Universität Bremen

Module guide

for M.Sc. Space Sciences and Technologies "Space-ST" (MPO 2020), v1.1

This module guide details the contents of the master's programme Space-ST and the course of studies.

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Programme scheme M.Sc. Space Sciences and Technologies (MPO 2020)

The module sequence is a recommendation. It may follow a more individual schedule.

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CP = Credit Points

Overview classified by module groups

1. Foundations

The foundation modules are compulsory and cover 30 CP during semester 1.

2. Remote Sensing and Communication

The modules in Remote Sensing and Communication are compulsory; they are recommended for semesters 2 and 3.

3. Specialization Areas

Specialization Areas are: Physics for Space Observations (PSO) and Information Technologies for Space (ITS) The choice of a specialization and the respective modules are compulosry.

3. 1. Physics for Space Observation

These modules are compulsory if the specialization area of choice is Physics for Space Observation (PSO).

3. 2. Information Technologies for Space

Alphabetical module list

Module AMMDA: Applied Mathematical Methods and Data Analysis

Applied Mathematical Methods and Data Analysis

MPO 2020

Module assignment:	Recommended content-related requirements:
• Foundations	none

Learning content:

The course lectures cover the theoretical basis of the following subject areas:

- Essential linear algebra (matrices, eigenvalues, linear systems of equations)
- Essential calculus (differentiation, integration, Taylor series)
- Essential statistics (error analysis, correlation, significance)
- Essential optimization (linear and nonlinear regression, parameter estimation, gradient methods)
- Essential differential equations (ordinary and partial differential equations, phase diagrams)

In the example classes students will learn how to apply this knowledge both analytically and numerically. In order to facilitate the latter, students will learn the basics of the Python programming language and how to use Python to solve real-world problems from the course's topic areas.

Learning outcome / Competence:

Basic knowledge in mathematical methods for data analysis and their application using the Python programming language

Calculating student workload:

The module comprises two courses: a lecture and an exercise of 2 credit hours each.

Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Prof. Dr. Mihalis Vrekoussis
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module 01-01-03 AtPhy: Atmospheric Physics Atmospheric Physics MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Foundations	none

Learning content:

The origin of the solar system and the earth’s atmosphere; the evolving atmospheric composition; the physical parameters determining conditions in the atmosphere (e.g. temperature, pressure, and vorticity); the laws describing electromagnetic radiation; the interaction between electromagnetic radiation and matter (absorption emission and scattering); atmospheric radiative transport; radiation balance, climate change; atmospheric thermodynamics and hydrological cycle; aerosols and cloud physics; an introduction into atmospheric dynamics (kinematics, circulation etc.).

References:

- Houghton, J.T., The physics of atmospheres, Cambridge University Press, 1977, ISBN 0 521 29656 0.
- Wallace, John M. and Peter V. Hobbs, Atmospheric Science, An Introductory Survey, Academic Press, 2nd Edition 2005, ISBN 0-12-732951-x

Learning outcome / Competence:

An adequate understanding of the fundamentals of atmospheric physics.

This addresses a) gaining an understanding the laws of physics, which determine the behaviour of the earth system comprising the sun the atmosphere and earth surface, b) learning the ability to apply the laws of physics to calculate parameters and forecast conditions in the atmosphere.

This knowledge is required for subsequent advanced courses in the M.Sc. programmes. In later life, these learning outcomes are essential for undertaking a) research in atmospheric, environmental and climate science Earth observation and remote sensing form ground based ship, aircraft and space based instrumentation, b) being employment in earth observation, earth science, meteorology, industry, or governmental and space agencies.

Calculating student workload:

The module comprises two courses: a lecture and an exercise of 2 credit hours each.

Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, examples: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Prof. Dr. John P. Burrows
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -

Credit points / Workload:	Contact hours:
6 / 180 hours	4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module ComSp: Communication Technologies for Space

Communication Technologies for Space

MPO 2020

Module assignment:	Recommended content-related requirements:
• Foundations	Basics in linear algebra, calculus, differential equations, fourier transformation and physics (basics in electromagnetic waves) are recommended.

Learning content:

- Introduction to communications: history of wireless communication and space communication
- Basic concepts and terminology in communications
- Recap of Fourier transformation
- Introduction to system theory (signals, linear time invariant systems, convolution, statistic process, etc.)
- Passband-Baseband transformation and receiver concepts
- Wireless channel basics (linear and non-linear distortions, noise, Nyquist, etc.)
- Analog modulation
- Basics in sampling theory and discrete systems and signals
- Digital modulation

Learning outcome / Competence:

As outcome, the students should be able to:

- explain basic communications concepts and theoretical foundations;
- apply mathematical tools and concepts relevant in communications;
- explain and apply analog and digital modulation.

Calculating student workload:

The module comprises a lecture and an exercise of 2 credit hours each.

Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Dr.-Ing. Carsten Bockelmann
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung (90 min.)

