Hochschule für Technik Stuttgart

University of Applied Sciences

Master of Science Programme Photogrammetry and Geoinformatics

Module Descriptions

Examination Regulation Part B,
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Module Descriptions

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1. Program Objectives

The program aims to prepare for international management and development tasks in Photogrammetry and Geoinformatics. In particular, the social and ethical responsibility of students should be developed further by giving the students the opportunity to acquire the necessary key skills. Especially for sustainable development and careful management of the resources of a country an indispensable prerequisite is Geoinformation. It is both the technical, management related, as well as economic and ergonomic basic skills which are aimed to be improved.

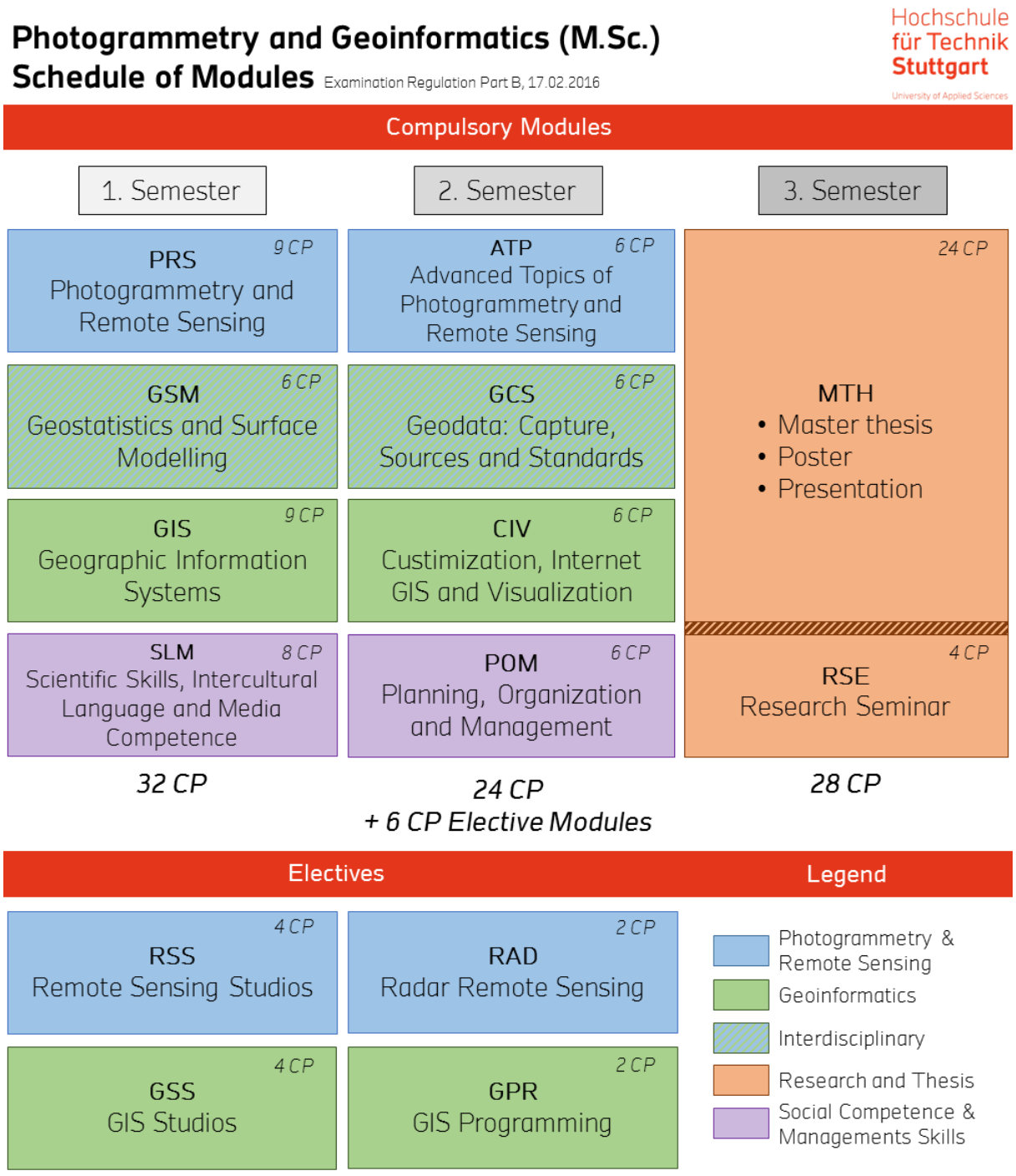
The intensive involvement of project work and case studies should develop on one hand the ability of self-organization. On the other hand, it should also encourage the ability to organize complex spatial projects and the organizations involved in processes to solve interdisciplinary problems in teams.

Special attention is given to the international and intercultural composition of the program participants, who have the opportunity to insert skills already acquired in their home countries in various disciplines and their previous professional experience into the course.

The following tables shows the general objectives and the competences linked to each of the modules.

General objectives	Competence - knowledge - professional skills - competences	Modules - knowledge - professional skills - competences
Awareness of the relevance of geodata for decision processes on different levels	– management of complex spatial relationships – basic competence in general management	GIS GCS PRS POM
Scientific based knowledge of basic theories and models	– basic technical competences – management of complex spatial relationships – solving of interdisciplinary problems	GIS PRS GSM ATP GCS CIV
Ability to implement the knowledge in practice	– case studies – project work – excursions	GIS PRS SLM POM/GSS/RSS
Preparation for an international and intercultural environment in an increasing globalized working environment	– learning and working in an international group – team work	Resulting from the composition of the group with different professional, national and cultural background. It is deepened by a number of case studies in different modules.
Preparation for further academic education	– actual directions of research – Scientific Writing, Proposal and Thesis presentation – Seminars – scientific presentation	ATP CIV Electives RSE Thesis

2. Schedule of Modules



Credit Points (CP) determined by the European Credit Transfer and Accumulation System (ECTS)
ECTS is a credit system designed to make it easier for students to move between different countries. In most cases, student workload ranges from 1,500 to 1,800 hours for an academic year, which means that one credit corresponds to 25 to 30 hours of work. It should be recognized that this represents the normal workload and that for individual learners the actual time to achieve the learning outcomes will vary.
http://ec.europa.eu/education/resources/european-credit-transfer-accumulation-system_en

3. Module Descriptions

Module	**Photogrammetry and Remote Sensing**
Module code:	**PRS**
Semester:	PG 1
Responsible for module:	Prof. Dr. Eberhard Gülch
Lecturer:	Prof. Dr. Gülch / Prof. Dr. Hahn / Braun
Relation to curriculum:	Compulsory module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/hours per week:	Lectures and Assignments: The central issues of Photogrammetry and Remote Sensing are presented in lectures. The lectures are accompanied by assignments with the aim to deepen the fundamental understanding of the mathematical principles, in particular, of Photogrammetry. The assignments, e.g., on spatial transformations, projection, orientation, and 3D restitution are based on MATLAB and are supported by tutorials or on up-to date Trimble Inpho Software. Knowledge of pre-processing and image classification in Remote Sensing can be deepened with the software ERMapper, Erdas Imagine and the software package for interactive self-directed learning provided with the text book by Mather. Photogrammetric Practice as training sessions: They are part of a two weeks lasting project work which is organised in group centred compact short lectures in the photogrammetric laboratory with the intention of working directly with a photogrammetric production system and prepare the students for working with the system without assistance. 6 SWS
Workload:	lecture: 75 h lab exercises: 15 h practice/workshop: 40 h self-study: 140 h (including 30 h for assignments) total: 270 h
Credit points:	9
Recommended prerequisite subjects:	MATLAB
Expected learning outcomes:	***Photogrammetry and Remote Sensing:*** On completion of this module, the learner will be able to: • Describe the theoretical principles underpinning the use of photogrammetric and remote sensing sensors • Select and justify appropriate systems and techniques, including the fusion of data from multiple sources for the provision of photogrammetric and remote sensing data sets • Advise on collection, processing, deliverables and management of photogrammetric and remote sensing data • Differentiate between the sources of error in photogrammetric and remote sensing technologies. • Apply and judge basic low-level image processing techniques • Translate complex photogrammetric and remote sensing problems into essential components and identify appropriate solutions • Source and access current research and best practice relating to photogrammetric and remote sensing systems and techniques

