Summary Descriptions of Modules and Courses
(Curriculum and Examination Regulations, Version 7/8)

International Geomatics Master program (GMC/M)

Modules/Courses		ECTS points			
Semester		1	2	3	Elective
GIS & Databases		5			
Object-Oriented & Web Programming		5			
Language & Academic Writing		5			
Software Engineering			6		
Web Services & Monitoring			6		
Geostatistics				6	
OpenSource GIS				6	
Pre-required Elective Courses					24
Elective Modules					
Virtual Reality					6
Combining Space and Marketing					6
Mobile Map Apps in Nature Conservation					6
Intelligent Systems and Engineering Geodesy					6
Building Information Modelling					6
Space-Time Visualization of Statistical Data					6
LBS for Business					6
Satellite Image Change Detection					6
Physical and Mathematical Geodesy					6
Navigation Technologies and Mobile GIS					6
Sum	S = 90	30	30	30	

International Geomatics Master program (GMC/M)

1st Semester	**Type**	**ECTS**	**Lecturer**
GIS	V+Ü	3	Schaab
Databases	V+Ü	2	Saler
Object-Oriented Programming	V+Ü	3	Bürg
Web Programming	V+Ü	2	Kuhn
Language	V+Ü	3	IFS
Academic Writing	V+Ü	2	Beechey-Volz
Remote Sensing and Digital Image Processing	V+Ü	3	Ruiz
Photogrammetry and Computer Vision	V+Ü	3	Lerma
Thematic Cartography	V+Ü	3	Brunn
3D Visualization	V+Ü	3	Günther-Diringer
Statistics and Adjustments	V+Ü	3	Saler
Advanced Parameter Estimation	V+Ü	3	Jäger
Satellite Geodesy	V+Ü	3	Jäger
Economics and Marketing	V+Ü	3	Kleinknecht
2nd Semester	**Type**	**ECTS**	**Lecturer**
Software Engineering	V+Ü	3	Bürg
Object-Oriented Programming 2	V+Ü	3	Bürg
Programming for Geomonitoring	V+Ü	3	Jäger
Web Processing Services	V+Ü	3	Stern
Virtual Reality	P	6	Günther-Diringer/Berner
Combining Space and Marketing	P	6	Freckmann
Mobile Map Apps in Nature Conservation	P	6	Schaab
Intelligent Systems and Engineering Geodesy	P	6	Jäger
Building Information Modelling	P	6	Saler
3rd Semester	**Type**	**ECTS**	**Lecturer**
Theory of Geostatistics	V	3	Saler
Application of Geostatistical Methods	Ü	3	Saler
Introduction to OpenSource GIS	V	3	Lechner
Application of OpenSource GIS	Ü	3	Lechner
Space-Time Visualization of Statistical Data	P	6	Schaab
LBS for Business	P	6	Freckmann/Kleinknecht
Satellite Image Change Detection	P	6	Schaab
Physical Geodesy	V+Ü	3	Müller
Mathematical Geodesy	V+Ü	3	Jäger
Navigation Technologies and Mobile GIS	P	6	Jäger/Akter
4th Semester	**Type**	**ECTS**	**Lecturer**
Seminar Work		5	
Thesis		22	
Colloquium		3	

Courses of International Geomatics Master program

Module	Semester	Type	ECTS	Study program
GIS & Databases				
GIS	***1.***	***V+Ü***	***3***	***GMC/M***

The focus is on spatial analysis, including overlay (vector-based), raster computations (weighted overlay, drainage, cost surface) integrating DEM data as well as network analyses. Further, an understanding for Internet-GIS and the programming within GI-Systems for applications from diverse fields is created. Thus, the students gain profound practical experience in the handling, analysis and visualization of geospatial data in a GIS environment.

