

# Module Catalog

*M.Sc. Cartography*

Civil, Geo and Environmental Engineering

Technische Universität München

[www.tum.de](http://www.tum.de)

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## Degree Requirements TUM (1. Semester)

## Module Description

### BV300025: Cartographic Foundations

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam of 90 min in total (100%). The students have to answer to the questions with own formulations partially they have to sketch issues or circumstances. No auxiliary materials are permitted within the written exam.

The written exam is a means to measure the students' ability to understand the whole cartographic visualization process and the relation of cartography to other fields.

Additionally the students have to create a sufficient user-oriented topographic and thematic map to verify their ability to apply and evaluate cartographic concepts and typographic guidelines in the context of map making.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

A basic knowledge in mathematics is desirable.

#### Content:

The course covers different aspects of cartography and cartographic research like:

- Fundamental cartographic concepts
- The cartographic visualization process
- Map and layout design
- Cartographic generalization
- Map projections
- Use and user issues in cartography
- Topographic and thematic mapping

#### Intended Learning Outcomes:

Upon completion of the module, students are able to...

- describe the relevance and influence of cartography to various associated fields;
- explain the cartographic visualization process;
- explain theories of perception;

- implement cartographic concepts on real world examples;
- implement different map-projections for different map use cases;
- assess effective user-driven map-design by up to date usability evaluation methods;
- design topographic and thematic maps using various visualization techniques based on cartographic concepts and the general typographic guidelines.

### **Teaching and Learning Methods:**

The module is structured in lectures and exercises. The lectures consisting of presentations of the supervisors and blended learning like map reviews and working on reading material to current cartographic research issues.

The exercises are carried out as individual work as well as group work under supervision. Within the exercises, the students have to create a topographic and a thematic map. The students have to define and solve cartographic visualization problems and should practice their skills within the cartographic domain by using cartographic software and tools. Feedback on the exercises (created maps and applied methodologies and techniques) is given to the groups or students by one to one discussions during the contact hours.

### **Media:**

Moodle e learning platform, presentations, pc-lab, discussions, reading material

### **Reading List:**

Anson, R. W., Ormeling, F. J. (1996): *Basic Cartography for Students and Technicians*. International Cartographic Association (ICA). Elsevier Science.

Bugayevskiy, L. M., Snyder, J. P. (1995): *Map Projections: A Reference Manual*. Taylor & Francis.

Field, K. (2018): *Cartography*. Esri Press.

Heywood, I, Cornelius, S., Carver, S. (2006): *An Introduction to Geographical Information Systems*. Pearson Education.

Keates, J. S. (1996): *Understanding Maps*. Addison Wesley.

Kraak, M. J., Ormeling, F.J. (1998): *Cartography: Visualization of Spatial Data*. Addison Wesley.

Robinson, A. H. et al. (1995): *Elements of Cartography*. John Wiley & Sons.

### **Responsible for Module:**

Liqiu Meng, liqiu.meng@tum.de

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Cartographic Foundations (Lecture with integrated exercises VI, 3 SWS)

Meng L, Cron J, Kumke H, Murphy C

## Module Description

### BV300003: Geo-Information

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

A written exam of 60 min takes place in the end of the semester (100%). By answering the questions the student should verify that they have gained the required knowledge about spatial data management, the analysis of geodata, spatial data mining and cartographic techniques for visualising spatial data. The exam contains questions in which they have to give valid definitions, explain concepts, theoretically implement and evaluate case studies, as well as mastering design challenges. All learning outcomes are covered by this written exam.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Knowledge of higher mathematics and experiences of handling spatial data is recommended.

#### Content:

This module includes the following topics:

- Introduction to GIS
- Spatio-temporal representations and databases
- Spatial data analysis
- Spatial data mining
- Data retrieval and cartographic techniques
- Case studies of Geoinformation
- Introduction to ArcGIS components
- Working with multiple data tables
- Learning spatial analysis methods
- Building 3D models
- Creating animations
- Designing a quality Map in a GIS
- Collecting spatial data during field work
- Integrating GPS data to a GIS
- Publishing geographic information online

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- illustrate the dimensions of geoinformation;
- explain the structure of a GIS;
- describe advantages and drawbacks of different spatial database systems;
- understand data mining concepts;
- implement concepts of geodata harmonization to integrate geodata into a GIS;
- integrate the functional and the organizational workflow of geodata-management and implement them into system-architectures using established concepts of geodata modelling;
- judging the influence of spatial data quality for geodata-management;
- create queries for geodata analysis;
- making well designed maps;
- generate three dimensional data models.

**Teaching and Learning Methods:**

The module is structured in lectures and exercises. The lectures provide the theoretical foundations of geoinformation. They impart knowledge about spatial data management, the analysis of geodata, spatial data mining and cartographic techniques for visualising spatial data. The exercise part of this module allows the students to employ their GIS knowledge to applied studies. An introduction to ArcGIS will be given and the students can analyse and visualise

geodata using a variety of analysis tools and visualisation techniques. A set of exercises put the theoretical knowledge into practice. The exercises are carried out in a computer lab individually, partly under supervision and partly in self-study. Feedback on the exercises is given to each student within a personal one-on-one discussion.

**Media:**

Moodle e learning platform, presentations, pc-lab, hand-outs, reading material

**Reading List:**

Law, M., Collins, A. (2013): *Getting to Know ArcGIS for Desktop*. Esri Press.