Module	**Photogrammetry and Remote Sensing**
	Photogrammetric Practice: On Completion of this module part, the learner will be able to • Understand the various photogrammetric data processing technologies. • Select an appropriate photogrammetric data collection technology to suit a particular application. • Collect reliable photogrammetric data. • Integrate processing options and deliverables to develop innovative solutions for a number of real-world scenarios. • Work effectively in a team situation. • Prepare and present professional reports and presentations.
Content:	1. Sensors of Photogrammetry and Remote Sensing 1a) Photogrammetric cameras systems, aerial and space photography. The metric camera (lens distortion, calibrated focal length, data of Interior Orientation) 1b) Remote Sensing sensors, optical sensors, Laser scanner, Radar 1c) Scanning principles 1d) Geometry: pointing principles, along-track, cross-track, flexible pointing 1e) General characteristics of remote sensing instruments, revisit time, spatial, spectral and temporal resolution, number of spectral bands 1f) Laser Scanning principles, pulsed laser, first and last pulse, imaging laser 1g) Radar, SAR, INSAR, basic processing principles 2. Photogrammetry 2a) Introduction and brief overview on the historical evolution of photogrammetry with an emphasis on the last 10 years 2b) Photogrammetric project planning (photo scale selection, camera types, accuracy in planimetry and height, model area, ground control, auxiliary data) 2c) The image-object relation as the basis of analytical solutions in photogrammetry 2d) Basic orientation procedures Exterior Orientation of a single image Relative and absolute orientation of photo pairs Aerial triangulation of image blocks, block adjustment 2e) Photogrammetric procedures for DEM and GIS data acquisition 2f) Orthophotos and ortho-mosaicing: basics, geometric radiometric adjustment, typical end product 3. Remote Sensing 3a) Basic Principles of Remote Sensing 3b) Definitions, Overall Remote Sensing process 3c) Electromagnetic radiation, electromagnetic spectrum, Energy sources and sensing 3d) Interaction of electromagnetic radiation with the atmosphere and with Earth-surface material 3e) Satellite images and visualization 3f) Pre-processing of remotely-sensed data, Removal of data errors 3g) Registration and geometric correction. 3h) Atmospheric correction, Sensor calibration 3i) Classification 3j) Concept of supervised and unsupervised classification

Module	**Photogrammetry and Remote Sensing**
	3k) Scatter plot and decision making 3l) Supervised classification, Parallelepiped, K-means, Maximum likelihood 3m) Unsupervised classification, K-means clustering, ISODATA algorithm 4. Photogrammetric Practice - Photogrammetric project work and training. Photogrammetric data can be collected using a variety of technologies. These data are subject to detailed processing flow-lines before deliverables are produced. Frequently, photogrammetric data are integrated with data from other sources and significant issues with respect to data compatibility need to be addressed so that reliable deliverables are produced. This intensive module is designed to integrate the knowledge acquired in Parts 1 and 2 of this module by applying the knowledge in an integrated project that simulates a real-world requirement. Learners work in teams from a project brief that is designed with specific technical requirements and represents a cutting-edge application. Solutions are learner-driven with academic staff acting as learning facilitators. A key element of the module is the necessity for cognitive flexibility and novelty in the development of solutions. In addition to the required technical skills, the learner will develop advanced problem-solving skills, team-working skills, and written and oral presentation skills. Detailed contents: 4a) Photogrammetric data processing, key modules and their relations, application areas. 4b) Digital automatic aerial triangulation: preparation, digital image matching procedures, GPS/INS data, analysis. 4c) Digital Photogrammetric Stereo Workstation: hardware, viewing system, measurement system, feature extraction: vector information, break-lines for automatic digital terrain model extraction, connection to CAD systems 4d) Automatic generation of terrain models: image matching procedures, analysis 4e) Airborne LIDAR data: Filtering and classification of data, editing and verification 4f) Semi-automatic building extraction from imagery and point clouds: matching procedures, measurement of simple and complex building structures and their analysis 4g) Orthophoto production and ortho-mosaicing: handling of image blocks, geometric radiometric adjustment and tools, examining typical problems in different data sets
Study assessment and Examination:	66 % written examination 22 % Professional individual presentation: Detailing the key elements of the placement and the learning outcomes achieved. 12 % Final student report: Reviewing the learning outcomes achieved through reflection (80% group-based, 20% individual-based) A prerequisite for admission to the written examination is the acceptance of the specified assignments.
Forms of media:	A wide range of multi-media materials help to enrich the learning experience, from paper based resources to state-of-the-art computer mediated learning and communication applications.
Literature:	**Photogrammetry** Chris McGlone with Edward Mikhail and James Bethel: Manual of Photogrammetry (5th Edition), American Society for

Module	**Photogrammetry and Remote Sensing**
	Photogrammetry and Remote Sensing (ASPRS), Bethesda, USA, 2004. Kraus, K.: Photogrammetry, Volume 1, Fundamentals and standard processes, Dümmler Verlag, 1990. Kraus, K.: Photogrammetry, Volume 2, Advanced methods and applications, Dümmler Verlag, 1997. Schenk, T.: Digital Photogrammetry, Volume 1, Background, fundamentals, automatic orientation procedures, TerraScience, 1999. Wolf, P., Dewitt, B.: Elements of Photogrammetry with Applications in GIS. Mc Graw Hill, 3rd edition, 2000. **Remote Sensing** Mather, P.M. and Koch, M. (2011): Computer Processing of Remotely-Sensed Images: An Introduction. Fourth Edition, Wiley-Blackwell, 504 pp. Sabins, F. (1997): Remote sensing: principles and interpretation, third edition, W.H. Freemann company, New York. Lillesand, T.M., Kiefer, R.W., and Chipman, J.W. (2004): Remote Sensing and Image Interpretation, John Wiley & Sons, New Yor, fifth edition Tempfli, K., Kerle, N., Huurneman, G.C. and Janssen, L.L.F. (eds., 2009): Principles of Remote Sensing - An introductory textbook, ITC Educational Textbook Series, fourth edition. www.itc.nl/library/papers_2009/general/PrinciplesRemoteSensing.pdf **Further sources** http://www.grss-ieee.org/recent-books-in-geoscience-and-remote sensing/ For the project work and training: Manuals and Tutorials for INPHO's Photogrammetric Workstation (SW and HW) with MATCH-AT, MATCH-T DSM, OrthoMaster, OrthoVista, inJECT, SCOP++, DTMaster, Building Generator Remote Sensing Tutorials: www.nasa.gov http://www.ccrs.nrcan.gc.ca/www.hawai.edu http://speclib.jpl.nasa.gov/ ERMapper, ErdasImagine Tutorials (Geocoding and classification of aerial and satellite data) eCognition Tutorials (Object based image classification) Hand-outs: Manuscript or PDFs from PowerPoint of lectures Exercise notes.
Software:	For the project work and training: INPHO's Photogrammetric Workstation (SW and HW) with MATCH-AT, MATCH-T DSM, OrthoMaster, OrthoVista, inJECT, SCOP++, DTMaster and Building Generator ERMapper, Erdas Imagine (Geocoding and classification of aerial and satellite data) eCognition (Object based image classification)

Module	**Geographical Information Systems**
Module code:	GIS
Semester:	PG 1
Responsible for module:	Prof. Dr. Schröder
Lecturer:	Singh, Prof. Dr. Schröder
Relation to curriculum:	Compulsory module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/hours per week:	Each topic is introduced by a lecture which seeks to identify the main issues in order to convey an understanding of the relative importance of different issues in GIS applications. The module is taught in a student centred manner; case studies and examples of best practice are used to stimulate class discussions and group sessions. It is expected that for standard issues like database handling or using SQL, the student uses the recommended online tutorials (CAL). (4SWS) The theoretical part of the lectures is supported by hands-on lab exercises; the students have to work out a number of group assignments including a poster presentation. (2 SWS) The GIS part is rounded off by two weeks' intensive project work**.** Each student has to work on at least two projects, which he or she can select from a catalogue of topics according to his or her preferences and background. (2 SWS)
Workload:	lecture: 60 h lab exercises: 30 h practice/workshop: 40 h self-study: 140 h (including 60 h for assignments and project presentation) total: 270 h
Credit points:	9
Recommended prerequisite knowledge:	Basic knowledge of database systems and module GIS
Expected learning outcomes:	On successful completion of this module, students should be able to: • discuss the difference of relational and object-relational database systems and their impact to spatial data modelling. • synthesize and implement data models combining spatial and non-spatial data tasks with respect to different application domains on the conceptual, logical, and physical level. • analyze spatial and non-spatial data using SQL. • discuss different geodetic reference systems and their transformation/conversion with respect to their relevance to GIS, Remote Sensing and Photogrammetry. • apply and evaluate the results of different transformations/conversions • explain the fundamental concepts of GIS (raster vs. vector representation, layers and objects, dimensions, topology, classification of GIS) • apply workflows for secondary data acquisition and data analysis in order to receive consistent spatial data.