Databases	***1.***	***V+Ü***	***2***	***GMC/M***

The course covers Entity Relation Diagrams, multiplicity, modeling of geo-data under consideration of national and international standards (OGC, ISO, INSPIRE, GDI-DE), UML, spatial data base models, indexing of geo-data, relational and object-relational data bases, and spatial queries with SQL. Exercises employ MS-ACCESS and PostgreSQL/PostGIS. The students have the ability to setup data models and understand the difference between non-spatial and spatial DB.

Object-Oriented & Web Programming				
Object-Oriented Programming	***1.***	***V+Ü***	***3***	***GMC/M***

The lecture introduces the Java programming language and hence object-oriented programming. Contents included are structured formulating algorithms, structure of programs, data types, expressions, statements, loops, classes, instances and inheritance. The students learn the concepts of a modern object-oriented programming language. They are able to solve simple problems and independently develop and implement these.

Web Programming	***1.***	***V+Ü***	***2***	***GMC/M***

Web programming encompasses HTML5, CSS3, JavaScript and libraries like Leaflet.js, Bootstrap and jQuery. This provides the basis for applying script languages to create and design dynamic and responsive Web pages. The students learn also to develop and prepare interactive maps with GIS functionality for the Internet.

Language & Academic Writing				
Language	***1.***	***V+Ü***	***3***	***GMC/M***

Courses as offered by the Institute for Foreign Languages (IFS): For international students 'German as Foreign Language' (each course 4-6 ECTS; target is min A2, B1 recommended), the appropriate course is decided by a placement test. For German students 'Advanced English' or 'Business / Technical English' (each 4-6 ECTS; target is C1 TE, min B2 required) emphasizing on professionally oriented communicative ability.

Academic Writing	***1.***	***V+Ü***	***2***	***GMC/M***

The course guides students through the process of writing an academic paper starting from the foundations of academic research and ending with formatting and submission recommendations. Students will write their own academic paper step-by-step, thus acquiring the skills for writing an academic paper in English.

Pre-required Elective Courses				
Remote Sensing and Digital Image Processing	***1.***	***V+Ü***	***3***	***GMC/M***

The course treats a wide range of topics from physical fundamentals on remote sensing, spectral properties of the Earth's surface, set-up, geometry and radiometry of passive and active sensor systems, digital image processing, and image classification. After having completed the course, the students are acquainted with the basics physics of remote sensing and its data acquisition systems, and the use of satellite imagery for various applications. They have gained first experiences in supervised image analysis.

Photogrammetry and Computer Vision	***1.***	***V+Ü***	***3***	***GMC/M***

Based on the fundamentals of photogrammetry (projective geometry, transformations, camera parameters, DLT, central projection, homography), the basics of photogrammetric processing such as single-image processing, standard stereo case, general stereo case and collinearity equation are taught. Also included are measurement campaigns. Computer vision content focuses on image types, image analysis, histograms, statistical image analysis and basic segmentation algorithms. Student use state-of-the-art scriptable image processing toolboxes to get hands on practical problems.

Thematic Cartography	***1.***	***V+Ü***	***3***	***GMC/M***

Students learn the basics of cartography in order to ensure a solid background for any visualization of geo-spatial data in thematic maps. Topics covered are basics of cartography (scale, projection, cartographic generalisation, base map, map design & layout, lettering, symbols, patterns, colour, graphic variables), transformation of statistical data into map symbols, the use of different map types, draft and production of thematic maps with different software tools.

3D Visualization ***1.*** ***V+Ü*** ***3*** ***GMC/M***
Based on 2D and 3D geo-data the students set up and edit 3D data structures with different 3D construction programs. For the visualization they learn different scale-based methods and dissemination techniques. The fields of application can differ from indoor-applications to 3D city models or 3D landscape models.

Statistics and Adjustments ***1.*** ***V+Ü*** ***3*** ***GMC/M***
The course aims at students understanding the application of statistical approaches on geo-data. They are able to determine confidence intervals and to test parameters regarding significance. Furthermore they can do data snooping and testing of stochastic and mathematical model. The students have the ability to apply the LSM onto all over-determined problems of geomatics.