Longley, P. A., Goodchild, M. F., Maguire D. J., Rhind, D. W. (Eds.) (2005): *Geographical Information Systems – Principles, Techniques*. Management and Applications. John Wiley & Sons.

**Responsible for Module:**

Liqiu Meng, liqiu.meng@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geoinformation (Lecture with integrated exercises VI, 4 SWS)

Murphy C, Meng L

## Module Description

### BGU30045: Geovisualization and Geostatistics

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester
<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam of 120 min in total (100%) at the end of the semester. The students have to answer to the questions with own formulations partially they have to sketch issues or circumstances. No auxiliary materials are permitted within the written exam.

The written exam gives the proof that the students have understood, can reflect and can apply statistical methods to spatial data as well as different visualization approaches to spatial and non- spatial data and that they can adapt their skills under time pressure to create visualizations using a combination of spatial and non-spatial data.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Knowledge of higher mathematics and experiences of spatial data handling, as well as a basic understanding of cartography and graphic design are desirable. 'R' programming experience is not required, but would be an advantage.

#### Content:

The content of this module covers geovisualization and geostatistics aspects including geomarketing which are combined to gain insights into spatial data analysis, using statistical methods and to visualize these insights using advanced visualization techniques.

During the lectures the following topics are covered:

- Geovisualization vs. information visualization
- Geospace vs. information space
- Animation and anamorphosis
- User interface design
- Point clustering and analysis
- Basic statistic methods and applications
- Statistical interpolation methods like IDW, kriging, spline etc. and density surfaces
- Components, methods and applications of geomarketing

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- describe the crucial components of geostatistics;
- explain the different usability evaluation methods;
- use methods of explorative spatial data analysis;
- implement geomarketing methods;
- comparing visualization approaches of spatial data and build new visualizations upon the theoretical framework;
- detecting anomalies/events in spatial data and non-spatial data using statistical methods;
- designing visualizations by combining spatial and non-spatial data.

**Teaching and Learning Methods:**

The module is structured in lectures and exercises. The lectures provide the theoretical foundation of geovisualization and geostatistics including geomarketing.

During the exercises, the students are gaining the possibility of applying the learned methods and methodologies to real world problems by implementing case studies to get deeper insights into cartographic- and graphic-design as well as the different statistical analysis methods. The integration of geographical intelligence into all marketing aspects including sales and distribution are introduced. The exercises are carried out individually under supervision. Feedback to the exercises is given to the students by one to one discussions during the contact hours. At the end of the semester, the students have to pass the written exam.

**Media:**

Moodle e learning platform, presentations, pc-lab, hand-outs, exercise sheets, reading material

**Reading List:**

Fry, B. (2008): *Visualizing Data*. O'Reilly.

Hake, G., Grünreich, D., Meng, L. (2002): *Kartographie*. Walter de Gruyter.

MacEachren, A. M. (1995): *How Maps Work*. The Guilford Press.

Slocum, T., McMaster, R. B., Kessler, F. C., Howard, H. H. (2005): *Thematic Cartography and Geographic Visualization*. Pearson.

Tufte, E. R. (1983): *The Visual Display of Quantitative Information*. Graphics Press.

Ware, C. (2004): *Information Visualization: Perception for Design*. Morgan Kaufmann.

**Responsible for Module:**

Liqiu Meng, liqiu.meng@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Visualization of Geodata (Lecture with integrated exercises VI, 2 SWS)

Jahnke M, Meng L

Geostatistics and Geomarketing (Lecture with integrated exercises VI, 2 SWS)

Zosseder K, Strobl C, 'Murphy C



## Module Description

### **BV480016: Introduction to Photogrammetry, Remote Sensing and Image Processing**

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The written exam takes 120 minutes with content of Photogrammetry and Remote Sensing on one hand and Image Processing on the other hand count both 50% of the achievable points. Questions contain drawing and explaining figures, answering questions on methods and solutions, calculations or comparisons of methods and their applicability. Additionally, multiple-choice-questions are including with statements that have to be evaluated as true or false. This part does not contain more than 20% of the total points. No aids or materials are allowed.

Additionally, 4 - 6 study projects are offered that can be used as a midterm exam and can be included in the module grade. They contain programming and documenting solutions for practical problems. As programming and documentation quality cannot be checked in an examination, this part is done as study work.

#### **Repeat Examination:**

Next semester: Yes

End of the semester: No

#### **(Recommended) Prerequisites:**

Linear algebra and MatLab basics for the exercises.

#### **Content:**

During the lectures the following topics are covered:

- Definition Photogrammetry and Remote Sensing
- Characteristics of Photogrammetry and Remote Sensing, applications and development
- Stereoscopic vision and measurement, photogrammetric image analysis, digital stereo processing
- Radiometric basics, multispectral classification
- Optical basics: models and geometric quality of optical projections, description of image quality
- Introduction to Image Processing
- Features of digital images, image transformation, convolution, edge detection
- Segmentation
- Binary image processing
- Vectorization and geometric primitives

- Feature extraction

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- remember the physical basics of the electromagnetic spectrum and radiometric basics;
- understand concepts of photogrammetric image analysis;
- understand the principles of supervised and unsupervised classification;
- understand the principles of stereoscopic records;
- compare image processing operations.
- apply different classifiers and evaluate the classification results;
- apply different image transformations;
- analyse applications from different points of view;
- analyse images by segmentation and feature extraction;
- analyse binary images and to assess results;
- evaluate stereo records and produce anaglyph images;
- evaluate the influence of different factors on the image quality;
- evaluate characteristic features of images;
- plan aerial image campaigns;

**Teaching and Learning Methods:**

The module consists of two lectures where the content is presented using slides, lecture notes, presentations and board. Applications and discussions activate the students to understand the contents. Important parts of the lectures are deepened in the exercise where students solve practical problems by mathematical calculations as well as small programming tasks.