Module courses

Course:	01-29-03-ComSp Communication Technologies for Space Lecture and Exercise
Frequency: WiSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Bockelmann, Carsten, Dr.-Ing.
Teaching method(s): Lecture with tutorial	**Associated module examination:** Modulprüfung

Module 01-15-03 CTh1(a): Contol Theory 1 / Regelungstheorie 1

Contol Theory 1

MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Foundations	none

Learning content:

- Definition and features of state variables
- State space description of linear systems
- Normal forms
- Coordinate transformation
- General solution of a linear state space equation
- Lyapunov stability
- Controllability and observability
- Concept of state space control
- Steady-state accuracy of state space controllers
- Observer
- Controller design by pole placement
- Riccati controller design
- Falb-Wolovitch controller design

References:

- K. Michels: Control Engineering (Script in German and English)

German:

- J. Lunze: Regelungstechnik 2
- O. Föllinger: Regelungstechnik
- H. Unbehauen: Regelungstechnik II

English:

- Norman S. Nise: Control Systems Engineering

Learning outcome / Competence:

- Understanding and handling of state space methodology
- Design of state space controllers with different methods
- Observer design

Calculating student workload:

The module comprises lectures and exercises of 4 credit hours.

Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English / German	**Module leader:** Prof. Dr.-Ing. Kai Michels
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Mündliche oder schriftliche Prüfung

Module courses

Course:	01-15-03-CTh1-V Control Theory 1
Frequency: WiSe, once a year	**Are there parallel courses?** no
Language: English / German	**University teacher(s):** Michels, Kai, Prof. Dr.-Ing.
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung

Module 01-29-03 SEM: Science and Exploration Missions Science and Exploration Missions MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Foundations	none

Learning content:

Introduction to completed and planned space missions:

Examples are (i) Gravity Probe A for testing the gravitational redshift, (ii) Gravity Probe B for testing the gravitomagnetic Schiff effect, (iii) Cassini for Saturn exploration and testing the gravitational time delay, (iv) Pioneer for planetary exploration and testing the gravitational field in the Solar system, (v) MICROSCOPE for testing the Equivalence Principle, (vi) LISA for searching for gravitational waves and the technology mission LISA pathfinder, (vii) GRACE and GRACE-FO for satellite based geodesy, (viii) ACES on the ISS for testing relativity and establishing space-based metrology, (ix) further missions testing Special and General Relativity using quantum optics, (x) asteroid and comet missions HAYABUSA and Rosetta.

For each mission the requirements on the payload technology, the spacecraft technology, and on the mission scenario will be derived.

A list of references will be provided at the start of the semester.

Learning outcome / Competence:

Participants are able to discuss science cases for space and exploration missions, measurement schemes and payload as well as technology requirements on payload and mission.

Calculating student workload:

- Contact hours (lecture): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 42 h (3 h x 14 weeks)
- Preparation for exam: 20 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. rer. nat. Claus Lämmerzahl
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Prüfungsleistung: oral or written examination

Module 01-29-03 SpEl(a): Space Electronics
Space Electronics
MPO 2020

Module assignment:	Recommended content-related requirements:
• Foundations	Basic knowledge of semiconductors, analog and digital circuits

Learning content:
- Radiation environments
- MOS Device and radiation
- Circuit Reliability basics
- Single event effects on analog and digital circuits, memories
- Displacement damage (DD) effects
- Radiation hard device technologies and circuit design
- Noise
- gm/Id Method
- Mismatch
- Two pole opamps (OTA)
- Feedback

Learning outcome / Competence:
After this course, students are able to:

- describe and characterize noise in electronics circuits,
- apply the gm/Id sizing method to design amplifier circuits for advance CMOS technologies,
- deal with process variations and mismatch,
- understand the frequency behaviour of amplifier circuits,
- understand and size compensation networks,
- use feedback to modify circuit characteristics,
- understand the impact of radiation on the behavior of circuits,
- design radition-hard circuits.

Calculating student workload:
- Contact hours (lecture + exercise): 42 h (3 h x 14 weeks)
- Preparation, learning, examples: 14 h (h x 14 weeks)
- Preparation for exam: 34 h

Total working hours: 90 h

Language of tuition:	Module leader:
English	Prof. Dr.-Ing. Alberto Garcia-Ortiz
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -

Credit points / Workload:	Contact hours:
3 / 90 hours	2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module 01-01-03 AtSp: Atmospheric Spectroscopy
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Remote Sensing and Communication	none

Learning content:

- Prism and grating spectrometers
- Fourier-Transform-Spectroscopy
- Transitions
- Rotational spectra
- Vibrational spectra
- Rotational-vibrational spectra
- Remote sensing methods

Learning outcome / Competence:

Basics of spectroscopy, basics of molecular spectroscopy. Understanding and interpretation of measured spectra with regard to the structure of the molecules. Basics of prism, grating and FTIR-spectroscopy, understanding of remote sensing methods.

Calculating student workload:

The module comprises a lecture and an exercise of 1 credit hour each.

- Contact hours (lecture + exercise): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 28 h (2 h x 14 weeks)
- Preparation for exam: 34 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. rer.nat. Justus Notholt
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung

Examination format: Announcement at the begin of the semester	Prüfungsleistung

Module CNSp: Communication Networks for Space
Communication Networks for Space
MPO 2020

Module assignment:	Recommended content-related requirements:
• Remote Sensing and Communication	none

Learning content:
Introduction into communication networks. Internet protocols, Internet of things, wireless sensor networks, delay-tolerant networks, opportunistic networks. Space networks: types of spacecraft, orbits and paths, properties of space communication, types of data, quality-of-service requirements, space network architecture, protocols and bearer technologies for space networks, communication infrastructure of governmental and private space agencies.