Module	**Geographical Information Systems**
	• design and arrange complex analysis workflow for spatial data for solving real world problems. • apply cartographic grammar to present analysis results e.g. on thematic maps
Content:	Part 1: Databases and spatial databases • Relational and object-relational database systems • High-level conceptual data models (Entity-Relationship model and UML). • The Structured Query Language (SQL) for non-spatial and spatial data. • Access methods for spatial access methods and spatial indexing. Part 2: Spatial Referencing • Spatial Reference Systems, Geodetic Datums and Datum Transformations • Map Projection Part 3: GIS • Review of GIS fundamentals • Raster data within a vector GIS • Secondary data acquisition for GIS (image geo-referencing, on-screen digitizing and CAD data) • Spatial analysis of vector and raster data • Linear referencing and dynamic segmentation • Thematic mapping and output
Study assessment and Examination:	66 % written examination 12 % presentation of project work including its defence 22 % assignments
Forms of media:	A wide range of multi-media materials help to enrich the learning experience, from paper based resources to state-of-the-art computer mediated learning and communication applications.
Literature:	Thomas Connolly and Carolyn Begg: Database Systems: A Practical Approach to Design, Implementation, and Management. Pearson, 6th Edition, 2014. Philippe Rigaux, Michel Scholl, Agnès Voisard: Spatial Databases with Application to GIS. Academic Press, 2002. Wolfgang Torge, Jürgen Müller: Geodesy. Walter de Gruyter, 2012. Burrough, McDonnell, Lloyd: Principles of Geographical Information Systems. Oxford University Press, 2015. Longley, Goodchild, Maguire, Rhind: Geographic Information Science and Systems. John Wiley, New York, 2015 (selected chapters) Krygier, J. and Wood, D.: Making Maps: A Visual Guide to Map Design for GIS. The Guilford Press; Second Edition, 2011 Wilpen L. Gorr and Kristen S. Kurland: GIS Tutorial 1: Basic Workbook, ESRI Press, 2013 David W. Allen: GIS Tutorial 2: Spatial Analysis Workbook, ESRI Press, 2013 David W. Allen and Jeffery M. Coffey: GIS Tutorial 3: Advanced Workbook, ESRI Press 2013 Divers GIS links, e.g.

Module	**Geographical Information Systems**
	Richard K. Burkard et al: Geodesy for the Layman. NOAA. http://www.ngs.noaa.gov/PUBS_LIB/Geodesy4Layman/toc.htm Huismann, de By: Principles of Geographic Information Systems. http://www.itc.nl/library/papers_2009/general/PrinciplesGIS.pdf http://www.opengis.org/techno/abstract.htm, e.g. Topic 2 - Spatial Reference Systems, Topic 8 - Relations Between Features Course material Recommended online tutorials for MS-Access: • http://www.dealing-with-data.net/index.html • http://www.fgcu.edu/Support/access2013.html • https://support.office.com/en-us/article/Access-2013-training-courses-videos-and-tutorials-a4bd10ea-d5f4-40c5-8b37-d254561f8bce?ui=en-US&rs=en-US&ad=US Recommended online tutorials for SQL: • http://sqlcourse.com • http://www.w3schools.com/sql/default.asp
Software:	Microsoft Access/Oracle/PostgreSQL ArcGIS ESRI/QGIS

Module	**Geostatistics and Surface Modeling**
Module code:	GSM
Semester:	PG 1
Responsible for module:	Prof. Dr. Rawiel
Lecturer:	Prof. Dr. Rawiel/ Prof. Dr. Lehmkühler
Relation to curriculum:	Compulsory module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/hours per week:	The teaching approach of this mathematics-based module is a mix of lectures (2SWS), tutorials and computer assisted exercises (2SWS). As a programming tool MATLAB will be used. In a number of assignments, the routines developed during contact hours are applied to typical use cases. In addition, the commercial software package SCOP/Trimble will be used. This part conducted with a high amount of self-directed learning and exploration.
Workload:	lecture: 30 h lab exercises: 30 h self-study 120 h (including 24 h for assignments) total: 180 h
Credit points:	6
Recommended prerequisite knowledge:	Basic mathematical principles of Analysis, Matrix Algebra
Expected learning outcomes:	The module aims at broadening the knowledge of the students in the field of Geostatistics and Surface Modelling together with strengthening their mathematical competence to analyze data and generate a variety of models, in particular, surface models to enable a better understanding for spatially distributed data. On successful completion of this module, students should be able to: • Apply the essential mathematical representations for scenes with points and surfaces and corresponding geometrical observations. • List the properties of the most important kinds of linear and linearized models used for adjustment and hypothesis testing applied to observational data. • List the properties of the most important interpolation methods. • Select corresponding models and data to be recorded in typical application fields of Photogrammetry and Data Acquisition for Geoinformatics. • Analyze spatial correlations of different sets of data • Setup aggregations of given software components using a universal mathematical problem handler (like MATLAB) to achieve evaluation or research tasks with limited but reasonable effort. • Analyze the theoretical background of commercial software solutions in Photogrammetry and Data Acquisition for Geoinformatics and Prepare practical use of them.
Content:	First part: Statistical Background • Matrix algebra and analysis

Module	**Geostatistics and Surface Modeling**
	• Statistical concepts and definitions • Uncertain quantities • The concept of a random variable • The m-dimensional random vector • Common density functions • Propagation of Variances and Covariance • Adjustment theory • The weighted least squares method • Robust estimation • Systematic errors, their effects and compensation • Test theory Second part: Surface Modelling and Geostatistical Interpolation • Basics of Interpolation Non-statistical and statistical approaches, local and global influence, artefacts, profile and terrain applications, Inclined plane vs. General Polynomial and Radial Base Function approaches, Statistical description of smoothness • Introduction to Surface Modelling • Triangular Irregular Networks (TINs), with Delaunay triangulation, • Regular Grid DTMs and hybrid DTM's • Quality Aspects (estimation of standard deviations) • DTM Applications (profiles, isolines, volumes, construction plans, visibility maps, ...) • Geostatistical Interpolation using Kriging Projects in the second part cover: • Experience and report on a commercial DTM software package (e.g. SCOP of TRIMBLE GmbH, Stuttgart/Germany) Data Input, point density and morphologic information, parameter settings, quality evaluation, interactive correction of the interpolation result. • Use of ArcGIS Geostatistical Analyst for Kriging Interpolation
Study assessment and Examination:	Written examination 80 % Assignments 20 %
Forms of media:	-
Literature:	Course material: Lecture Notes Karl-Rudolf Koch: Parameter estimation and hypothesis testing in linear models. Berlin; Heidelberg: Springer, 1999 John R Taylor: An introduction to error analysis – the study of uncertainties in physical measurements ISBN 093570275X Mikhail: Observations and least squares ISBN 0700224815 Zhilin Li et al.: Digital Terrain Modelling: Principles and Methodology. CRC Press, 2005 George Casella, Statistical Interference (The Wadsworth & Brooks/Cole Roger L Berger: Statistics/Probability Series) IEP New York ISBN 0534119581

Module	**Geostatistics and Surface Modeling**
	Launer, Wilkinson: Robustness in Statistics Academic Press ISBN 0124381502 H Rieder (ed): Robust Statistics Springer ISBN 0387946608 Charles D. Ghilani: Adjustment Computations: Spatial Data Analysis, John Wiley & Sons Ltd 2010
Software:	MATLAB, SCOP/Trimble, ArcGIS Geostatistical Analyst

Module	**Scientific Skills, Intercultural, Language and Media Competence**
Module code:	SLM
Semester:	PG 1
Responsible for module:	Prof. Dr. Franz-Josef Behr
Lecturer:	Prof. Dr. Behr / Mamier / Singh / Bax / Horlacher / Knaus / Madew / Salazar
Relation to curriculum:	Compulsory subject MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/hours per week:	The module covers a range of soft skills ranging from scientific communication and presentation, intercultural and language competencies, up to the competent use of modern media. It provides cross-sectional skills and understanding needed for carrying out scientific work as well as for entering a professional career. The basic scientific skills on the Master level include vocal presentation techniques, and scientific principles on reading, writing and working. The teaching approach is a very interactive one: Samples of scientific presentations are analysed and discussed, impulse lectures are given, and examples of scientific work are outlined by case studies. Media competence is achieved in lectures with practical exercises (partially group work). As a project, each student has to prepare and give a presentation to verify the gained presentation skills. The student himself has to guide the discussion with the audience. Feedback is given by the lecturers and students after the presentation. Regarding the use of the Internet the different ways of professional communication and presentation are discussed. Students are taught by lectures and practical exercises to present oneself and own competencies with standard technologies, i.e. HTML5, CSS, and JavaScript. (5 SWS) The objective of the intercultural training part is to handle diversity in a group of students who will work together for 18 months in the course program. Thus this part is organized as a weekend seminar at the beginning of each new batch. Cultural diversity will be discussed by simulated activities, case studies, critical incidents, role playing, lecture input, group discussions. To work on a thesis project externally, to do an internship, or to start a professional career in a context where English or the mother tongue is not the main language, good language skills are necessary. This holds true for international students as well for German students. Thus a foreign language is taught in a modern communicative manner using this language itself as a mean for communication. By its initiation, the learner moves to the center of the teaching. (2 SWS)
Workload:	Part Scientific Skills and Media Competence: Contact hours: 75 h, Self-study: 85 h Part Language: Contact hours :30 h, Self-study: 30 h Part Intercultural Competence: weekend seminar 20 h Total : 240 h
Credit points:	8