**Media:**

Presentations, hand-outs, exercise sheets, reading material

**Reading List:**

Castleman, A. (1995): *Digital Image Processing*. Prentice Hall, New Jersey.

Haralick, S. (1992): *Computer and Robot Vision (Vol. 1)*. Addison-Wesley, New York.

**Responsible for Module:**

Ludwig Hoegner, ludwig.hoegner@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Photogrammetry and Remote Sensing (Lecture VO, 2 SWS)

Stilla U

Image Processing (Lecture VO, 2 SWS)

Hoegner L

Exercise in Photogrammetry, Remote Sensing and Digital Image Processing (Exercise UE, 1 SWS)

Hoegner L

## **Elective Studies TUM (1. Semester)**

## Module Description

### BGU30047: Principles of Databases (UT/ITC online module)

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	105	45 (online)

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam (100%) at the end of the semester. The students have 120 min. to answer to the exam questions with own formulations, partially they have to mark answers of multiple-choice questions. The exam contains questions related to fundamentals of database management and designing. Within the exam, theoretic case studies on data management are given on which the students show their knowledge to design and construct a specific database model according to the given problem with the appropriate database technology. Furthermore, the student's ability is examined to make SQL queries for handling relational databases.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

- Basic computer handling skills and familiarity with Windows software
- Secondary school discrete mathematics and linear algebra
- Ability to explore new software and new data sets

#### Content:

Geoinformation professionals should be aware of databases as one of the fundamental technologies in their field. Databases are typically used to organize very large, well-structured data collections for multiple user groups and purposes. This is especially important to organizations in which the information provisioning (internally as well as externally) is a critical success factor to the organization's mission. But database technology can also be extremely useful in smaller, one-off single-user projects with a short life-cycle. This presents the rationale for the course.

This course introduces the notion of database and data manipulation. We focus on thematic (also known as attribute) databases, the relational data model, and queries in the query language SQL. Database engineering as we discuss it in this course is an important tool for any type of information management. The techniques learned in this course will be useful throughout the further study, and indeed later in professional life.

The following topics are covered within the lectures:

- Introduction to database technology
- Database management systems

- Relational data model
- Logic & set theory
- Principles of data extraction from databases
- Operating on databases using mathematics in queries
- JSP queries
- Parametric & nested queries
- Summary queries
- Database updating
- Introduction to database design
- Database implementation

### **Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- recognize the knowledge of mathematical logic, statistics, GIS and remote sensing;
- describe the first principles of database design;
- illustrate when to apply database technology and when not;
- explain the fundamentals of the relational data model;
- testing simple queries in mathematics and predicate logic;
- making SQL queries against an existing relational database.

### **Teaching and Learning Methods:**

This is a distance education module. All learning activities, including the examinations take place through the Blackboard electronic learning environment. Each lesson in a unit contains the following elements:

- Demonstration, a digital movie which shows certain theoretical concepts in 'action'
- Exercise, in three forms of discussion (using the discussion board on blackboard), mathematical exercises (using an educational applet) and quizzes
- Self-tests, to help students assess their knowledge typically after completion of a lesson

### **Media:**

Canvas learning platform, courseware package in offline and online format including: lectures, exercises, quizzes, demonstrations, self-tests and book.

### **Reading List:**

Date, C. J. (1990): *An introduction to database systems (Vol. 7)*. Reading, MA: Addison-Wesley.

Elmasri, R. (2008): *Fundamentals of database systems*. Pearson Education.

Stephens, R. K., Plew, R. R. (2001): *Database Design*. SAMS, USA.

Ullman, J (1988): *Principles of Database and Knowledge-Base Systems*. Computer Science Press.

Ramakrishnan, R., Gehrke, J. (2003): *Database management systems (Vol. 3)*. New York: McGraw-Hill Higher Education.

### **Responsible for Module:**

Menno-Jan Kraak, m.j.kraak@utwente.nl

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Principles of Databases (Lecture with integrated exercises VI, 3 SWS)

Pasha Zadeh Monajjemi, P

## Module Description

### BGU30048: Spatial Decision Support Systems (UT/ITC online module)

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester
<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	105	45 (online)

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam (100%) at the end of the semester. The exam duration is 120 min. The students have to answer to the exam questions with own formulations partially they have to mark answer of multiple-choice questions. The exam contains questions related to the learning outcome. By answering these questions under time pressure, the student should verify that he/she has gained the learning outcomes 1,2,3,5,7 listed below about Spatial Decision Support Systems (SDSS), definitions of decision making and framework of decision making processes, methods and software tools for spatial decision support and particularly spatial multi-criteria evaluation. Questions to the accomplished exercise are as well included within the exam. In addition, the exam tests concepts applied to a realistic case study of applying SMCE.