References:

- J. Kurose/K. Ross: Computer Networking: A Top-Down Approach. 6th ed., Pearson Education, 2013.
- A. Förster: Wireless Sensor Networks. Wiley, 2016.
- J. Taylor: Deep Space Communications. Wiley, 2016.

Learning outcome / Competence:
The participants are able to describe exemplary systems of communication networks, know the basic design principles used for communication protocols on the different layers, can explain the special properties of space networks.

Calculating student workload:
- Contact hours (lecture + exercise): 42 h (3 h x 14 weeks)
- Preparation, learning, exercises: 28 h (2 h x 14 weeks)
- Preparation for exam: 20 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. Anna Förster
Frequency: WiSe, SoSe	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 3 hours

Module examinations

Type of examination: Kombinationsprüfung

Examination format: Announcement at the begin of the semester	Successful assessment of homework assignments and a successful poster preparation and presentation (graded)

Module 01-01-03 DIP: Digital Image Processing
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Remote Sensing and Communication	none

Learning content:

- Digital images, sampling
- Grey level transformations, color images
- Image enhancement using filters
- Image analysis methods using segmentation, feature extraction and classification
- Fourier transformation of digital images, linear filters in spatial and frequency domains
- Data compression, image coding, image formats

References:

- K. R. Castleman: Digital Image Processing. Prentice Hall, Englewood Cliffs, 1996.
- R. C. Gonzalez, R. E. Woods: Digital Image Processing. Addison-Wesley, Second Edition, 2002.
- B. Jähne: Digital Image Processing. Springer, 2002.
- J.C. Russ: The Image Processing Handbook, 5th Edision. CRC Press, 2006 (ISBN 0-8493-7254-2).
- R. A. Schowengerdt: Remote Sensing, Models and Methods for Image Processing. Academic Press, 1997.

Learning outcome / Competence:

Fundamentals, basic concept and methods of digital image processing, enabling the students to identify and understand image processing problems (encountered in Environmental Physics, Space Science etc.) and to find appropriate solutions

Calculating student workload:

The module comprises a lecture of 1 semester hour and an exercise of 1 credit hour each.

- Contact hours (lecture + exercise): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 28 h (2 h x 14 weeks)
- Preparation for exam: 34 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Dr. Christian Melsheimer Prof. Dr. Grunnar Spreen
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Kombinationsprüfung	
Examination format: Announcement at the begin of the semester	Oral examination and successful assessment of exercise courses

Module 01-29-03 GG: Geodesy and Gravity
Geodesy and Gravity
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Remote Sensing and Communication	none

Learning content:

Classical geodesy

- Repetition of Newtonian gravitational theory
- Multipole moments of the Earth and the gravitational field of the Earth
- Definition of the geoid on the rotating Earth
- Equation of motion for satellites
- Calculation of satellite orbits
- Description of orbits for satellite formation flight and extraction of the gravitational field

Relativistic geodesy

- Elements of relativistic gravity theory
- Post-Newtonian solution for the gravitational field of the Earth
- Definition of the geoid
- Clocks in the gravitational field: clock geodesy
- Relativistic satellite orbits, basic effects

Learning outcome / Competence:

The students gain knowledge of notions of nonrelativistic gravity theory, knowledge of basic notions of geodesy, an understanding of methods to measure the gravitational fields, knowledge of basic principles of relativistic gravity and an understanding of clock geodesy.

Calculating student workload:

- Contact hours (lecture + integrated exercise): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 42 h (3 h x 14 weeks)
- Preparation for exam: 20 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. rer. nat. Claus Lämmerzahl
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Written or oral examination

Module GNSS: The Global Navigation Satellite System

The Global Navigation Satellite System

MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Remote Sensing and Communication	none

Learning content:

Understanding of the working principles of global navigation satellite systems.

This consists on (i) the physical requirements regarding the main working principles. Here clocks, the electromagnetic signals propagation in the Earth's atmosphere, and the targeted accuracy are discussed. In the second step (ii) the theoretical analysis of the whole problem has to be carried through. This includes basic effects of the moving clocks (special relativistic time dilation) and clocks in gravitational fields (gravitational redshift) and the calculation of the position from the clock signals. Moreover, theoretical concepts within geodesy regarding reference surfaces and coordinate systems such as WGS84 will be introduced. In the third part (iii) the technological realization is described.

References:

- Werner Mansfeld: Satellitenortung und Navigation. Grundlagen, Wirkungsweisen und Anwendung globaler Satellitennavigationssysteme. Vieweg, Wiesbaden 2010.
- Manfred Bauer: Vermessung und Ortung mit Satelliten. Globale Navigationssysteme (GNSS) und andere satellitengestützte Navigationssysteme. Wichmann, Berlin 2011
- B. Hoffmann-Wellenhof, H. Lichtenegger, and J. Collins: GPS - Theory and Practice, (Springer, Wien and New York, 2001)

Learning outcome / Competence:

Knowledge in and understanding of

- the physical and theoretical principles of positioning,
- GNSS satellites, payload, clocks;
- the technology requirements.

