Lecture	2	3
Advanced Topics in Control (L0662)	Recitation Section (small)	1	1
Introduction to Electromagnetic Waveguides and Antennas (L1669)	Lecture	2	2
Design Optimization and Probabilistic Approaches in Structural Analysis (L1817)	Seminar	3	3
Fatigue & Damage Tolerance (L0310)	Lecture	2	3
Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics (L1514)	Lecture	2	2
Lightweight Construction with Fibre Reinforced Rolymers - 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
Metallic Materials for Aircraft Applications (L0514)	Lecture	2	3
Optimal and Robust Control (L0658)	Lecture	2	3
Optimal and Robust Control (L0659)	Recitation Section (small)	1	1
Turbo Jet Engines (L0908)	Lecture	2	3
System Analysis in Air Transportation (L0855)	Lecture	3	3
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

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Hydraulics • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way through selected special areas within systems engineering, air transportation system and material science • Students are able to explain basic models and procedures in selected special areas. • Students are able to interrelate scientific and technical knowledge.
Skills	Students are able to apply basic methods in selected areas of engineering.
Personal Competence	
Social Competence	
Autonomy	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L0661: Advanced Topics in Control	
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	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	• Linear Parameter-Varying (LPV) Gain Scheduling - Linearizing gain scheduling, hidden coupling - Jacobian linearization vs. quasi-LPV models - Stability and induced L2 norm of LPV systems - Synthesis of LPV controllers based on the two-sided projection lemma - Simplifications: controller synthesis for polytopic and LFT models - Experimental identification of LPV models - Controller synthesis based on input/output models - Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator • Control of Multi-Agent Systems - Communication graphs - Spectral properties of the graph Laplacian - First and second order consensus protocols - Formation control, stability and performance - LPV models for agents subject to nonholonomic constraints - Application: formation control for a team of quadrotor helicopters • Control of Spatially Interconnected Systems - Multidimensional signals, l2 and L2 signal norm - Multidimensional systems in Roesser state space form - Extension of real-bounded lemma to spatially interconnected systems - LMI-based synthesis of distributed controllers - Spatial LPV control of spatially varying systems - Applications: control of temperature profiles, vibration damping for an actuated beam
Literature	• Werner, H., Lecture Notes "Advanced Topics in Control" • Selection of relevant research papers made available as pdf documents via StudIP

Course L0662: Advanced Topics in Control	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1669: Introduction to Electromagnetic Waveguides and Antennas	
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	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	Introduction to the principles and applications of electromagnetic wave propagation, electromagnetic waveguides and antennas for students without background in electrical engineering.
Literature	- S. Ramo, J. Whinnery, T. Van Duzer, "Fields and Waves in Communication Electronics", Wiley (1994) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - C. A. Balanis, "Antenna Theory: Analysis and Design", Wiley (2005)

Course L1817: Design Optimization and Probabilistic Approaches in Structural Analysis	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Hausarbeit
Examination duration and scale	10 Seiten und Diskussion
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	SoSe
Content	
Literature	

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. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L1514: Lightweight Construction with Fibre Reinforced Rolymers - 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	Christian Mittelstedt
Language	DE
Cycle	WiSe
Content	**Fundamentals of Anisotropic Elasticity** Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law **Behaviour of a single laminate layer** Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules **Fundamentals of Micromechanics of a laminate layer** Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer **Classical Laminate Plate Theory** 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 **Strength of Laminated Plates** Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin **Bending of Composite Laminated Plates** Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions **Stress Concentration Problems** Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis **Stability of Thin-Walled Composite Structures** 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 **Written exercise (report required)** Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1515: Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Christian Mittelstedt
Language	DE
Cycle	WiSe
Content	**Fundamentals of Anisotropic Elasticity** Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law **Behaviour of a single laminate layer** Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules **Fundamentals of Micromechanics of a laminate layer** Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer **Classical Laminate Plate Theory** 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 **Strength of Laminated Plates** Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin **Bending of Composite Laminated Plates** Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions **Stress Concentration Problems** Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis **Stability of Thin-Walled Composite Structures** 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 **Written exercise (report required)** Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1258: Lightweight Design Practical Course	
Typ	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	SoSe
Content	Development of a sandwich structure made of fibre reinforced plastics • getting familiar with fibre reinforced plastics as well as lightweight design • Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA) • Determination of material properties based on sample tests • manufacturing of the structure in the composite lab • Testing of the developed structure • Concept presentation • Self-organised teamwork
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005. • Puck, A., „Festigkeitsanalsyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996. • R&G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009. • VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“ • Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006. • Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989. • Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986. • Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986. • Backmann, B.F., „Composite Structures, Design, Safety and Innovation”, Oxford (UK), Elsevier, 2005. • Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012. • Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005.