To pass the exam the student must have at least 60% of the total points of the written exam.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Experiences of handling spatial data, as well as a basic understanding of geographic information systems.

#### Content:

This course introduces participants to techniques for selecting and processing data, a view of decisions to be made to generate meaningful and timely information to support the better management of resources. To improve decision making, the required information, tools, techniques, models and decision-making procedures can be integrated in a user-friendly information processing system called a spatial decision support system (SDSS). In contrast to other geo-information systems, an SDSS provides insight into assessments of trade-offs between the various spatial management options under different scenarios open to decision makers, for instance in location-allocation problems. The course provides state of the art developments to prepare students for inclusion of SDSS as part of their research thesis. We particularly address the development and continuity of web-based SDSS as well as collaborative SDSS and serious games in decision rooms.

The following topics are covered within the lectures:

- Why do we need to support decision makers?
- Perspectives on the decision-making process

- What is the role of spatial decision support systems in the decision-making process?
- Basic principles of multicriteria analysis
- Spatial multicriteria analysis
- State of the art development in Spatial Decision Support Systems
- Application of the theory of the decision-making process, multicriteria analysis and spatial multicriteria analysis to case studies

### **Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- recognize the principles of decision-making processes and decision support systems;
- compare between various phases of the decision-making process and their required types of information;
- compare different multi-criteria evaluation techniques;
- describe the linkages between GIS and decision support systems;
- implement spatial multi-criteria decision analysis techniques to combine various layers of information "criteria" of different quality, format and type to support the planning and decision-making process;
- use spatial multi-criteria evaluation techniques in proposing an appropriate solution to a spatial problem;
- assess and interpret the results of the multi-criteria evaluation process;
- develop state of the art research questions about spatial decision support systems.

### **Teaching and Learning Methods:**

This is a distance education module. All learning activities, including the examinations take place through the Blackboard electronic learning environment. Each lesson in a unit contains the following elements:

- Demonstration, a digital movie which shows certain theoretical concepts in 'action'
- Exercise, in three forms of discussion (using the discussion board on blackboard), mathematical exercises (using an educational applet) and quizzes
- Self-tests, to help students assess their knowledge typically after completion of a lesson

Within the exercise, the students have the ability to apply the learned theories and foundations to real world applications. A realistic case study allows students to integrate their understanding obtained from individual readings and exercises. Feedback on the exercise is given to each student by discussion board forum and with web-based meetings (the discussion board forum and the web-based meetings are substituting the face to face discussion) via Blackboard.

To that end, the student is expected to independently follow a very highly structured series of lessons, of different reading assignments and exercises. Additionally 3-4 web-based meetings will be organized to address questions and assess learning progress.

### **Media:**

Blackboard learning platform, courseware package in offline and online format including: lectures, exercises, quizzes, demonstrations, self-tests and book.

### **Reading List:**

Ackoff, R. L. (1981): *The art and science of mess management*. Interfaces 11(1): 20-26.

Boerboom, L. G. J., Oskay, A. (2013): *Distributed open source web - application for spatial multi - criteria evaluation for decision support systems infrastructure*. In: International Journal of Multicriteria Decision Making, 3(2013)2/3, pp. 114-128.

Bojesen, M., Boerboom, L.G.J., Skov-Petersen, H. (2015): *Towards a sustainable capacity expansion of the Danish biogas sector*. Land Use Policy 42: 264-277.

Sharifi, A., (2004). *Spatial Decision Support System*. International Institute for Geo-information Science and Earth Observation (ITC), Enschede, the Netherlands.

Zucca, A. (2008): *Application of spatial multi-criteria analysis to site selection for a local park: A case study in the Bergamo Province, Italy*. In: Journal of Environmental management 88: 752-769.

**Responsible for Module:**

Menno-Jan Kraak, m.j.kraak@utwente.nl

**Courses (Type of course, Weekly hours per semester), Instructor:**

Spatial Decision Support Systems (Lecture with integrated exercises VI, 3 SWS)

Boerboom, L



## Modulbeschreibung

### IN2026: Visual Data Analytics

Fakultät für Informatik

<b>Modulniveau:</b> Master	<b>Sprache:</b> Englisch	<b>Semesterdauer:</b> Einsemestrig	<b>Häufigkeit:</b> Wintersemester
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<b>Credits*:</b> 5	<b>Gesamt- stunden:</b> 150	<b>Eigenstudiums- stunden:</b> 90	<b>Präsenz- stunden:</b> 60
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\* Die Zahl der Credits kann in Einzelfällen studiengangsspezifisch variieren. Es gilt der im Transcript of Records oder Leistungsnachweis ausgewiesene Wert.

#### Beschreibung der Studien-/Prüfungsleistungen:

The exam takes the form of a written test of 75 minutes. Questions allow to assess acquaintance with concepts and algorithms of scientific visualization and visual data analysis, and the application domains where visualization methods are used. The students learn to differentiate common visualization techniques regarding the data modalities they are suited for. Small tasks using public domain visualization tools assess the ability to apply suitable visualization techniques to specific kinds of data and let the students become familiar with common visualization options.

#### Wiederholungsmöglichkeit:

Im Folgesemester: Nein

Am Semesterende: Ja

#### (Empfohlene) Voraussetzungen:

None.