Calculating student workload:

- Contact hours (lecture): 28 h (2 h x 14 weeks)
- Preparation, learning, examples: 28 h (2 h x 14 weeks)
- Preparation for exam: 34 h

Total working hours: 90

Language of tuition:	**Module leader:**
English	Prof. Dr. rer. nat. Claus Lämmerzahl Dr. Dennis Philipp
Frequency:	**Duration:**
SoSe, once a year	1 semester[s]
The module is valid since:	**The module is valid until:**
-	-
Credit points / Workload:	**Contact hours:**
3 / 90 hours	2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Written or oral examination

Module 01-15-03 SAMS(a): Sensors and Measurement Systems
Sensors and Measurement Systems
MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Remote Sensing and Communication	none

Learning content:

- Basics of Sensors
- Thermal Sensors
- Sensor Technology
- Force and Pressure Sensors
- Inertial Sensors
- Magnetic Sensors
- Flow Sensors

References:

Walter Lang: Sensors and Measurement systems, ISBN-10: 877022028X

Learning outcome / Competence:
After this course, students should be able to:

- name and explain important sensors,
- apply characterization parameters for sensors,
- choose sensors for a given application and apply them,u
- understand micromachining technologies for sensors.

Calculating student workload:
The module comprises two courses: a lecture and an exercise of 2 credit hours each.
Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Prof. Dr.-Ing. Walter Lang
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module courses

Course:	01-15-03-SAMS(a)-V Sensors and Measurement Systems
Frequency: SoSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Lang, Walter, Prof. Dr.-Ing.
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung

Module LSpa1: Space Lab Part 1
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Remote Sensing and Communication	none

Learning content:
A set of practical measurements of meteorological quantities, atmospheric trace gases, ocean currents, environmental radioactivity, and absorption cross-sections using different techniques is performed by the students under supervision of tutors. The measurements obtained in the lab will then be analysed, and the experiment, its background and the results as well as their interpretation be documented in a written report.

Learning outcome / Competence:
Participants learn to perform measurements central to Space Sciences and Technologies using scientific techniques and methods. They learn to analyse the measurements and to document the results in a written report.

Calculating student workload:
- Contact hours (lecture): 24 h (6 h x 4 weeks)
- Contact hours (lab): 12 h (6 h x 2 weeks)
- Preparation, reports: 24 h (2 x 12 weeks)
- Preparation for exam: 30h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Dr. Andreas Richter
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Kombinationsprüfung

Examination format: Announcement at the begin of the semester	Examination performance: Oral examination and reports

Module LSpa2: Space Lab Part 2
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Remote Sensing and Communication	none

Learning content:
Application of control basics, measurements of Embedded Systems and Communications.

Learning outcome / Competence:
Participants learn

- the basics of control and measurement techniques in Space Sciences and Technologies;
- the basic structure and concepts of communications systems for space;
- implementation and visualization of communications algorithms and concepts via Matlab or Python;
- performance measurements of communication protocols using a simulation tool.

Calculating student workload:
The module comprises lectures and lab work.

- Contact hours: 28 h (2 h x 14 weeks)
- Reports: 42 h (3 x 14 weeks)
- Preparation: 20h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr.-Ing. Kai Michels Prof. Dr. Anna Förster, Prof. Dr. Armin Dekorsy
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung

Examination format: Portfolio	Successful conduct of experiments, reports thereof

Module AtCM1(a): Atmospheric Chemistry Modelling: Part 1 (Theory)
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Specialization Areas / Physics for Space Observation	none

Learning content:

- Concept of chemistry transport models
- Atmospheric Chemical Composition/Processes Model equations and numerical approaches focusing on the: a) formulation of atmospheric rates, and b) numerical methods for chemical systems
- Surface fluxes/emissions
- Observations and model evaluations
- Inverse modeling for atmospheric chemistry
- Concepts of inverse modelling

A list of references will be provided at the start of the semester

Learning outcome / Competence:

Participants:

- get a theoretical overview of the concepts of numerical atmospheric chemistry modelling
- review fundamentals of atmospheric chemistry and physics,
- formulate model equations and numerical (differential) approaches for various systems focusing on atmospheric chemistry mechanisms, and
- assess the role of chemistry transport models as components of the atmospheric observing system.

Calculating student workload:

The module comprises a lecture and an exercise of 1 credit hour each.

Workload:

- Contact hours (lecture + exercise): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 42 h (3 h
- Preparation for exam: 20 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. Mihalis Vrekoussis
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Oral examination

Module 01-16-03 CliS1: Climate System I MPO 2020

Module assignment: • Specialization Areas / Physics for Space Observation	**Recommended content-related requirements:** none

Learning content:
- Climate on earth
- Climate variations
- The climate system
- Energy balance models
- Radiation & convection
- The role of the ocean in climate

Learning outcome / Competence:
Knowledge in and understanding of climate physics

Calculating student workload:
The module comprises a lecture and an exercise of 1 credit hour each.

- Contact hours (lecture + exercise): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 42 h (3 h x 14 weeks)
- Preparation for exam: 20 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. Torsten Kanzow
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 3 hours

Module examinations

Type of examination: Kombinationsprüfung	
Examination format: Combination examination	Written examination and exercises

Module 01-29-03 RSOC: Remote Sensing of Ocean and Cryosphere

Remote Sensing of Ocean and Cryosphere

MPO v. 05.04.2017

Module assignment:	**Recommended content-related requirements:**
• Specialization Areas / Physics for Space Observation	none

Learning content:

- Error analysis and statistics
- Techniques for the optimal solution of under and over determined systems of linear equations including methods for calculating variances and covariances of the solutions
- Concepts of resolution and methods to calculate them
- Practical examples and applications to test data sets from oceanography
- Image processing
- Atmospheric remote sensing

A list of references will be provided at the start of the semester.