Advanced Parameter Estimation ***1.*** ***V+Ü*** ***3*** ***GMC/M***
The course treats sequential adjustment procedures, (quasi)integrated geodesy, Gauß-Markov model, generalized M-Estimation and Kalman filtering, Bayesian estimation, adjustment of free networks, as well as measures to quantify and describe distortions of parameters and geodetic networks due to deterministic and stochastic errors in coordinate space. Specific tasks allow for training on software tools and programming.

Satellite Geodesy ***1.*** ***V+Ü*** ***3*** ***GMC/M***
The students get a deep insight in the mathematical and physical foundations, algorithms and concepts of satellite geodesy. As concerns GNSS-based positioning (geometrical satellite geodesy) the topics of reference frames, GNSS data acquisition, algorithms and data processing, software and RTCM-corrections are treated. The other focus is on satellite-based gravity field determination (dynamical satellite geodesy), satellite interferometry and altimetry. Exercises cover RTK measurements and transformation using SAPOS, and GNSS data processing using Bernese GNSS, GPSLab, etc.

Economics and Marketing ***1.*** ***V+Ü*** ***3*** ***GMC/M***
The course covers topics like communication and management, organisation, corporate culture, product and brands, marketing activities, consumer behaviour and international trade. So students get an overview of the most important aspects in economics and marketing. Case studies and practical examples from the management point of view help the students to understand economic processes and the competitive market economy as well as the structure of companies.

Software Engineering

Software Engineering ***2.*** ***V+Ü*** ***3*** ***GMC/M***
The students learn the methods of information technology and are capable of high quality software development. The students learn both the classic and the modern object-oriented development methods. As such the lecture treats problems in software development, the software development process, structured analysis and design techniques (e.g. flow charts, Jackson-diagram), object-oriented modeling, UML, software testing, and project management.

Object-Oriented Programming 2 ***2.*** ***V+Ü*** ***3*** ***GMC/M***
Based on the lecture 'Object-Oriented Programming' of the first semester, the following themes are treated: methods, graphical output with AWT and Swing, threads, exceptions, applets, events, animations, and class libraries. Concrete tasks ensure experience in usage and handling of tools from software engineering. The students are able to develop independently problem-solutions with an average degree of difficulty and implement these as software package.

Web Services & Monitoring

Programming for Geomonitoring ***2.*** ***V+Ü*** ***3*** ***GMC/M***
The students learn about the present profile, the hardware, software and communication design and intensively about the mathematical models of scalable multi-sensor geodetic monitoring systems. The application domain is manifold and covers different estimation concepts in deformation networks, observation and coordinate related adjustment approaches, as well as quality control and statistically based concepts for forecasting and alert setting in real time (e.g. displacement estimation, Kalman filter). Programming exercises make use of the systems GOCA and MONIKA in real-data environment.

Web Processing Services ***2.*** ***V+Ü*** ***3*** ***GMC/M***
The course starts with an introduction to the OGC specification for WPS as well as to programming with Python. Further, the setting-up of a WPS is discussed and an example of a complex process programmed by the student. Here, the students learn how to combine Esri's ModelBuilder for configuring and/or customizing scripts with own scripting in order to be most flexible. In addition, service chaining is also covered including so-called zip & ship.

Virtual Reality (Elective)

Virtual Reality ***2.*** ***P*** ***6*** ***GMC/M***
Students import geospatial 2D data and additional 3D data into a georeferenced 3D model. Input data sources could be point clouds by 3D laser scanning, structure light techniques, computed digital elevation models, 3D photogrammetry, or remote sensing image data from satellites or drones. Programming of interactive activities in the constructed 3D environment enhances the augmented and virtual reality applications (e.g. virtual sights, flight-overs and movements in the 3D environment). The 3D visualisations can be run on diverse output devices like head-mounted displays, mobile devices, or virtual walls.