#### Inhalt:

Visualization pipeline (data acquisition, filtering, display), information visualization vs. scientific visualization, grids and grid construction (Delaunay triangulation), interpolation in grids (inverse distance weighting, radial basis functions), discretization aspects, visualization of scalar fields (color coding, iso-contours and iso-surfaces, volume rendering, vector field visualization (particle-based visualization, line integral convolution, topological approaches), terrain rendering including adaptive meshing techniques and hierarchical data representations using quadtree and octrees.

#### Lernergebnisse:

After successful completion of the module, the students have gained advanced knowledge concerning the visualization pipeline, ranging from data acquisition to the final image of the data. This includes knowledge about the application specific data representations, data interpolation and approximation techniques for discrete data sets, data filtering techniques like convolution, as well as the final mapping stage to generate a renderable representation from the data. The students know the common methods which are used in information visualization to graphically depict abstract data, and in scientific visualization to graphically depict 2D and 3D scalar and vector fields, including isocontouring, direct volume rendering, flow visualization, and terrain rendering. They can analyse and categorize available techniques in terms of quality, efficiency, and suitability for a particular data type, and they can model and develop new approaches considering application-specific requirements. In the practical exercises the student learn about the functionality of commonly used visualization tools, they can evaluate available tools based on their functionality, and they can apply these tools to create own visualizations of given data sets.

#### Lehr- und Lernmethoden:

The modul consists of the lecture and an accompanying practical exercise. In the lecture, the lecturer conveys to the students the area-specific knowledge, points towards relevant articles and encourages the students to read and put into relation the presented approaches, and gives examples demonstrating the application of these approaches. In the practical exercises, state-of-the-art tools for scientific visualization are demonstrated online. The students are introduced to these tools so that they can use them on their own. The students are supposed to apply some of the tools for the visualization of 3D data sets from a number of different application domains.

#### Medienform:

Powerpoint course slides, white board exercises, online tutorials and demonstrations

**Literatur:**

Schumann, Müller: Visualisierung - Grundlagen und allgemeine Methoden, Springer Verlag  
C. Hansen, C. Johnson (Ed.): The handbook of Visualization, Academic Press

**Modulverantwortliche(r):**

Westermann, Rüdiger; Prof. Dr.: [westermann@tum.de](mailto:westermann@tum.de)

**Lehrveranstaltungen (Lehrform, SWS) Dozent(in):**

0000001387 Wissenschaftliche Visualisierung - Algorithms for Data Visualization (IN2026, IN8019) (4SWS VI, WS 2018/19) [BF]  
Kehrer J, Westermann R

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Weitere Informationen zum Modul und seiner Zuordnung zum Curriculum:

<https://campus.tum.de/tumonline/wbModHb.wbShowMHBReadOnly?pKnotenNr=1528428>

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## Module Description

### BGU30046: Mapping Project

<b>Module Level:</b> Master	<b>Language:</b> English	<b>Duration:</b> one semester	<b>Frequency:</b> winter semester
<b>Credits:*</b> 5	<b>Total Hours:</b> 150	<b>Self Study Hours:</b> 105	<b>Contact Hours:</b> 45

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written report containing the results of the intended project as well as state of the art, applied methods and methodologies. In addition, a presentation of content and result of the project in a 15 min oral report, including subsequent discussion is part of the overall project work. The written report is rated 70%, the presentation 30% of the overall grade.

The presentation is a means to measure the student's ability to summarize the project, to present the results to an audience in a suitable manner and to conduct a subsequent discussion about the presented project with experts. In particular, the subsequent discussion offers the possibility to evaluate the student's ability to discuss and argue on the applied cartographic techniques, principles and methodologies.

The written report of approx. 20-25 pages measures the student's competence of developing the project from the initial idea to the complete picture. This includes understanding the intended project topic and relating them to cartographic research questions and issues, to evaluate, combine and process spatial and non-spatial data using different tools as well as to evaluate and apply different cartographic techniques, principles and methodologies to gain user- and purpose-oriented results.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

The students should have a basic understanding of cartographic methodologies and techniques and a feeling for a suitable and good graphic design. Programming skills are desirable.

#### Content:

The content varies with the intended project topic related to cartography or comes from associated fields like:

- Geoinformation
- Geovisualization
- Routing (indoor and outdoor)
- Navigation
- Cognition
- Usability engineering

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- understand current cartographic research issues and research questions;
- analyse and process geodata within a spatial context and combine these spatial data with other non-spatial data;
- evaluate different cartographic techniques, principles and methodologies according to the applicability to the intended project;
- create purpose and user oriented results for the intended project;
- discuss and present the applied cartographic/design methodologies with/to experts.

**Teaching and Learning Methods:**

The students are working in groups of two or three persons under supervision on current cartographic research questions/intended project topics. Based on the intended project topic they have to implement a case study, which shows the ability to create sufficient user- and purpose-oriented results, to apply appropriate methods and methodologies and to combine different kinds of data (spatial and non-spatial). Feedback to the groups concerning the implemented case study, the applied methods and methodologies as well as concerning the progress of their project is given to each group by one to one discussions during the contact hours.

Each group has to give a presentation concerning the final results of the intended project at the end of the course. Until the end of the course, each group has to accomplish a written report about the intended project.

**Media:**

Moodle e learning platform, presentations, pc-lab, discussions, reading material

**Reading List:**

Bertin, J. (1967): *Semiologie Graphique*. Mouton/Gauthier-Villars.