Learning outcome / Competence:

Students gain background knowledge in basics and application of remote sensing of sea ice extent and thickness, sea surface height, winds over the ocean, waves, ocean bottom, surface temperature and salinity, ocean color and other remote sensing applications for ocean and cryosphere.

Calculating student workload:

The module comprises two courses: a lecture of 2 semester hours and an exercise of 2 semester hours.

Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, examples: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition:	**Module leader:**
English	Prof. Dr. Monika Rhein Prof. Dr. Astrid Bracher, Dr. Georg Heygster, Dr. Gunnar Spreen, Prof. Dr. Christian Haas, Prof. Dr. Ben Marzeion
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 17/18	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Prüfungsleistung	
Examination format: Announcement at the begin of the semester	Written/oral examination

Type of examination: Studienleistung	
Examination format:	Course performance: Successful assessment of exercise classes

Module courses

Course:	01-29-03-RSOC-V Vorlesung Remote Sensing of the Ocean and Cryosphere
Frequency: SoSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Rhein, Monika, Prof. Dr.
Teaching method(s):	**Associated module examination:**

Module 01-15-03 BiM: BioMEMS
BioMEMS
MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Specialization Areas / Information Technologies for Space	none

Learning content:

- Organisation, introduction, basics of microfluidics and BioMEMS
- Flow control: valves and pumps
- Sensors and analysis in BioMEMS devices
- Technology and packaging
- Examples of BioMEMS devices
- Modeling and simulation of microfluidic structures

A list of references will be provided at the start of the semester.

Learning outcome / Competence:
An overview is given of the developments in the area of microfluidic and BioMEMS devices from the early start (where especially silicon integrated valves and pumps were investigated) to the lab-on-a-chip devices of today. The functionality of the sensors and actuators, the technologies applied, and the design of fluidic chips will be discussed. Some basic fluidics aspects will be presented and a practical in which COMSOL is used for the simulation of microfluidic elements is included. A series of examples of currently investigated BioMEMS devices will be shown, e.g. chips for capillary electrophoresis, cytometry and optofluidics.

After this course, students are able to:

- understand the basics of microfluidics,
- understand and explain the functioning of µfluidic devices,
- apply characterization parameters for (elements of) µfluidic and BioMEMS devices,
- understand fabrication technologies for microfluidic and BioMEMS devices.

Calculating student workload:
The module comprises two courses: a lecture and an exercise of 2 credit hours each.

Workload:

- Contact hours: 56 h (4 h/week x 14 weeks)
- Preparation: 28 h (2 h/week x 14 weeks)
- Learning and exercises: 28 h (2 h/week x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition:	**Module leader:**
English	Prof. Dr.-Ing. Michael Vellekoop
Frequency:	**Duration:**
SoSe, once a year	1 semester[s]

The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Portfolio aus schriftlicher Prüfung und Simulationsaufgaben

Module courses

Course:	01-15-03-BiM-V BioMEMS
Frequency: SoSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Vellekoop, Michael, Prof. Dr.-Ing.
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung

Module 01-15-03 DiTe(a): Digital Technology
Digital Technology
MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Specialization Areas / Information Technologies for Space	none

Learning content:
- Timing strategies
- Non-programmable hardware modules
- Programmable hardware modules
- Selected algregraic and Boolean operations
- Introduction to digital coding

Learning outcome / Competence:
Die Studierenden

- erlernen spezielle Fähigkeiten zur Realisierung funktionsspezifischer digitaler, kombinatorischer und komplexer sequentieller Schaltungen;
- erwerben Grundwissen zur Realisierung digitaler Module;
- erlernen verschiedene Strategien für die Realisierung digitaler Module (z.B. Datenpfad+Steuerpfad, Synchron vs. Asynchron, Programmierbarkeit, …);
- beherrschen Entwurfs- und Analysemethoden von Schaltnetzen und Schaltwerken;
- erlernen spezielle Fähigkeiten zur Realisierung funktionsspezifischer digitaler Systeme.

Calculating student workload:
The module comprises lecture and exercises of 2 credit hours each.

Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Prof. Dr.-Ing. Alberto Garcia-Ortiz
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module courses

Course:	01-15-03-DiTe(a)-V Digital Technology
Frequency: WiSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Garcia-Ortiz, Alberto, Prof. Dr.-Ing.
Teaching method(s): Lecture with tutorial	**Associated module examination:** Modulprüfung

Module 01-15-03 RFC(a): RF Frontend Devices and Circuits

RF Frontend Devices and Circuits

MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Specialization Areas / Information Technologies for Space	none

Learning content:

- Two-port circuits
- Noise in electronic circuits (thermal noise, noise figure, noise temperature, Friis formula, antenna noise, etc.)
- Fundamentals of non-linear devices (gain compression, desensitization, IP2, IP3 points, …)
- RF devices & RF circuits and frontends (amplifier, mixer, oscillator)

A list of references is given in the manuscript.