Course L1549: Aviation Security	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies
Literature	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L1550: Aviation Security	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	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. 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: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies
Literature	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L0514: Metallic Materials for Aircraft Applications	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Joachim Albrecht
Language	EN
Cycle	SoSe
Content	Titanium and Titanium alloys: Extraction and melting, phase diagrams, physical properties. CP-Titanium and Alpha alloys: Processing and microstructure, properties and applications. Alpha+Beta alloys: Processing and microstructure, properties and applications. Beta alloys: Processing and microstructure, properties and applications 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
Literature	G. Luetjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397 C.T. Sims, W.C. Hagel: The Superalloys, John Wiley & Sons, New York, 1972, ISBN 0-471-79207-1

Course L0658: Optimal and Robust Control	
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	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	• Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman's identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H2 and H∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	• Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewhaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

Course L0659: Optimal and Robust Control	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0908: Turbo Jet Engines	
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. Burkhard Andrich
Language	DE
Cycle	WiSe
Content	• Cycle of the gas turbine • Thermodynamics of gas turbine components • Wing-, grid- and stage-sizing • Operating characteristics of gas turbine components • Sizing criteria's for jet engines • Development trends of gas turbines and jet engines • Maintenance of jet engines
Literature	• Bräunling: Flugzeugtriebwerke • Engmann: Technologie des Fliegens • Kerrebrock: Aircraft Engines and Gas Turbines

Course L0855: System Analysis in Air Transportation	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	60 Minuten
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	1. Introduction to the Air Transport System 2. System analysis methodologies 3. Technology management 4. Technical analysis methods 5. Economical analysis methods 6. Ecological analysis methods 7. Societal analysis methods 8. Research on the future 9. Synthesis, overall assessment, decision making 10. Case studies – Technology Push 11. Case studies – Scenario Pull
Literature	Hand out

Course L0176: Reliability in Engineering Dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min.
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	Method for calculation and testing of reliability of dynamic machine systems • Modeling • System identification • Simulation • Processing of measurement data • Damage accumulation • Test planning and execution
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

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

Course L1554: Reliability of avionics assemblies	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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: • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F^3I concept • Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L1555: Reliability of avionics assemblies	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	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: • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F^3I concept • Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L0749: Reliability of Aircraft Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
Language	DE
Cycle	WiSe
Content	• Functions of reliability and safety (regulations, certification requirements) • Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment) • Reliability analysis of electrical and mechanical systems
Literature	• CS 25.1309 • SAE ARP 4754 • SAE ARP 4761

Module M1032: Airport Planning and Operations

Courses

Title	Typ	Hrs/wk	CP
Airport Operations (L1276)	Lecture	3	3
Airport Planning (L1275)	Lecture	2	2
Airport Planning (L1469)	Recitation Section (small)	1	1

Module Responsible	Prof. Volker Gollnick
Admission Requirements	None
Recommended Previous Knowledge	• Bachelor Mech. Eng. • Vordiplom Mech. Eng. • Lecture Air Transportation Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	1. Regulatory principles of airport planning and operations 2. Design of an airport incl. Regulatory baselines 3. Airport operation in the terminal and at the airfield
Skills	• Understanding of different interdisciplinary interdependencies • Planning and design of an airport • Modelling and assessment of airport operation
Personal Competence	
Social Competence	• Working in interdisciplinary teams • Communication
Autonomy	Organization of workflows and -strategies
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	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

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Axel Christian Husfeldt
Language	DE
Cycle	WiSe
Content	FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground handling Terminal operations
Literature	Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003

Course L1275: Airport Planning	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	1. Introduction, definitions, overviewg 2. Runway systems 3. Air space strucutres around airports 4. Airfield lightings, marking and information 5. Airfield and terminal configuration
Literature	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	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1024: Methods of Integrated Product Development

Courses

Title	Typ	Hrs/wk	CP
Integrated Product Development II (L1254)	Lecture	3	3
Integrated Product Development II (L1255)	Problem-based Learning	2	3

Module Responsible	Prof. Dieter Krause
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of Integrated product development and applying CAE systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After passing the module students are able to: • explain technical terms of design methodology, • describe essential elements of construction management, • describe current problems and the current state of research of integrated product development.
Skills	After passing the module students are able to: • select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundary conditions, • solve product development problems with the assistance of a workshop based approach, • choose and execute appropriate moderation techniques.
Personal Competence	
Social Competence	After passing the module students are able to: • prepare and lead team meetings and moderation processes, • work in teams on complex tasks, • represent problems and solutions and advance ideas.
Autonomy	After passing the module students are able to: • give a structured feedback and accept a critical feedback, • implement the accepted feedback autonomous.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Oral exam
Examination duration and scale	30 Minuten
Assignment for the Following Curricula	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: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1254: Integrated Product Development II	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe
Content	**Lecture** 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. Topics of the course include in particular: • Methods of product development, • Presentation techniques, • Industrial Design, • Design for variety • Modularization methods, • Design catalogs, • Adapted QFD matrix, • Systematic material selection, • Assembly oriented design, Construction management • CE mark, declaration of conformity including risk assessment, • Patents, patent rights, patent monitoring • Project management (cost, time, quality) and escalation principles, • Development management for mechatronics, • Technical Supply Chain Management. **Exercise (PBL)** In the exercise the content presented in the lecture “Integrated Product Development II” and methods of product development and design management will be enhanced. 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.
Literature	• Andreasen, M.M., Design for Assembly, Berlin, Springer 1985. • Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007. • Beckmann, H.: Supply Chain Management, Berlin, Springer 2004. • Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und Trainer, Weinheim, Beltz 2007. • Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006. • Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000. • Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York, Springer 2013.