Fry, B. (2008): *Visualizing Data*. O'Reilly.

Hake, G., Grünreich, D., Meng, L. (2002): *Kartographie*. Walter de Gruyter.

Klanten, R., Ehmann, S., Schulze, F. (2011). *Visual Storytelling – Inspiring a New Visual Language*. Gestalten Verlag.

MacEachren, A. M. (1995): *How Maps Work*. The Guilford Press.

Slocum, T., McMaster, R. B., Kessler, F. C., Howard, H. H. (2005): *Thematic Cartography and Geographic Visualization*. Pearson.

**Responsible for Module:**

Liqiu Meng, liqiu.meng@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Mapping Project (Project PT, 3 SWS)

Cron J, Jahnke M

## Module Description

### BV030012: Engineering Databases

Civil, Geo and Environmental Engineering

<b>Module Level:</b> Master	<b>Language:</b> English	<b>Duration:</b> one semester	<b>Frequency:</b> winter semester
<b>Credits:*</b> 3	<b>Total Hours:</b> 90	<b>Self-study Hours:</b> 60	<b>Contact Hours:</b> 30

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In the 60-minute exam the students have to demonstrate that they understand and are able to repeat the basic working principles of database theory within a limited timeframe. Additionally, they have to identify solutions and their implementations to technical application problems under time pressure accurately.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic programming skills.

#### Content:

This module includes the following topics:

- Conceptual database design
- Relational algebra
- Query language SQL
- Normalization
- Transactions
- Indexing
- Engineering applications

#### Intended Learning Outcomes:

After completion of the module the students are able to:

- create a conceptual database design using the entity-relationship model;
- apply relational database theory;
- use the query language SQL;
- normalize a relational database schema;
- understand indexing structures;
- use databases for engineering applications.

#### Teaching and Learning Methods:

The teaching results of the module are achieved by multiple coordinated components. The lectures are supported by PowerPoint presentations, blackboard scripts and movies illustrating computer simulations. The lecture contents are completed by exercises in the lecture hall.

#### Media:

Moodle e learning platform, presentations

**Reading List:**

Elmasri, R. Navathe, S.B. (2015): Fundamentals of Database Systems. 7th Edition, Pearson.

**Responsible for Module:**

Alex Braun (alex.braun@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Engineering Databases (lecture, 2 SWS)

Abualdenien J, Vilgertshofer S

For further information in this module, please click  
[campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV570007: Observing and Modeling Global Dynamic Processes

Civil, Geo and Environmental Engineering

<b>Module Level:</b> Master	<b>Language:</b> English	<b>Duration:</b> one semester	<b>Frequency:</b> winter semester
<b>Credits:*</b> 3	<b>Total Hours:</b> 90	<b>Self-study Hours:</b> 60	<b>Contact Hours:</b> 30

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Type of assessment: written exam

Duration of assessment: 60 minutes

The expected learning outcomes are verified by a written exam of 60 min duration. In the exam it is verified that the students understand the theoretical basis, can describe dynamic processes and interactions in the Earth system, and can assess model results. With the discussion of typical examples and specific problem settings the theoretical understanding and the evaluation skills are examined. Through questions at different levels of difficulty, the written exam allows for an individual verification of the understanding and thus a realistic assessment of the acquired competencies.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Required: Knowledge in linear algebra, calculus, signal analysis, programming in Matlab.

#### Content:

Teaching and improving knowledge about:

- Earth system and its components,
- Atmosphere and Ocean: Dynamics and interactions
- Atmosphere- and ocean models,
- Impact of atmosphere and ocean on Earth rotation, gravity field and surface geometry

#### Intended Learning Outcomes:

After successful participation at this module students are capable

- to understand the components of the Earth system and their exchange mechanisms,
- to understand interactions between global dynamic processes on one hand and geodetic parameters on the other hand (Earth rotation, gravity field, surface geometry),

- to analyze and apply models of the atmosphere and ocean for geodetic applications and to assess model results and related predictions,
- to identify the tasks of international organisations monitoring Earth rotation and reference systems,
- to discuss with experts from different geoscientific disciplines.

**Teaching and Learning Methods:**

The content of the course is taught in a lecture in interaction with the students. The learning success is continuously verified with questions. Mathematical derivations are shown at the black board. Selected literature is discussed with the students.

**Media:**

- board content
- presentations in electronic Form and as handouts
- Topic-related publications and book chapters

**Reading List:**

- Lecture Notes

Emanuel, K. (2007): What we know about climate change, Boston Review Books.