Learning outcome / Competence:

After successful completion of this module the students:

- can describe two-port circuits by matrices (Z, Y, ABCD, …)
- know the basic schematics of typical transmitter and receiver circuits
- can analyze the noise performance of receiver circuits
- can perform a signal and noise budget analysis of typical wireless communication links (microwave backhaul systems, mobile communications, satellite communications)
- can analyze the non-linear behavior of practical RF devices (amplifier, mixer)
- can design and analyze fundamental oscillator topologies
- are able to discuss the pros and cons of different RF frontend architectures and can design first basic analogue RF frontend circuits.

Calculating student workload:

The module comprises two courses: a lecture and an exercise of 2 credit hours each.

Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Prof. Dr.-Ing. Martin Schneider
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module courses

Course:	01-15-03-RFC(a)-V RF Frontend Devices and Circuits
Frequency: SoSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Schneider, Martin, Prof. Dr.-Ing.
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung

Module 01-01-03 BGC: Biogeochemistry MPO 2020	
Module assignment: • Electives Space-ST	**Recommended content-related requirements:** none
Learning content: • Global biochemical cycles of elements • Important biophysical processes in atmosphere and ocean • Carbon, methane, nitrogen and water cycles • Greenhouse gases A list of references will be provided at the start of the semester.	
Learning outcome / Competence: Advanced biogeochemistry	
Calculating student workload: The module comprises a lecture and an exercise of 1 credit hour each. • Contact hours (lecture + exercise): 28 h (2 h x 14 weeks) • Preparation, learning, exercises: 28 h (2 h x 14 weeks) • Preparation for exam: 34 h Total working hours: 90 h	
Language of tuition: English	**Module leader:** Dr. Annette Ladstätter-Weißenmayer
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Written or oral examination

Module 01-01-03 Dyn1: Dynamics I MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Electives Space-ST	none

Learning content:

- Governing equations
- Conservation laws
- Balances
- Circulation and vorticity
- Large-scale circulation
- Planetary boundary layer
- Rossby waves

References:

- Holton: An Introduction to Dynamic Meterorology, Elsevier Academic Press
- Marshall and Plumb: Atmosphere, Ocean, and Climate Dynamics, An
- Wallace and Hobbs, Atmospheric Science: An Introductory Survey, Academic Press

Learning outcome / Competence:

Understanding of the basic dynamical processes in atmosphere and ocean; learning how to interpret physical equations physically

Calculating student workload:

The module comprises a lecture and an exercise of 2 semester hours each.

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Prof. Dr. Thomas Jung
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module 01-15-03 CCod(a): Channel Coding

Channel Coding

MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Electives Space-ST	Basics of Communication Technologies or equivalent

Learning content:

- Information Theory
- Blockcodes
- Convolutional Codes
- Concatenated Codes

Learning outcome / Competence:

After this course, the students should be able to

- understand the fundamentals of information theory and the concept of channel coding;
- understand the fundamentals of block and convolutional codes;
- apply encoding and decoding algorithms;
- understand the concept of concatenated codes and iterative decoding.

Calculating student workload:

The module comprises a lecture with exercises of 2 credit hours:

- Contact hours (lectures and exercises): 28 h (2 h x 14 weeks)
- Preparation, learning and exercises: 28 h (2 h x 14 weeks)
- Preparation for exam: 34 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Dr.-Ing. Dirk Wübben
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung

Examination format: Oral	Prüfungsleistung

Module courses

Course:	01-15-03-CCod(a)-V Channel Coding
Frequency: SoSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Wübben, Dirk, Dr.-Ing.
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung

Module 01-15-03 InS(a): Integrated Circuits
Integrated Circuits
MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Electives Space-ST	none

Learning content:

- Noise
- gm/Id Method
- Mismatch
- Two-pole opamps (OTA)
- Feedback

A list of references will be provided at the start of the semester.

Learning outcome / Competence:
After this course, students are able to:

- describe and characterize noise in electronics circuits,
- apply the gm/Id sizing method to design amplifier circuits for advance CMOS technologies,
- deal with process variations and mismatch,
- understand the frequency behaviour of amplifier circuits,
- understand and size compensation networks,
- use feedback to modify circuit characteristics.

Calculating student workload:
The module comprises two courses: a lecture and an exercise of 2 credit hours each.
Workload:

- Contact hours (lecture + exercise): 56 h (4 h x 14 weeks)
- Preparation, learning, exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180 h

Language of tuition: English	**Module leader:** Prof. Dr.-Ing. Steffen Paul
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module courses

Course:	01-15-03-InS(a)-V Integrated Circuits
Frequency: WiSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Paul, Steffen, Prof. Dr.-Ing.
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung

Module 01-15-03 WCom(a): Wireless Communications
Wireless Communications
MPO v. 04.12.2019

Module assignment:	**Recommended content-related requirements:**
• Electives Space-ST	Basics of Communication Technologies or equivalent

Learning content:

- Stochastic description of Mobile Radio Channels
- Time/Frequency Diversity Techniques
- Multi-Carrier-Systems (Filterbank Modulated, OFDM)
- Code-Division-Multiple Access (e.g. DS-CDMA)

A list of references will be provided at the start of the semester.