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

Module M1231: High Frequency and Communication Theory in Avionics for Aircraft Systems Engineers

Courses

Title	Typ	Hrs/wk	CP
Introduction to Electromagnetic Waveguides and Antennas (L1669)	Lecture	2	2
High Frequency and Communication Engineering in Avionics (L0750)	Lecture	2	2
High Frequency and Communication Engineering in Avionics (L0751)	Recitation Section (small)	1	2

Module Responsible	Prof. Frank Gronwald
Admission Requirements	None
Recommended Previous Knowledge	Electrical Engineering Fundamentals
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain the fundamental principles, inter-dependencies, and methods of avionics and the integration of avionic systems in aircraft. This includes • concepts of electromagnetic field theory and wave propagation • concepts of antenna theory • classical and satellite based navigation system • identification systems and radar applications • communication systems • lightning protection of aircraft • analysis and integration of avionic components with respect to Electromagnetic Compatibility
Skills	Students are able to apply a series of modeling methods to avionic systems. They are able to determine the most important effects that these models are predicting for the application of avionic systems. They can classify these effects and they can quantitatively analyze them. They are capable of deriving problem solving strategies from these predictions and they can adapt them to applications in avionic practice. They can evaluate their problem solving strategies against each other.
Personal Competence	
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English, during exercises, e.g..
Autonomy	Students are capable to gather necessary information from the references provided 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. Theoretical Electrical Engineering and Communication Theory). They can communicate problems and solutions in the field of Avionics in english language.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Oral exam
Examination duration and scale	2 x (30 to 60 minutes)
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory

Course L1669: Introduction to Electromagnetic Waveguides and Antennas	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction into the topics of electromagnetic wave propagation, guiding, sending, and receiving for graduate engineering students that do not have a specific 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 electromagnetic wave propagation will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)

Course L0750: High Frequency and Communication Engineering in Avionics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Gronwald
Language	DE/EN
Cycle	WiSe
Content	In avionics several electrical engineering disciplines are combined within aeronautic systems. In this lecture the concepts of high frequency theory and communication theory in avionics are explained and combined. These concepts also are of importance for the design of other complex systems, such as those of the automotive industry, e.g.. The following topics are discussed in the lecture: • Basics of electromagnetic theory • Basics of antenna theory • Wave propagation in real environments • Classical navigation systems • Satellite-based navigation systems • Radar and other identification systems • Communication Systems • Electromagnetic Compatibility in aerospace
Literature	• H. Flühr: „Avionik und Flugsicherungstechnik – Einführung in Kommunikationstechnik, Navigation und Surveillance“, 2. Auflage, (Springer, Berlin, 2012). • R.P.G. Collinson: „Introduction to Avionics Systems“, 3rd ed. (Springer, Dordrecht, 2011). • A. Helfrick: „Principles of Avionics“, 6th ed., (Avionics Communivarion Inc., Leesburg, 2010). • Standards and Documents used by the aerospace industry

Course L0751: High Frequency and Communication Engineering in Avionics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Frank Gronwald
Language	DE/EN
Cycle	WiSe
Content	The exercises provide a deeper understanding of the content and concepts of the lecture
Literature	• H. Flühr: „Avionik und Flugsicherungstechnik – Einführung in Kommunikationstechnik, Navigation und Surveillance“, 2. Auflage, (Springer, Berlin, 2012). • R.P.G. Collinson: „Introduction to Avionics Systems“, 3rd ed. (Springer, Dordrecht, 2011). • A. Helfrick: „Principles of Avionics“, 6th ed., (Avionics Communivarion Inc., Leesburg, 2010). • Standards and Documents used by the aerospace industry • Scientific articles and papers

Module M0808: Finite Elements Methods

Courses

Title	Typ	Hrs/wk	CP
Finite Element Methods (L0291)	Lecture	2	3
Finite Element Methods (L0804)	Recitation Section (large)	2	3

Module Responsible	Prof. Otto von Estorff
Admission Requirements	none
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	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.
Skills	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.
Personal Competence	
Social Competence	-
Autonomy	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.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	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 Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: 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: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Technomathematics: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	- General overview on modern engineering - Displacement method - Hybrid formulation - Isoparametric elements - Numerical integration - Solving systems of equations (statics, dynamics) - Eigenvalue problems - Non-linear systems - Applications - Programming of elements (Matlab, hands-on sessions) - Applications
Literature	Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

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

Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §24 (1): At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. • 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. • The students can place a research task in their subject area in its context and describe and critically assess the state of research.
Skills	The students are able: • To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. • 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. • To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can • Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way. • 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.
Autonomy	Students are able: • To structure a project of their own in work packages and to work them off accordingly. • To work their way in depth into a largely unknown subject and to access the information required for them to do so. • To apply the techniques of scientific work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Examination	according to Subject Specific Regulations
Examination duration and scale	see FSPO
Assignment for the Following Curricula	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