- IPCC (2007): Climate Change 2007: Synthesis Report, Geneva.
- Kandel, R. (1980): Earth and Cosmos, Pergamon Press, Oxford
- Selected scientific publications will be distributed in the course

**Responsible for Module:**

Prof. Dr.-Ing. Florian Seitz (florian.seitz@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Earth System Dynamics (lecture, 2 SWS)  
Seitz F [L], Bloßfeld M

For further information in this module, please click

[campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV230050: Atmospheric Physics and Remote Sensing

Civil, Geo and Environmental Engineering

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester
<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self-study Hours:</b>	<b>Contact Hours:</b>
3	90	60	30

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

With an oral examination it shall be ensured that the students are able to remember and to understand the individual concepts and processes of atmosphere and its composition, weather and climate, the Earth's energy budget and radiation balance, and climate predictions. The students should verify that they are able to build interrelations among these concepts, and that they have an insight into their contribution to the overarching concept of system Earth. By means of dedicated questions, it is verified that the students are able to interpret results of observation technologies and that they are able to build connections to physical modelling. The format of an oral exam allows interactive queries, and the students are required to give precise and well-structured answers in real time.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Mathematics, experimental Physics

#### Content:

Atmospheric Physics and Remote Sensing: Introduction to atmospheric physics with an emphasis on remote sensing of atmospheric components and processes from space:

- atmosphere, weather and climate,
- clouds, aerosols and trace gases,
- radiative transfer,
- Earth's energy budget,
- remote sensing of the atmosphere,
- climate modelling and climate change

#### Intended Learning Outcomes:

- After the successful conclusion of the module, the students are able to
- to understand the basic principles of atmosphere, weather, and climate;
  - to understand the methods for determining atmospheric composition and dynamics from space;
  - to apply analysis methods for practical problems related to atmosphere and climate;
  - to apply atmospheric remote sensing methods, and to analyze the results;
  - to link these topics to the monitoring of the Earth system.

**Teaching and Learning Methods:**

Power point presentations; handouts in electronic form; blackboard

**Media:**

- presentations in electronic form
- Blackboard
- Selected text books and scientific publications

**Reading List:**

F.W. Taylor, Elementary Climate Physics, Oxford University Press, 2005.

J.M. Wallace and P.V. Hobbs, Atmospheric Science: An Introductory Survey, Academic Press, 2nd edition, 2006.

W. Roedel, Physik unserer Umwelt: Die Atmosphaere, Springer, 3. Auflage, 2000.

L. Bergmann und C. Schaefer, Lehrbuch der Experimentalphysik Band 7: Erde und Planeten, de Gruyter, 2. Auflage, 2001.

**Responsible for Module:**

Roland Pail (pail@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Atmospheric Physics and Remote Sensing (lecture, 2 SWS)

Kiemle C

For further information in this module, please click

[campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0453: English - Scientific Presentation and Writing C2

Civil, Geo and Environmental Engineering

<b>Module Level:</b> Bachelor/Master	<b>Language:</b> English	<b>Duration:</b> one semester	<b>Frequency:</b>
<b>Credits:*</b> 3	<b>Total Hours:</b> 90	<b>Self-study Hours:</b> 60	<b>Contact Hours:</b> 30

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Grades for oral presentations including a handout and visual aids (25%), written homework assignments (50%), and a final exam (25%) contribute equally to the final course grade. Duration of the final examination: 60 minutes.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Ability to begin work at the C2 level as evidenced by a placement test score in the range of 80 % - 100 percent. (Please check current announcements as the exact percentages may vary each semester.)

#### Content:

This course allows students to practice for formal speaking tasks in English such as a class presentation, dissertation defense or conference talk, and for completing formal written tasks such as a journal article, report, project proposal or a literature summary.

#### Intended Learning Outcomes:

After completion of this module students can understand with increased ease virtually everything heard or read; they can summarize information from different spoken and written sources, reconstructing arguments and accounts in a coherent presentation, and they can express themselves spontaneously very fluently and precisely, differentiating finer shades of meaning even in more complex situations.

#### Teaching and Learning Methods:

This course makes use of video-taping and classroom evaluation to help students develop their public speaking skill. Techniques for evaluating one's own writing will be practiced, with opportunities to revise drafts. Oral and written peer evaluations will form a regular component of the class sessions including use of an online peer forum and online instructor feedback.

#### Media:

Course handouts, online platform, video taping

#### Reading List:

Some recommended reference works:

Silyn-Roberts, Heather. (2000) Writing for Science and Engineering: Papers, Presentations and Reports. Butterworth Heinemann Publishers. ISBN 0-7506-4636-5.

Reinhart, Susan (2002) Giving Academic Presentations. Ann Arbor: University of Michigan Press. ISBN 0-472-

08884.

Oshima, Alice, Ann Hogue (2006) Writing Academic English 4th Ed. Pearson Longman. ISBN 0-13-152359-7.

Williams, Joseph (2000) Style: Ten Lessons in Clarity and Grace Addison, Wesley Longman Co. ISBN 0-321-28831-9.

**Responsible for Module:**

Heidi Minning

**Courses (Type of course, Weekly hours per semester), Instructor:**

English - Scientific Presentation and Writing C2 (seminar, 2 SWS)

Minning H [L], Clark R

For further information in this module, please click

[campus.tum.de](https://campus.tum.de) or [here](#).

## **Degree Requirements Wien (2. Semester)**

## Module Description

### **BV300027: Cartographic Theories and Applications**

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	summer semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
9	270	180	90

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination consists of a written exam (70%) and a project report (30%). The written exam which takes place at the end of the semester has a duration of 120 min. The students have to answer to the questions of the written exam with own formulations partially they have to sketch issues or circumstances. No auxiliary materials are permitted during the written exam. The written exam is a means to measure the student's ability of understanding, analysing and applying fundamentals of cartographic theories, the key criteria for developing cartographic research projects and the interoperability aspect of cartographic spatial data handling.