Learning outcome / Competence:
After this course, the students will be able to

- understand the fundamentals of mobile communication channels (Doppler-Spread, Delay-Spread, Angular-Spread, Frequency and time selectivity) as well as channel models (Rice/Rayleigh fading);
- explain the concept of communication diversity and related techniques;
- understand the principles of mapping information onto F/T-grids, to explain the ambiguity function, inter-carrier and inter-symbol-interference, to design multi-carrier-systems like OFDM, FBMC);
- understand the principle of separating signals in the code domain, to explain the design of (composite) spreading sequences, and to design CDMA receivers used in modern communication systems.

Calculating student workload:
The module comprises a lecture, exercises and laboratory exercises of 4 credit hours:

- Contact hours: 56 h (4 h x 14 weeks)
- Preparation, learning and exercises: 56 h (4 h x 14 weeks)
- Preparation for exam: 68 h

Total working hours: 180h

Language of tuition: English	**Module leader:** Prof.Dr.-Ing. Armin Dekorsy
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 6 / 180 hours	**Contact hours:** 4 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Written examination	Prüfungsleistung

Module courses

Course:	01-15-03-WCom(a)-V Wireless Communications
Frequency: SoSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Dekorsy, Armin, Prof.Dr.-Ing.
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung

Module 01-16-03 CM1: Climate Modelling: Part 1
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Electives Space-ST	none

Learning content:
- Types of Climate Models
- Energy Balance Models
- Radiative-Convective Models
- Components of Atmosphere Ocean General Circulation Models (GCMs)
- Fundamentals and representation in GCMs: atmospheric component
- Fundamentals and representation in GCMs: ocean and sea ice component
- Fundamentals and representation in GCMs: terrestrial component
- Steps in Model Formulation
- Introduction to the Coupled Model Intercomparison Project (CMIP)
- Results from GCMs: Climate change and climate warming
- Climate model evaluation with observations
- Frequently Asked Questions IPCC Assessment Reports
- Computational exercises with simple climate models
- Computation exercises in Python

Learning outcome / Competence:
Understanding simple climate models and General Circulation Models (GCMs), their results and limitations; basics in Python.

Calculating student workload:
- Contact hours (lecture and exercise): 28 h (block course 5 days)
- Preparation, learning + examples: 42 h
- Preparation for exam: 20 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. Veronika Eyring
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Written or oral examination

Module SpTe: Space Telescopes
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Electives Space-ST	Basic optics

Learning content:

Introduction of completed and planned space telescope missions, payloads and instruments

Possible space telescopes to be discussed are (i) Hubble Space Telescope, (ii) James Webb Space Telescope, (iii) Telescopes searching for Exo-planets such as Kepler or PLATO (iv) X-Ray telescopes such as Chandra, XMMNewton and Athena (v) Gamma-Ray Telescopes such as Fermi and INTEGRAL (vi) CMB observatories such as Planck (vii) LISA for the observation of gravitational waves

The aim is to discuss for each Space Telescope

- the science objectives of the mission,
- the mission scenario and operational aspects,
- the design of the telescope and requirements driving the design,
- the instruments and the underlying technologies.

References:

- Max Born, Emil Wolf: Principles of Optics

Learning outcome / Competence:

- Understand the basic aspects of science cases for several space telescopes
- Learn about mission scenarios for completed, ongoing and planned space telescopes operating in various regions of the electromagnetic spectrum
- Learn about operation principles and technological aspects of space telescope payloads

Calculating student workload:

- Contact hours (lecture + exercise): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 28 h (2 h x 14 weeks)
- Preparation for exam: 34 h

Total working hours: 90 h

Language of tuition: English	**Module leader:** Prof. Dr. rer. nat. Claus Lämmerzahl Dr. Sven Herrmann
Frequency: WiSe, once a year	**Duration:** 1 semester[s]
The module is valid since: SoSe 20	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Written or oral eamination

Module 01-29-03 Eng E: Engineering Ethics

Engineering Ethics

MPO v. 05.04.2017

Module assignment:	Recommended content-related requirements:
• Electives Space-ST	none

Learning content:

- Basic moral concepts
- Basic moral theories and values and their rationale
- Codes of Ethics (examples from Associations and Agencies)
- Case Studies from engineering
- Professional ideals, social and environmental responsibility

A list of references will be provided at the start of the semester.

Learning outcome / Competence:

After the course the students will be able to

- discuss and apply professional codes of ethics;
- distinguish normative from descriptive judgements;
- describe basic norms, values and ethical theories;
- determine conditions of responsibility;
- apply norms and theories to concrete cases in engineering and identify ethical issues at different stages.

Calculating student workload:

The module comprises one course: a lecture of 1 semester hours and an exercise of 1 semester hour.

Workload:

- Contact hours (lecture + exercise): 28 h (2 h x 14 weeks)
- Preparation, learning, exercises: 28 h (2 h x 14 weeks)
- Preparation of report and exam: 34 h

Total working hours: 90 h

Language of tuition:	Module leader:
English	Prof. Dr. Dagmar Borchers MA Björn Haferkamp
Frequency: SoSe, once a year	**Duration:** 1 semester[s]
The module is valid since: WiSe 17/18	**The module is valid until:** -
Credit points / Workload: 3 / 90 hours	**Contact hours:** 2 hours

Module examinations

Type of examination: Studienleistung	
Examination format: Announcement at the begin of the semester	Protokoll

Type of examination: Prüfungsleistung	
Examination format: Oral	Oral Examination

Module courses

Course:	01-29-03-EnE-V Lecture Engineering Ethics
Frequency: SoSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):**
Teaching method(s):	**Associated module examination:** Prüfungsleistung Studienleistung

Module 04-M30-CEM-SFI-1: On-Board Data Handling

On-Board Data Handling

MPO 05.04.2017

Module assignment:	**Recommended content-related requirements:**
• Electives Space-ST	none

Learning content:

On-Board Data Handling (OBDH) includes all aspects from payload data processing to mission critical control tasks. The OBDH system can in principle be considered as an embedded system that is subject to strong requirements with respect to reliability and availability in harsh environments with minimal or no maintenance.