Combining Space and Marketing (Elective)

Combining Space and Marketing ***2.*** ***P*** ***6*** ***GMC/M***

Each student team works on a strategic planning problem in business geographics with real geo data and in cooperation with a company. Standard Geographical Information Systems (ArcGIS, MapInfo), OpenSource GIS and special tools for tasks in business geographics (RegioGraph, MarktAnalyst, Map&Market) are applied. Students get to know how business geographic methods and tools are used in a company's internal processes.

Mobile Map Apps in Nature Conservation (Elective)

Mobile Map Apps in Nature Conservation ***2.*** ***P*** ***6*** ***GMC/M***

The project work covers the development of a mobile map app of use in nature conservation. Students build on programming hands-on of Qt / QML and AppStudio as well as on studying similar mobile map applications. This allows them to conceptualize the envisaged app. For actual app development, students have to concentrate on app design (prototyping, GUI design), database entry via forms, the use of map services, and the implementation of specific functionality depending on the app task. The students per group have to organize themselves for working as a team following project management methods as well as sharing and integrating code developed by different members of the group.

Intelligent Systems and Engineering Geodesy (Elective)

Intelligent Systems and Engineering Geodesy ***2.*** ***P*** ***6*** ***GMC/M***

The module comprises recursive parameter estimation, machine control, computer vision, machine learning and photogrammetry in order to provide students with an understanding of intelligent systems. Attendees build a sample robot using available robotic kit and equip the systems with off-the-shelf sensors for navigation, obstacle detection and data acquisition. By means of the project work students gain rapid prototyping skills and capabilities of active participation in industrial-level product development.

Building Information Modelling (Elective)

Building Information Modelling ***2.*** ***P*** ***6*** ***GMC/M***

The students are enabled to capture building geometries with mobile mapping systems and to prepare the data for BIM. After an introduction to BIM and the BIM data model, information acquisition is performed with the newest generation of surveying instruments and software. Here, current state-of-the-art methods for real-time acquisition as well as post-processing information extraction methods are presented to the attendees. The acquired data is transferred into a BIM structure.

Geostatistics

Theory of Geostatistics ***3.*** ***V*** ***3*** ***GMC/M***

The students get an overview on spatial variability, the modelling of spatial characteristics for variables as well as interpolation methods including Kriging. It enables the students to derive area-related information from point data.

Application of Geostatistical Methods ***3.*** ***Ü*** ***3*** ***GMC/M***

Student apply methods of multivariate statistics and geostatistics. Procedures of geostatistical analysis are implemented in Geographic Information Systems and need to be understood.

OpenSource GIS

Introduction to OpenSource GIS ***3.*** ***V*** ***3*** ***GMC/M***

Students learn about the current range of software tools available in OpenSource GIS. Further, the concepts of OpenSource software are taught. Students understand the theory of OGC standards like WMS, WFS and are able to solve problems with the related methods.

Application of OpenSource GIS ***3.*** ***Ü*** ***3*** ***GMC/M***

Students broaden their knowledge about OpenSource GIS programming for solving space-related questions and enhance their capabilities in preparing technical documentations. The students are familiar with QGIS, UMN-Mapserver, GeoServer, PostgreSQL/PostGIS, PHP and OpenLayers/ GeoEXT. They have the competence to develop and use OpenSource WebGIS tools.

Space-Time Visualization of Statistical Data (Elective)

Space-Time Visualization of Statistical Data ***3.*** ***P*** ***6*** ***GMC/M***

By analyzing individually chosen, time-dependent multivariate statistical data, each student needs to come up with a concept for a static and a dynamic interactive map depiction. For the static map, the participants are asked to apply Illustrator to assure understanding of principles in thematic cartography. In regard to the dynamic tool, the students should work with HTML5, JavaScript and the relevant libraries (e.g. Leaflet, D3). Here, the students have to decide on where to place the emphasis on, either more towards cartographic communication or more towards geographic visualization. Students are thus able to use a range of state-of-the-art software tools available for thematic cartography.