Module	**Scientific Skills, Intercultural, Language and Media Competence**
Recommended prerequisite subjects:	-
Expected learning outcomes:	On successful completion of this module, students should be able to: • critically review the ethical principles of research. • assess different forms of scientific publication and knowledge exchange with means of Internet technology. • do a profound literature search and review, embed their own work into a scientific context and present their results adequately. • set up the structure of any form of scientific presentation or scientific publication including electronic methods of scientific presentations and publishing. • critically listen to a scientific presentation or read a written report, understand its purpose and evaluate its relevance for their own scientific work. • prepare and deliver an oral presentation including the effective use of the voice, eye contact, posture, gestures, and enthusiasm. • discuss the theoretical bases of intercultural communication discipline and the rationale behind intercultural learning. • adapt to a multi-cultural workplace. • communicate in a foreign language in addition to the mother tongue, and the language used as medium of instruction. • master basic technologies for Internet presentation. • apply the design principles and usability criteria for Internet presentation to present oneself and scientific results using standard technologies and to active participation in scientific information exchange.
Content:	Part1: Scientific Skills and Web Media • Scientific working principles and ethics • How to prepare and deliver an oral presentation including the effective use of the voice, eye contact, posture, gestures, enthusiasm and visual aids • Writing Scientific Papers (Literature Research, Structure, Literature Quotes, Good and Bad practice, etc.) • Basic knowledge about web based presentation: Social media, professional networking, information interchange in mailing lists, forums, and working groups • Practical experience about web site implementation using HTML5, JavaScript, and CSS Part 2: Intercultural Training (at the beginning of the course) • What is culture? Understanding concepts of interculturalism, multiculturalism, diversity, cultural programming, cultural Perception. • Skills and Processes: Perceiving; Communicating; Managing Cultural Conflict; Coping with Diversity Part 3: Language Experience (parallel course)

Module	**Scientific Skills, Intercultural, Language and Media Competence**
	• German Course (for those who do not speak German) • Topics from Ethics or Sustainability coursework or comparable programs
Study assessment and Examination:	Scientific and Media Skills Presentation Project 35 % Written examination: 65 % Preparatory Assessment in Language course and attendance intercultural training
Forms of media:	Lectures, workshops, simulation games etc.
Literature:	Baeza-Yates, R. & Berthier Ribeiro-Neto, B. (2010): Modern Information Retrieval. Addison Wesley, 944 pp. Rowland, R.: The creative Guide to Research. Career Press 2000. Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams (2008): The Craft of Research. University of Chicago Press; Third Edition. Ben Frain (2015): Responsive Web Design with HTML5 and CSS3 - Second Edition. Packt Publishing Steve Krug (2013): Don't Make Me Think: A Common Sense Approach to Web Usability. New Riders; 3rd revised edition Shea, Dave, Holzschlag , Molly E. (2005): The Zen of CSS design: visual enlightenment for the Web. Peachpit Press Eric A. Meyer (2006): CSS: The Definitive Guide. O'Reilly Media; 3 edition Hofstede, G., Hofstede, G. (2010): Cultures and Organizations: Software of the Mind. Third Edition, McGraw Hill, 2004 Stephen M. Croucher, Mélodine Sommier and Diyako Rahmani (2015): Intercultural communication: Where we've been, where we're going, issues we face. Communication Research and Practice, 2015, Vol. 1, No. 1, 71–87 Bob Dignen (2011): 50 Ways to Improve Your Presentation Skills in English. Summertown Publishing. Orient Black Swan Web Resources http://www.w3.org/ http://www.csszengarden.com/ http://www.w3schools.com/
Software:	HTML Kit Tools (http://www.htmlkit.com/, campus license)

Module	**Advanced Topics in Photogrammetry and Remote Sensing**
Module code:	ATP
Semester:	PG 2
Responsible for module:	Prof. Dr. Michael Hahn
Lecturer:	Prof. Dr. Hahn / Prof. Dr. Gülch
Relation to curriculum:	Compulsory subject MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/SHW:	Teaching in this module is composed of teaching through lectures and demonstrations and inquiry-based learning that focuses on student investigations and hands-on learning. The advanced issues of Digital Photogrammetry and Remote Sensing are presented in lectures; the lectures are accompanied by lab assignments and homework assignments. The assignments aim to foster investigative self-learning and team-learning and deepen the understanding of advanced photogrammetric and remote sensing techniques. 4 SWS
Workload:	contact hours 60 h self-study 120 h
Credit points:	6
Recommended prerequisite modules:	Photogrammetry and Remote Sensing, Geostatistics and Surface Modelling
Expected learning outcomes:	On successful completion of this module, students should be able to • develop, experiment and critically analyse image feature extraction and matching procedures for different application areas in Digital Photogrammetry and Computer Vision • select and employ sophisticated techniques of data processing in Remote Sensing • apply principles of colour transformations to solve image data fusion tasks • analyse and propose solutions for image and point cloud classification and accuracy assessment • examine the advances in image classification • analyse R&D developments in cartographic feature extraction from photogrammetric imagery • propose design strategies for automation tasks in Digital Photogrammetry and Remote Sensing • recognise leading edge research topics in Digital Photogrammetry and Remote Sensing, judge their importance for various practical applications and debate about pro´s and con´s • evaluate current key research and development issues of Digital Photogrammetry and Remote Sensing and their applicability to practice

Module	**Advanced Topics in Photogrammetry and Remote Sensing**
Content:	**Advanced Topics in Photogrammetry** Feature extraction, points, lines and regions (Interest -operators for extracting prominent points, detection, localisation, and classification) Image matching (Area based matching, feature based matching, relational matching, semi-global matching, search processes, image pyramids and scale space, coarse-to-fine processing, robust estimation in matching) Automated aerial triangulation (concepts, solutions, analysis) Automatic DTM and DSM acquisition (solutions, limitations, quality checks, interactive control) True-orthophoto Automated building, road and vegetation extraction from imagery and point clouds **Advanced Topics in Remote Sensing** Colour (Colour and the spectrum, additive and subtractive colour mixing, colour transformations, selective absorption of light) Spectroscopy (continuum vs. resonance bands, influences on spectra, spectra of common earth-surface materials) Image transformation and Indices (principal component analysis, rationing, vegetation indices) Separability analysis (linear discriminant analysis) Advances in image classification: from pixel to object, from hard to soft classifiers, from parametric to non-parametric classifiers Parametric and non-parametric classifiers (maximum likelihood, artificial neural networks, support vector machines) Classification of point clouds (point cloud classification concepts, morphological filtering, morphological reconstruction) Post-classification processing (filtering, methods for combining classifiers) Classification accuracy assessment (reference source, sampling strategies, confusion matrix) Each topic is related to applications, e.g. color to pan-sharpening of images, spectroscopy to hyperspectral data processing, indices to vegetation mapping, etc.)
Study assessment and Examination:	written examination
Forms of media:	Lecture notes, made available by learning management system Moodle e-learning text book: Principles of Remote Sensing, Tempfli et al. (cf. literature) tutorial: Fundamentals of Remote Sensing, CCRS
Literature:	Text books: Chris McGlone with Edward Mikhail and James Bethel.: Manual of Photogrammetry, 5th edition, American Society for Photogrammetry and Remote Sensing Bethesda, USA, 2004. Schenk, T.: Digital Photogrammetry, Volume1, TerraScience, 1999. Wolf, P., Dewitt, B.: Elements of Photogrammetry with Applications in GIS. Mc Graw Hill, 3rd edition, 2000.

Module	**Advanced Topics in Photogrammetry and Remote Sensing**
	Gülch, E., Kaartinen, H., Hyppä, J.: Quality of Buildings Extracted from Airborne Laserscanning Data – Results of an Empirical Investigation on 3D Building Reconstruction. In Shan/Toth (Eds.) Topographic Laser Ranging and Scanning: Principles and Processing. Taylor & Francis / CRC Press 2009. Mather, P.M. and Koch, M.: Computer Processing of Remotely-Sensed Images: An Introduction. Fourth Edition, Wiley-Blackwell, 2011. Sabins, F.: Remote sensing: principles and interpretation, 3rd edition, W.H. Freemann, 1997. Lillesand, T.M., Kiefer, R.W., and Chipman, J.W: Remote Sensing and Image Interpretation, 6th edition, John Wiley Book series, 2007. Tempfli, K., Kerle, N., Huurneman, G.C., and Janssen, L.L.F. (eds., 2009): Principles of Remote Sensing - An introductory textbook, ITC Educational Textbook Series, 4th edition. free download www.itc.nl/library/papers_2009/general/PrinciplesRemoteSensing.pdf Congalton, R. G. and K. Green. 1999. Assessing the accuracy of remotely sensed data: Principles and practices. Lewis Publishers, Boca Raton. *Proceedings*: International Archives of Photogrammetry and Remote Sensing, http://www.isprs.org/publications/archives.aspx *Scientific journals* Remote Sensing of Environment, ISPRS Journal of Photogrammetry and Remote Sensing, Photogrammetric Record, IEEE Transactions on Geoscience and Remote Sensing, IEEE Applied Earth Observations and Remote Sensing, Remote Sensing, International Journal of Remote Sensing, Remote Sensing Letters *Tutorial* on Fundamentals of Remote Sensing prepared by CCRS (Canada Centre for Mapping and Earth Observation) http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9309 *Course material:* Manuscript of lectures, Hand-outs
Software:	INPHO's Photogrammetric Workstation (SW and HW) with MATCH-T DSM, inJECT, DTMaster and Building Generator Agisoft PhotoScan Erdas Imagine eCognition MATLAB (educational license) is available for all students with a huge number of toolboxes. They can be used to implement and investigate algorithmic developments.