The lecture considers various aspects from general mission scenarios and their impact on the OBDH system, examples for typical architecture, techniques for Failure Detection Isolation and Recovery (FDIR) and approaches for guaranteeing functional correctness of the hardware and/or software. Relevant standards are introduced.

A coarse table of contents reads as follows:

- Mission scenarios and implications on the OBDH system
- Tasks for OBDH
- Standards for space applications
- Architectures for OBDH system considered as embedded systems
- Hardware and software solutions
- Functional correctness

A list of references will be provided at the start of the semester.

Learning outcome / Competence:

The students should be able to explain typical scenarios for space missions, to understand and derive mission-specific requirements for the On-Board Data Handling (OBDH) system, to explain relevant standards, to explain and justify typical test approaches for OBDH systems, to understanding approaches for Failure Detection Isolation and Recovery (FDIR) and to have the ability to specify an OBDH system.

Calculating student workload:

The module comprises two courses: a lecture of 2 semester hours and an exercise of 1 semester hour.

Workload:

- Contact hours (lecture + exercise): 42 h (3 h x 14 weeks)
- Preparation, learning, exercises: 28 h (2 h x 14 weeks)
- Preparation for exam: 20 h

Total working hours: 90 h

Language of tuition:	**Module leader:**
English	Dr. Frank Dannemann
Frequency:	**Duration:**
SoSe, once a year	1 semester[s]
The module is valid since:	**The module is valid until:**
WiSe 17/18	-

Credit points / Workload: 3 / 90 hours	**Contact hours:** 3 hours

Module examinations

Type of examination: Modulprüfung	
Examination format: Announcement at the begin of the semester	Oral examination

Module courses

Course:	04-M30-CEM-SFI-1 On-Board Data Handling
Frequency: WiSe, once a year	**Are there parallel courses?** no
Language: English	**University teacher(s):** Dannemann, Frank, Dr.
Teaching method(s):	**Associated module examination:**

Module 01-29-03 PrSpa: Project
MPO 2020

Module assignment:	**Recommended content-related requirements:**
• Project & Master's Thesis Space-ST	none

Learning content:
The content is related to the respective area of research of the individual project. The project is an independent, autonomous, though supervised piece of scientific work. The project is carried out at the laboratories of the Institute of Environmental Physics, at the Insitutes of Electrical Engineering, at the Alfred-Wegener-Institute or at a cooperating institute or entity under individual instruction. The scientific investigations necessary for a research project are followed by the preparation of a written report. The topic of the project should - as a rule - be related to the topic of the subsequent Master’s Research (Master Thesis).

Learning outcome / Competence:
The students should be able to:

- transfer a scientific problem/question into an experimental and/or theoretical study,
- develop successful strategies for the planning and conducting of scientific studies,
- be able to summarize and present preliminary scientific results in a thesis paper.

Calculating student workload:
360 working hours

Language of tuition:	**Module leader:**
English	Prof. Dr. John P. Burrows Lecturers of Department 1 Physics/Electrical Engineering
Frequency: WiSe, SoSe	**Duration:** 1 semester[s]
The module is valid since: WiSe 20/21	**The module is valid until:** -
Credit points / Workload: 12 / 360 hours	**Contact hours:** -

Module examinations

Type of examination: Kombinationsprüfung

Examination format:	Written report and oral presentation thereof
Project report	

Module 01-29-03 ThsSpa: Masterarbeit (inkl. Kolloquium)
Master's Thesis
MPO 05.04.2017

Module assignment:	**Recommended content-related requirements:**
• Project & Master's Thesis Space-ST	Passing of all the mandatory exams of the module sections “Compulsory”, “Compulsory Elective” and the module “project”.

Learning content:
The students learn to:

- transfer a scientific problem/question into an experimental and/or theoretical study,
- develop successful strategies for the planning and conducting of scientific studies,
- conduct a critical evaluation, assessment and discussion of own scientific results,
- summarize and present scientific results in a thesis and in a colloquium.

Learning outcome / Competence:
The students are enabled to transfer a scientific problem/question into an experimental and/or theoretical study, to develop successful strategies for the planning and conducting of scientific studies and to summarize and present scientific results.

Calculating student workload:
Working hours: 900 h

Language of tuition:	**Module leader:**
English	N.N. Lectureres of Department 1 Physics/Electrical Engineering
Frequency: WiSe, SoSe	**Duration:** 1 semester[s]
The module is valid since: WiSe 17/18	**The module is valid until:** -
Credit points / Workload: 30 / 900 hours	**Contact hours:** -

Module examinations

Type of examination: Masterarbeit	
Examination format: Dissertation	Written dissertation

Type of examination: Kolloquium	
Examination format: Colloquium	Kolloquium