LBS for Business (Elective)

LBS for Business ***3.*** ***P*** ***6*** ***GMC/M***

The introduction covers Customer Relationship Management in combination with Geographical Information Systems and geobusiness tools. On this basis student teams develop in various projects Location-Based Services applications. The focus lies on the visualisation of LBS use cases on mobile devices connected with Customer Relationship Management systems.

Satellite Image Change Detection (Elective)

Satellite Image Change Detection	***3.***	***P***	***6***	***GMC/M***

Students in groups of three are asked to develop a concept for a change detection study. Dependent on a particular topic chosen or provided, the task is to find an appropriate workflow by reviewing literature. The workflow has to cover pre-processing, classification and analysis of multispectral satellite image data. Here, satellite image analysis can follow pixel-based or object-based approaches and is mainly performed by means of Erdas Imagine. Students with experience can also explore possibilities with ArcGIS, eCognition or R. The students will thus obtain the qualification to determine and apply a suitable processing chain, this dependent on the available satellite image data and the concrete task.

Physical and Mathematical Geodesy (Elective)

Physical Geodesy	***3.***	***V+Ü***	***3***	***GMC/M***

Lectures cover the history of Physical Geodesy, gravitation and gravitational potential, gravity potential and level surfaces, spherical harmonics, level ellipsoid and normal field, geodetic boundary value problems (Stokes, Molodensky, …), temporal variations in the gravity field, absolute and relative gravimetry, geoid determination with satellite methods, as well as regional and high accuracy geoid determination. Practical experience is gained by solving fundamentals and complex problems of gravity field determination with different methods.

Mathematical Geodesy	***3.***	***V+Ü***	***3***	***GMC/M***

Mathematical Geodesy starts with interpolation and prediction (Kernel-based Methods, Kriging, Collocation) an reference surfaces. Problems of datum transformations, estimation of surface parameters and height reference systems are also covered. A further topic is advanced mapping. Exercises encompass diverse methods in the field of geoid computations and make use of the DFHBF, WTRANS and COPAG software.

Navigation Technologies and Mobile GIS (Elective)

Navigation Technologies and Mobile GIS	***3.***	***P***	***6***	***GMC/M***

Students learn about the various mathematical models and algorithms for designing multi-sensor multi-platform systems for different outdoor/indoor-technologies and applications in navigation and geo-referencing. These include deep and tight coupling of GNSS, MEMS and camera sensor data, modelling, and self-calibration of distributed sensors and platform navigation. It also related to mobile computing and mobile GIS. Therefore, the students can use partly their own hardware for the project tasks of complex software and algorithmic developments. Software development is based on Java (typically under Eclipse), and the use of OpenSource software (e.g. RTKLIB, KITTI) and non-open software.

Master Thesis

Seminar for Master Thesis	***4.***		***5***	***GMC/M***
Master Thesis	***4.***		***22***	***GMC/M***
Colloquium of Master Thesis	***4.***		***3***	***GMC/M***

After selecting a topic for the Master thesis, the student is given a month time to familiarize him/herself with the topic by means of scientific publications, to phrase objectives for the thesis and to plan the work. The result has to be delivered to the referees as a report, i.e. the seminar work (about 3000 words, in English) and also includes the elaboration of the task description. With this work the candidate demonstrates his/her knowledge of scientific rules and standards. With the Master thesis the student shows his/her ability to independently work on a scientific topic. Purpose of the thesis is to develop a research topic, to convert it methodically, to analyze it critically and to evaluate the results. The work is to make a contribution for knowledge extension to the selected scientific topic. It usually investigates a research problem in a theoretical and in a practical part. The Master thesis has to be written in English. In the colloquium the candidate presents the thesis (talk of 30 min) and is expected to sufficiently answer questions in the discussion afterwards.