Module	**Customization, Internet GIS, Visualisation**
Module code:	CIV
Semester:	PG 2
Responsible for module:	Prof. Dr. Franz-Josef Behr
Lecturer:	Prof. Dr. Behr / Prof. Dr. Coors
Relation to curriculum:	Compulsory subject MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/SHW:	Each topic is introduced by a lecture which seeks to identify the main issues in order to convey an understanding of the relative importance of the technical issues to the customization of software tools, Internet GIS and Visualization methods related to geomatics. The lectures are accompanied by guided practices and hands-on workshops in the computer lab. Students are expected to use the recommended online tutorials for the standard issues of programming language used (4 SWS).
Workload:	contact hours 60 h self-study 120 h
Credit points:	6
Recommended prerequisite modules:	Basic knowledge of a programming languages, XML/HTML, CSS, JavaScript Knowledge of GIS and geospatial data processing and modelling
Expected learning outcomes:	On successful completion of this module, students should be able to: • list different customization approaches in modern system architectures and apply them, • explain how geospatial applications works in the Internet and judge different approaches, applications, interfaces, and architectures to implement such applications, • set up a multi-tier Internet / Intranet applications based on standard software components, • list which components are required in modern visualization techniques and integrate them into existing workflows, • set up a web-based 3D-visualization based on OGC standards.

Module	**Customization, Internet GIS, Visualisation**
Content:	Part 1: Customization • Customizing a graphical user interface • Adding tools and Add-Ins • Visual geoprocessing modelling Part 2: Web Mapping and Internet GIS • client / server and multi-tier architectures • relevant protocols for client / server communication (HTTP, FTP, AJAX) • client-side and server side technologies • administration of Web servers (like Apache) • Map Servers and Mapping Clients • Server side programming and geo-database integration • Internet Mapping in the Web 2.0 context Part 3: Visualization • Computer Assisted Cartography • data aspects, 3D data formats (X3D, CityGML) • simplification of terrain models • visualization from urban and regional model to digital globes
Study assessment and Examination:	Written examination As a prerequisite for the written exam, a number of assignments have to be prepared.
Forms of media:	Lecture, Project based Learning, Moodle, video tutorials
Literature:	Peng, Z., Tsou, M. (2003): Internet GIS: Distributed geographic information services for the internet and wireless networks. Wiley, New Jersey. Darie, C., Bucica, M., Chereches-Toşa, F., Brinzarea, B.: AJAX and PHP: Building Responsive Web Applications, Packt Publishing, 2005, ISBN 13: 978-1-904811-82-4 Tyler M. (2005): Web Mapping Illustrated O'Reilly Media, ISBN: 0596008651 Li, S., Dragicevic, S. & Veenendaal, B., Eds. (2011): Advances in Web-based GIS, Mapping Services and Applications. ISPRS Book Series, ISBN 9780415804837 Fu, P. & Sun, J. (2011): Web GIS – Principles and applications. ESRI Press, Redlands, CA Masser I., Crompvoets, J. (2015): Building European Spatial Data Infrastructures. Environmental Systems Research Institute Inc., U.S.; Auflage: 3 (9. Februar 2015) Web3D conference proceedings (selected papers) Course material • Internet GIS: Client Side Technologies (HFT Stuttgart), Server Side Technologies (HFT Stuttgart) • Online tutorial x3dom and geovisualization (Fraunhofer IGD / HFT Stuttgart)
Software:	• ESRI ArcGIS • Apache HTTPD, PHP, MySQL, JavaScript, d3js, OpenLayers

Module	**Geodata: Capture, Sources and Standards**
Module code:	GCS
Semester:	PG 2
Responsible for module:	Prof. Dr. Lehmkühler
Lecturer:	Prof. Dr. Huep, Prof. Dr. Lehmkühler, Prof. Dr. Schröder
Relation to curriculum:	Compulsory subject MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/SHW:	Each topic is covered by a lecture addressing the main issues and their impact on GIS related processes. The lectures are designed to stimulate further self-studies based on provided and recommended (printed and electronic) material. Emphasis is put on providing cornerstones within which the student is enabled and encouraged to identify, develop and assess suitable process chains for various applications. Especially the GIS format/interface issues will become more evident by appropriate, tutored assignments, using recent CAD, GIS and Web-GIS software solutions. SDI's subsume the preceding GIS contents as de-facto or planned ways to use geodata in future. Because the core metadata topic is difficult but essential it is broadly introduced and justified, discussed in detail and trained in a supervised assignment. Students are motivated to create own ideas for business concepts. (5 SWS)
Workload:	contact hours 75 h self-study 105 h (including 36 h for assignments)
Credit points:	6
Recommended prerequisite modules:	GIS with GIS-Practice
Expected learning outcomes:	On successful completion of this module, students should be able to: • Value and Illustrate direct Geo-referencing, • Assess suitable positioning methods (especially GNSS) and differentiate their observables, setups, and error budgets, • Describe the workflows and parameters necessary in data acquisition and data analysis, in order to receive consistent geometric data, • design suitable positioning methods for direct geo-referencing purposes depending on the use of data, • Differentiate the structure and content of geodata formats in all levels of detail, • State the differences between CAD- and GIS formats, • Differentiate exchanging data and interoperability, • Apply standard methods to transform data from one data model into another one, • Define the scope of OGC and ISO work as given in the different standards, • Value and Illustrate OGC Web Services as a basic technology for spatial data infrastructures, • Design a data distribution and data retrieval infrastructure,

Module	**Geodata: Capture, Sources and Standards**
	• Value the need for metadata with suitable degree of detail, • Distinguish the relevant standardization initiatives with their underlying technical concepts and business ideas, • design suitable structures for state, regional or local geodata infrastructures, • Apply typical business concepts to geodata services.
Content:	Topic 1: Data Capture and Geo-Referencing: • Positioning: Observables (distances, angles, accelerations etc.) and representation of objects (by points, lines and surfaces) in various levels of accuracy. • Surveying and Positioning Methods: Polar (total stations, laserscanners), satellite-based (GNSS) and dynamic (inertial) systems. Other positioning techniques (mobile phone networks, hot spots etc.). Special emphasis put on Global Navigation Satellite Systems (GPS, GLONASS, Galileo), their enhancements (EGNOS, WAAS) and ground network services. Various GPS positioning modes, such as GPS, DGPS, PDGPS, A-GPS to be discussed. • Error Budgets in Positioning: Gross, systematic and random errors; probabilities and related confidence regions. Kinematic modeling of moving measurement platforms. • Geodetic Reference Systems: Their impact on the use of various positioning methods, e.g. GPS satellite observations (WGS 84) not complying with national datums, height impacts on GPS results, etc. Boresight alignment and direct geo-referencing in photogrammetry and LIDAR applications. Topic 2: GIS Formats and Interfaces In the introduction the economic importance of using data from other institutions and systems is explained as well as the differences between exchanging data and using data in an interoperable way. The simple feature specification of the OGC is taken as a base to compare other formats and structures. Main subjects of this lecture are the discussion of common data formats like • Data Exchange Format DXF (AutoCAD), • ArcView Shape (ESRI), • Geographic Markup Language (GML), and the interoperable use of data based on Web Services (especially WMS and WFS) and on a common database format like Oracle SDO_Geometry. Main topics of assignments are related to these subjects: Exchanging data between different systems using the on board interfaces as well as the Feature Manipulating Engine (FME) as an independent transformation software. Thereby students also can see the importance of knowledge in spatial coordinate systems. Interoperable use of data and combining local data with Web Services. Topic 3: Spatial data Infrastructures

Module	**Geodata: Capture, Sources and Standards**
	Metadata: Criteria about data, Quality: Metadata Content Standards and Profiles (CSDGM, ISO 19119), Metadata software: editors, checkers, search engines, gazetteer and thesauri services Service Oriented Architectures Spatial Data Infrastructures the concept of OGC service definitions regarding SDI's: Data, Process, Library and Human Interface Services, Sensor integration Proprietary and Non-Proprietary software for SDI's The Geodata Market: Private, Business and Governmental actors, Geodata Business
Study assessment and Examination:	80% written examination 20 % assignments / project
Forms of media:	-
Literature:	Course material and white papers. Descriptions on web sites of various developers and suppliers in the fields of surveying, GIS and CAD systems Smith, J.R.: Introduction to Geodesy, The History and Modern Concepts of Geodesy. John Wiley & Sons. Burkard, R.K. et al: Geodesy for the Layman. NOAA. Seeber, G.: Satellite Geodesy – Foundations, Methods and Applications. Walter de Gruyter. OGC Specifications: - Simple Feature Specification, - Geography Markup Language (GML), - Web Map Service (WMS), - Web Feature Service (WFS) and others http://www.opengeospatial.org/ Lake, R. et al: Geography Mark-Up Language (GML), John Wiley & Sons White Papers of ESRI and Autodesk for ArcView Shape and DXF Burrough, P.A.; McDonnell, R.A.: Principles of Geographical Information Systems. Oxford University Press, 1998, reprinted 2000 (Chapters about Data Quality) FGDC: The Federal Geographic Data Committee's Website http://www.fgdc.gov/standards/, checked 2016 Nebert, D. (Editor): Global spatial data infrastructure. Developing Spatial Data Infrastructures: The SDI Cookbook, 25 January 2004, p.8. Ordnance Survey: Future trends in geospatial information management: the five to ten year vision, 2012
Software:	ArcGIS, FME, Autodesk MAP

Module	**Planning, Organisation and Management**
Module code:	POM
Semester:	PG 2
Responsible for module:	Prof. Dr.-Ing. Dieter Uckelmann
Lecturer:	Prof. Dr.-Ing. Dieter Uckelmann / Wilfer
Relation to curriculum:	Compulsory module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/SHW:	Lecture, student seminar, case studies, presentations, tutorials, discussions and assignments, in order to provide an in-depth sight into general business and marketing processes. Additionally, each student has to carry out and present an individual business plan, based on his/her personal background and interest. (5 SWS)
Workload:	contact hours: 75 h self-study: 105 h (including 30 h for assignments / project)
Credit points:	6
Recommended prerequisite subjects:	-
Expected learning outcomes:	On successful completion of this module, students should be able to: • contrast and describe the specific characteristics of marketing, market segmentation and pricing. • distinguish different business organization types. • distinguish different legal forms for businesses. • analyze and create business potentials based on the Business Model Canvas model. • apply fundamental investment calculations. • construct and evaluate a business plan. • describe cost structures of a company. • analyze self-costs. • calculate key financial figures and requirements for a possible start-up business. • judge the accuracy of financial plans. • describe and apply fundamental project management principles. • analyze project tenders. • apply tools and IT for planning and project management.
Study assessment and Examination:	80% written examination 20% project work (business plan, case study project)
Forms of media:	Presentations/slides, Moodle, readings
Literature:	Course material, company publications, brochures, etc., varying from case to case.

Module	**Planning, Organisation and Management**
	Books: Makers: The New Industrial Revolution; Chris Anderson, 2012 Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers; Alexander Osterwalder, Yves Pigneur, 2011 Marketing Management; Philip Kotler, Kevin Lane Keller, 2011 The New Strategic Selling: The Unique Sales System Proven Successful by the World's Best Companies; Robert B. Miller, 2011 The Project Management Life Cycle: A Complete Step-by-Step Methodology for Initiating, Planning, Executing and Closing a Project Successfully; Jason Westland, 2006.
Software:	MS-Excel

Module	**Remote Sensing Studios (Elective)**
Module code:	RSS
Semester:	PG 2
Responsible for module:	Prof. Dr. Michael Hahn
Lecturer:	Prof. Dr. Hahn / Prof. Dr. Gülch
Relation to curriculum:	Elective module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/hours per week:	The teaching method of this module follows a kind of project-based learning approach. The challenge for the lecturer is to guide students in the process while the students study topics with a well-defined purpose. Projects have a complex but flexible framework within which advise given by the lecturer and learning are seen as interactive processes. Students work together in small groups in a studio atmosphere with the aim to master a problem and solve it together. To promote independent and self-organised work of the students the contribution of the lecturer is limited to a small number of contact hours, e.g. one afternoon every two weeks for all groups. The project approach promotes research oriented group work and aims at an in-depth understanding of challenging issues. A variety of studio projects is offered as electives to the students. Each student must undertake one of the studio projects. The topics stem from the field of advanced remote sensing. The working environment for a studio is typically the laboratory or other student working spaces. The research work of a studio project typically consists of several phases: analysis of the problem and literature survey, development of a possible solution, poster presentation and defence of the proposed solution, implementation (e.g. scripts with Matlab or Python), experimental investigation and report writing, and finally the presentation of the project. (2 SWS)
Workload:	contact hours 30 h, self-study 90 h
Credit points:	4
Recommended prerequisite modules:	PRS, GSM
Expected learning outcomes:	On successful completion of this module, students should be able to: • develop own research proposals in a group and compare and contrast published research to their own original thoughts, • structure the research project activities efficiently with the aim to solve a given problem within a specified time frame, • monitor and assess their research progress, • practice successful team work, audit the achievements of the group on a weekly basis and anticipate the challenges for the following week, • understand and apply sophisticated techniques for acquiring remotely sensed data, • investigate advanced methods for image and point cloud processing and analysis, • criticize, assess and evaluate the applicability of remotely sensed data for various applications

Module	**Remote Sensing Studios (Elective)**
Content:	Content is given exemplary. The project topics change from year to year. 1. Acquisition of remotely sensed data with RGB and VIS-NIR cameras, thermography camera, time-of-flight camera, spectrometer, UAV lights, mobile mapping, hand-held laserscanning 2. Image and point cloud processing and analysis Band ratios, texture, segmentation, filtering, image matching, point cloud generation and filtering, point cloud feature extraction and matching 3. Image classification Pixel and object based classifier, multi- and hyperspectral classifier (HyMap data), random forests, Neural Network, deep learning, change detection with e.g. Landsat and Worldview data 4. Processing and applications of remotely sensed data Geometric and radiometric calibration, vegetation stress mapping, urban heat islands, solar potential of a 3D city model, road crack detection, indoor mapping, etc.
Study assessment and Examination:	50 % written report 50 % presentation (individual defence of the project work)
Forms of media:	Concept development on paper or chalkboard, communication tools for co-ordination of the activities and for time management, poster presentations for the mid-term review
Literature:	**Text books** Lillesand, Kiefer, and Chipman “Remote Sensing and Image Interpretation”, 6th edition 2007, John Wiley Prasad, Bruce, Chanussot (Eds.) “Optical Remote Sensing. Advances in Signal Processing and Exploitation Techniques”, 2011, Springer Verlag **Proceedings** International Archives of Photogrammetry and Remote Sensing http://www.isprs.org/publications/archives.aspx **Scientific journals** Remote Sensing of Environment, ISPRS Journal of Photogrammetry and Remote Sensing, IEEE Transactions on Geoscience and Remote Sensing, IEEE Applied Earth Observations and Remote Sensing, Remote Sensing, International Journal of Remote Sensing, Remote Sensing Letters **Tutorial** on Fundamentals of Remote Sensing prepared by CCRS (Canada Centre for Mapping and Earth Observation) http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9309 **Course material**: Selected papers, Hand-outs
Software:	MATLAB (educational license) is available for all students with a huge number of toolboxes. They can be used to implement and investigate algorithmic developments. Erdas Imagine, eCognition, Agisoft PhotoScan, SAGA GIS with Laserdata LIS, CloudCompare, Meshlab, other open source software

Module	**GIS Studios (Elective)**
Module code:	GSS
Semester:	PG 2
Responsible for module:	Prof. Dr. Franz-Josef Behr
Lecturer:	Prof. Dr. Behr / Prof. Dr. Coors
Relation to curriculum:	Elective module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/SHW:	The teaching method of this module follows a project-based learning approach. The project approach promotes research oriented group work and aims at an in-depth understanding of challenging issues. A variety of studio projects is offered as electives to the students. Each student must undertake one of the studio projects. The topics stem from the field of advanced Geoinformatics. Students work together in small groups in a studio atmosphere with the aim to master a problem and solve it together. To promote independent and self-organised work of the students the contribution of the lecturer is limited to a small number of contact hours, e.g. one afternoon every two weeks for all groups. The project approach promotes research oriented group work and aims at an in-depth understanding of challenging issues. The working environment for a studio is typically the laboratory or other student working spaces. The research work of a studio project typically consists of several phases: analysis of the problem and literature survey, development of a possible solution, poster presentation and defence of the proposed solution, implementation, experimental investigation and report writing, and finally the presentation of the project. (2 SWS)
Workload:	contact hours 30 h self-study 90 h
Credit points:	4
Recommended prerequisite subjects:	Basic knowledge of a programming languages, XML/HTML, CSS, JavaScript
Expected learning outcomes:	On successful completion of this module, students should be able to: • develop own research proposals in a group and compare and contrast published research to their own original thoughts. • structure project activities efficiently with the aim to solve a given problem within a specified time frame. • assess and document a research progress • structure a research topic and work successfully in a research project. • understand and apply techniques for customization approaches in modern system architectures, • explain and implement different approaches, applications, interfaces, and architectures to implement geospatial applications, • integrate modern visualization techniques into existing workflows

Module	**GIS Studios (Elective)**
Content:	Content is given exemplary. The project topics change from year to year. • Cluster detection in ArcGIS desktop Programming an ArcGIS Add-In in Python tool for point pattern analysis. The task is to find clusters of points based on their spatial and temporal characteristics using statistical methods, like Knox's method. • Point cloud analysis and visualization Develop a software to read a point cloud into a kd-Tree (use existing library), and apply an algorithm to detect windows in a given point cloud. (Java programming) • Implementing a complete OS GIS stack on a single-board computer Implement a full OS GIS stack, like OSGeo-Live, on a computer like Banana PI or banana PRO to provide a chip platform for geodata distribution and education. Banana Pi is a single-board computer based on open source software. • Modelling of dormers to enhance 3D city model Extend an existing 3D city model by modeling dormers and "shadow elements" into the roof structure to improve photovoltaic potential analysis. Modelling should be done using Google SketchUp and the GeoRes CityGML plugin.
Study assessment and Examination:	50 % written report 50 % presentation (individual defence of the project work)
Forms of media:	Project based Learning, Moodle, video tutorials
Literature:	Peng, Z.-R., Tsou, M.-H. (2003): Internet GIS: Distributed geographic information services for the internet and wireless networks. Wiley, New Jersey. Darie, C., Bucica, M., Chereches-Toşa, F., Brinzarea, B. (2005): AJAX and PHP: Building Responsive Web Applications, Packt Publishing, ISBN: 978-1-904811-82-4 Tyler Mitchell (2005): Web Mapping Illustrated O'Reilly Media, ISBN: 0596008651 Li, S., Dragicevic, S. & Veenendaal, B., Eds. (2011): Advances in Web-based GIS, Mapping Services and Applications. ISPRS Book Series, ISBN 9780415804837 Fu, P. & Sun, J. (2011): Web GIS – Principles and applications. ESRI Press, Redlands, CA Masser I., Crompvoets, J. (2015): Building European Spatial Data Infrastructures. Environmental Systems Research Institute Inc. U.S.; Auflage: 3 (9. Februar 2015) Newton, T., Villarrea O. (2014): Learning D3.js Mapping. Packt Publishing Course material • Internet GIS: Client Side Technologies (HFT Stuttgart), Server Side Technologies (HFT Stuttgart) • Online tutorial x3dom and geovisualization (Fraunhofer IGD / HFT Stuttgart)
Software:	As required, e.g. • ESRI ArcGIS, QGIS, WhiteBox • Eclipse • Apache HTTPD, PHP, MySQL, JavaScript, d3js, OpenLayers

Module	**Radar Remote Sensing (Elective)**
Module code:	RAD
Semester:	PG 2
Responsible for module:	Prof. Dr. Michael Hahn
Lecturer:	Dr. Esch / (Prof. Dr. Hahn)
Relation to curriculum:	Elective module MSc Photogrammetry and Geoinformatics
Teaching methods SWS/hours per week:	Teaching in this module is divided into two units. In the first unit the fundamentals of Synthetic Aperture Radar (SAR) are introduced by lectures. For preparation and review of the SAR fundaments the students are encouraged to review the Microwave Remote Sensing tutorial prepared by the Canada Centre for Mapping and Earth Observation. In the second unit the principles of SAR image understanding and analysis are introduced to the students in a mix of class room lectures and hands-on training with remote sensing software. Collaborative work in lab exercises is expected; students will give presentations on the results of the exercises and the gained practical skills regarding the analysis of SAR data. Applications related to InSAR, coherence and time series analysis, supplemented on-demand by other processes, are presented by case studies to put attention to the growing importance of SAR remote sensing. (2 SWS)
Workload:	contact hours 30 h self-study 30 h
Credit points:	2
Recommended prerequisite modules:	Photogrammetry and Remote Sensing Geostatistics and Surface Modelling
Expected learning outcomes:	On successful completion of this module, students should be able to: • describe the essentials of radar sensors and explain the similarities and differences to optical remote sensing sensors • point out why the use of a SAR is the only practical option for radar remote sensing from space • explain the SAR processing chain for generating calibrated radar products • discuss the image effects of radar's side-looking geometry and justify why this geometry makes radar so useful for terrain analysis • interpret radar images with respect to forest, land use and land cover areas based on the knowledge of how radar energy interacts with a target • analyse radar images with respect to the recorded frequency bands, polarization

Module	**Radar Remote Sensing (Elective)**
	• analyse radar images with respect to object specific imaging parameters, in particular surface roughness, scattering, terrain and object geometry • evaluate the results of applying speckle filtering • understand phase difference measurements to derive the speed of motion of targets and discuss applications like determination of sea-ice drift, ocean currents, and ocean wave parameters • carry out data stretching, speckle suppression and textural feature extraction • apply classification techniques for identification of built-up areas • apply techniques for calculating polarimetric and coherence-related parameters • explain applications in which polarimetric SAR is used for crop type identification, soil moisture measurement, shoreline detection, ship detection and classification, sea ice identification, coastal windfield measurement
Content:	1. Fundamentals SAR principle: RADAR, imaging concept, viewing concept, geometric resolution System-specific imaging parameters: frequency, polarization, imaging geometry Object-specific imaging parameters: surface roughness, dielectric properties, terrain and object geometry, scattering mechanism SAR image data: data properties, speckle effect 2. SAR image understanding and analysis Image interpretation, Image enhancement: data stretch, speckle suppression, textural features Image classification: Identification of built-up areas 3. Applications Interferometry (InSAR), D-InSAR, velocity measurement, polarimetry (PolSAR), coherence analysis, urban analysis
Study assessment and Examination:	100 % written examination
Forms of media:	Lectures with digital or printed notes, supervised exercises, CCRS tutorial with quiz
Literature:	Text books: F. T. Ulaby, R. K. Moore and A. K. Fung, Microwave Remote Sensing - Active and Passive, Vol. I: Microwave Remote Sensing Fundamentals and Radiometry. Artech House, Norwood, US. 1981. F. T. Ulaby, R. K. Moore and A. K. Fung, Microwave Remote Sensing - Active and Passive, Vol. III: From Theory to Applications. Artech House, Norwood, US. 1986. C. Oliver and S. Quegan, Understanding Synthetic Aperture Radar Images, Boston: Artech House, 1998. Papers, Book chapters:

Module	**Radar Remote Sensing (Elective)**
	Henderson, F.M. and Z.G. Xia, Radar Applications in Urban Analysis, Settlement Detection and Population Analysis. In: Henderson, F.M. and A.J. Lewis (Eds.): Principles and Applications of Imaging Radar, Chapter 15. New York, S. 733-768, 1998. J. W. Goodman, Some fundamental properties of speckle, J. of the Optical Society of America, Vol. 66, pp.1145 – 1150, 1976. Lee, J.S., A Simple Speckle Smoothing Algorithm for Synthetic Aperture Radar Images. In: SMC (13), 1983, pp. 85-89., 1983. Esch, T., Marconcini, M., Felbier, A., Roth, A., Heldens, W., Huber, M., Schwinger, M., Taubenböck, H., Müller, A., Dech, S., Urban Footprint Processor – Fully Automated Processing Chain Generating Settlement Masks from Global Data of the TanDEM-X Mission. IEEE Geoscience and Remote Sensing Letters, Vol. 10, No. 6, pp. 1617-1621, 2013 Esch, T., Taubenböck, H., Roth, A., Heldens, W., Felbier, A., Thiel, M., Schmidt, M., Müller, A., Dech, S., TanDEM-X mission-new perspectives for the inventory and monitoring of global settlement patterns. J. of Applied Remote Sensing, Vol. 6, Issue 1; 21 pp. 2012 Esch, T., Schenk, A., Ullmann, T., Thiel, M., Roth, A. And S. Dech, Characterization of Land Cover Types in TerraSAR-X Images by Combined Analysis of Speckle Statistics and Intensity Information, IEEE Transactions on Geoscience and Remote Sensing, 15 pp., 2011. Esch, T., Thiel, M., Schenk, A., Roth, A., Muller, A. And Dech, S., Delineation of Urban Footprints from TerraSAR-X Data by Analyzing Speckle Characteristics and Intensity Information, IEEE Transactions on Geoscience and Remote Sensing, Vol. 48, Issue 2, pp. 905-916, 2010. Tutorial on Microwave Remote Sensing prepared by CCRS (Canada Centre for Mapping and Earth Observation) http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9309 Course material: Manuscript of lectures, Hand-outs
Software:	For the exercises and training: Erdas Imagine, Nest und PolSAR-Pro

Module	**GIS Programming (Elective)**
Module code:	GPR
Semester:	PG 2

Responsible for module:	Prof. Dr. Dietrich Schröder
Lecturer:	Prof. Dr. Dietrich Schröder
Relation to curriculum:	Elective module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/hours per week:	In the lecture part the theoretical background in the use of a modern scripting language like Python will be discussed. The focus will be in using the scripting language in the context of geoprocessing in proprietary GIS like ArcGIS as well as Open Source GIS. The lectures are accompanied by guided practices and intensive hand-on workshops in the computer lab. (2 SWS)
Workload:	contact hours 30 h self-study 30 h
Credit points:	2
Recommended prerequisite knowledge:	Basic knowledge of a programming language
Expected Learning outcomes:	On completion of this module, the learner will be able to • to use Python as a programming tool • to apply the basic concepts of object-oriented programming to solve geoprocessing problems in an application oriented manner • to transform a typical abstract geoprocessing task into an executable tool • to integrate scripting tools into a proprietary and open source GIS environment • to extend and customize existing component-based software programs using a scripting language.
Content:	Programming techniques using Python • Python as scripting language • Classes and objects: properties, methods and events • scripting for geoprocessing with ArcGIS • scripting for customizing ArcGIS projects • geoprocessing with Python in an open source environment
Study assessment and Examination:	written exam
Forms of media:	Lecture and guided exercises in the lab, self-study
Literature:	Python org (2015): Beginner's Guide to Python Allen, David (2014): GIS Tutorial for Python Scripting. ESRI Press Jennings, Nathan (2011): A Python Primer for ArcGIS. Zandbergen, Paul (2014): Python Scripting for ArcGIS. ESRI Press Chris Garrard (2009): Geoprocessing with Python using Open Source GIS. http://www.gis.usu.edu/~chrisg/python/2009/
Software:	Eclipse, Python, ESRI ArcGIS, QGIS, OGR/GDAL

Module	**Research Seminar**
Module code:	RSE
Semester:	PG 3
Responsible for module:	Prof. Dr. Eberhard Gülch
Lecturer:	Prof. Dr. Gülch / Prof. Dr. Hahn and other faculty members depending on actual focal points.
Relation to curriculum:	Compulsory module MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/hours per week:	Each student has to select one topic for the project proposal which is the key result of this module. The selection is from a list of topics provided by supervisors or according to own personal interests. ***Lectures:*** Will provide an introduction to the key topics of the module and these will be supported by structured class discussions. ***Class and Group Discussion:*** Class and group discussions will be driven and supported by appropriate academic literature and will allow for ideas and issues to be clarified. These discussions will enable students to draw on their own knowledge of the research process and they will be encouraged to evaluate the different approaches to research. Students get hints on how to co-operate with their supervisor and how to actually perform research work including the monitoring of progress. ***Independent Study:*** Participants will be responsible for engaging in independent reading in order to consolidate and expand on the material covered in lectures and class discussions ***Research Seminar:*** The students present and defend their research plans in a research seminar attended by all candidates. It is stimulating scientific discussion of the individual proposals and allows to identify possible synergy effects. ***Post-graduate seminar:*** A post-graduate seminar with external guest professors and docents, professors at HFT and PhD students at HFT gives insight in key research topics in the fields related to this course. (3 SWS)
Workload:	contact hours 45 h self-study 75 h
Credit points:	4
Recommended prerequisite modules:	All preceding modules

Module	**Research Seminar**
Expected learning outcomes:	On completion of this module, the learner will be able to • define research and the aims of research • identify issues and problems which are of professional concern and which are capable of further exploration and research • formulate research objectives and questions • critically appraise a range of different research methodologies and research methods and select appropriate options to apply in relevant research settings • make decisions about quantitative and qualitative approaches to research • formulate/draw-up an acceptable research proposal suitable for a dissertation topic at postgraduate level • defend the research proposal in a seminar with fellow students and supervisors
Content:	This module provides an understanding of the nature of, and the different approaches to, contemporary research and support participants in planning and writing a research proposal within an applied construction context at postgraduate level. This is a specialised module intended for participants proceeding to conduct a masters' dissertation within an applied construction setting. The module is structured to give participants an understanding of contemporary research paradigms, methodologies and methods. The module will deal with issues and concerns around the • setting of research objectives, • development of analytical and communication skills by investigating, in depth, a topic of interest and relevance to the course, • evaluating and selecting an appropriate methodology, • conducting a critical literature review, • analyzing potentials and risks, • setting up a realistic research plan, including working packages, resource requirements and feasible milestones, • exploring methodological issues related to the presentation and analysis of qualitative and quantitative research findings and the drawing of appropriate conclusions, • indicating the major goal and the scientific and commercial) benefits, • considering the ethical dimensions of research, • writing a scientific thesis proposal, • identifying and applying a close communication with the supervisor(s), • participating in post-graduate seminar to acquire knowledge on a broader level of research topics in the fields of this course, • basic issues on how to present work in scientific posters and writing articles for scientific journals.

Module	**Research Seminar**
	Presentations in thesis-accompanying seminars focus on: • presenting current status of work, reporting on intermediate results also with posters, • identifying research and time problems (actual-nominal comparisons), • analyzing the seminar group's feedback for further research input, • re-adjusting preliminary and final proposal due to external input and further research.
Study assessment and Examination:	Assignment (Proposal for Master´s Thesis) • Report 50% • Presentation of proposal including its defence in the Research Seminar 50%
Forms of media:	A wide range of multi-media materials help to enrich the learning experience.
Literature:	Handouts (as pdfs) on proposal preparation, writing thesis report, evaluation criteria and mark sheets, writing journal articles and ethical issues. James Mauch & Namgi Park (2003). Guide to the successful Thesis and Dissertation; Fifth Edition, Marcel Dekker, Inc., 270 Madison Avenue, New York, New York 10016, U.S.A. Maria Piantanida & Noreen Garman (2009). The Qualitative Dissertation; 2nd Edition, Corwin Press Inc California Anderson, J. & Poole, M. (2001). Assignment and thesis writing (4th Edn.). Brisbane: John Wiley & Sons
Software:	Science Direct, Google Scholar et al.

Module	**Master Thesis**
Module code:	MTH
Semester:	PG 3
Responsible for module:	Prof. Dr. Dietrich Schröder
Lecturer:	All faculty members supervising a thesis
Relation to curriculum:	Compulsory subject MSc Photogrammetry and Geoinformatics
Teaching methods, SWS/SHW:	Individual research work Regularly discussion meetings with supervisor
Workload:	Self-study 720 h
Credit points:	24
Recommended prerequisite modules:	All preceding modules
Expected learning outcomes:	On successful completion of this module, students should be able to: • Acquire more in -depth knowledge of the field of study • Independently search and apply theory and concepts to the problem under study • Independently select, justify and apply an appropriate research method for the research to be performed • Demonstrate the capability to use a holistic view to critically and independently identify, formulate and deal with complex issues • Critically and systematically evaluate and integrate knowledge from different sources • Demonstrate verbal and written communication skills to clearly present, discuss and defend a clear and well-structured account in English • Reflect critically on his or her own research process and outcomes and relate them to related research • Finish the master thesis within the time period specified
Content:	Actual domain specific topics in research and development. Individual topics from home countries are encouraged
Study assessment and Examination:	• Thesis • Poster • Presentation and defence of thesis
Forms of media:	Supervised self study
Literature:	See module RSE
Software:	As required

4. Technical Journals

Most of the journals available at the faculty and at the library of HFT are in German language. At the faculty, you will find the following English journals

- *Geoinformatica* (print and electronic) a scientific English journal and
- ArcUser and ArcNews, the ESRI journals
- *The Photogrammetric Record* an International journal of Photogrammetry
- *Inside GNSS* a technical journal about global navigation systems

and others.
English articles you will also find in

- GIS Zeitschrift für Geoinformatik and
- PFG Photogrammetrie, Fernerkundung und Geoinformation

Many (business) journals nowadays are available online for free, e.g. *GIM Global Magazine for Geomatics* http://www.gim-international.com/

You should keep up to date with the new development by having a look into the journals regularly!

In addition, the electronic domain specific database *ScienceDirect / Elsevier* can be used for information retrieval via the homepage of our library.

Additional technical journals you will find at the library of the University Stuttgart. Use the ZDB (The ZDB is the world's largest specialized database for serial titles (journals, annuals, and newspapers etc., incl. e-journals) where the journals you are looking for are available.

5. Additional Courses and Offers

German Language Courses

During the whole study period, additional German language courses are offered for a low fee sponsored by the University. Even if the medium of instruction of the course is English, these courses are highly recommended. You will live in a German environment, some of you may want to get a job outside the University or take part at an additional internship.
Every semester during lecture period, students from the German courses will offer discussion groups for non-German speaking students, so that you can enjoy practicing your German in an informal and relaxed manner.

Other Language Courses

Besides German, there are other languages courses like French, Italian, etc. offered by the Foreign Language Institute. All these courses are offered for free! Please see the announcement of the Institute.

MATLAB Tutorial

As MATLAB will be used as a tool in several modules, an additional introduction tutorial will be offered at the beginning of the first semester.