The project report is a documentation of a prototype application development which was carried out during the semester. The project report should discuss the applied methods and methodologies as well as illustrate the individually chosen approach to solve the cartographic/visualization problem. This report should cover approx. 15 pages. The project report measures the student's ability to evaluate and to judge on methodologies of cartographic projects.

#### **Repeat Examination:**

Next semester: Yes

End of the semester: No

#### **(Recommended) Prerequisites:**

Knowledge of cartographic communication principles, technology-based web mapping, as well as a basic understanding of carto-graphic methodology and graphic-design are recommended.

#### **Content:**

The topics of this module are major theories and methods of scientific cartography. By evaluating the research agenda of Cartography relevant paradigms are assessed. Basic knowledge concerning cartographic methodology, influencing research and scientific theories are imparted and are enriched by focusing on selected topics of current scientific interest, such as generalisation, interactivity or visualisation. A major focus is dealing with cartographic interfaces and cartographic information systems, thus applying theories and methods of cartographic communication processes in various technological environments, such as the web. By acknowledging the principles of cartographic data handling in the context of interactive systems, interoperability, Spatial Data Infrastructures and Spatial Data Handling the relevance and importance of cartography-based interfaces and system development becomes a competence.

The following topics are covered within the lectures:

- Cartographic research and drivers of research
- Cartographic research agenda
- Advanced definitions and theories
- Geospatial information management
- Cartographic and model generalisation
- Spatial data infrastructure (SDI) and standards (OGC, ISO)
- Service-oriented cartography
- Interoperability
- Mashups and web-services
- OpenData and OpenGovernment data
- Advanced interface design (theories, methods, applications)
- Modelling interactive interfaces
- Cartographic application development

### **Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- apply advanced cartographic theories and key criteria for developing cartographic research projects;
- apply concepts, methods and methodologies of spatial data handling;
- evaluate and judge influencing factors of cartographic projects in the context of a spatial data infrastructure;
- create components and relations of contemporary scientific cartographic projects in the realm of SDI.

### **Teaching and Learning Methods:**

The module is structured in lectures, exercises and project work. The lectures provide the theoretical foundation of theoretical cartography, cartographic interfaces and cartographic information systems. Guest lectures of selected representatives of academia and industry gives insights into advanced cartographic topics related to research and business. Within the exercises, the students have the ability to apply the learned theories and foundations to real word applications. The exercises are carried out individually under supervision

The project work focuses on the whole picture from the initial idea to a prototype application and puts the individual steps applied during the exercises together. Until the end of the semester the students have to write a short report concerning the project topic, the applied methods and methodologies as well as about the chosen approach to solve the cartographic/visualization problem. At the end of the semester the students can give oral presentations summarizing their project work in order to receive expert feedback.

The exercises as well as the project work are carried out individually under supervision. Feedback to each student is given by e-mail and by face-to-face discussions during the contact hours.

### **Media:**

TUWEL e-learning platform, presentations, script, pc-lab, hand-out, exercise sheets

### **Reading List:**

Burghardt, D. et al (2014): *Abstracting Geographic Information in a Data Rich World*. Springer.

Dykes, J. et al (2005): *Exploring Geovisualization*. Elsevier.

Kraak, M.J. et al (1996): *Cartography*. Prentice Hall.

Lemmers, M. (2011): *Geo-Information*. Springer.

MacEachren, A. M. (1995): *How Maps Work: Representation, Visualization and Design*. The Guilford Press.

Peterson, M. (2003): *Maps and the Internet*. Elsevier.

UN-GGIM (2014): *United Nations Global Geospatial Information Management*.

**Responsible for Module:**

Georg Gartner, georg.gartner@tuwien.ac.at

**Courses (Type of course, Weekly hours per semester), Instructor:**

Theoretical Cartography (Lecture VO, 2 SWS)

Gartner G

Cartographic Interfaces (Lecture with integrated exercises VI, 2 SWS)

Jobst M

Cartographic Information Systems (Lecture with integrated exercises VI, 2 SWS)

Porras Bernardez F



## Module Description

### BV300028: LBS and Multimedia Cartography

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	summer semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
10	300	195	105

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam of 120 min (30%) and a written project report (70%). The students have to answer to the exam questions with own formulations partially they have to sketch issues or circumstances. No auxiliary materials are permitted within the written exam.

The written exam measure the students ability to understand the basic concepts of location based services and multimedia cartography, the important key issues/concepts which have to be taken into account for a successful project as well as issues from related fields. Different legal and intellectual property (ip) issues have to be theoretically evaluated for locations based services (lbs) and multimedia cartography applications.

Additionally, the students have to write one project report. The written project report measures the student's competence of developing three different short projects from the initial idea to a prototype application and to concatenate these projects in the context of location based services and multimedia cartography. The three short project parts of the project report are complementary in achieving all learning outcomes. This ensures the students understand the relation of the projects, can evaluate, combine and process spatial data using contemporary programming languages and frameworks, can generate results, which can be used by the subsequent projects, and can evaluate and apply different visualization techniques, principles and methodologies to gain user and purpose-oriented results.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Knowledge as presented by the Cartography M.Sc modules:

- Geovisualization and Geostatistics
- Cartographic Foundations

Recommended Cartography M.Sc. module:

- Mapping Project

Knowledge of fundamental cartographic principles, map design, web mapping, as well as a basic understanding of multimedia, web publishing and programming are recommended.

**Content:**

This module deals with Location-based Services. By evaluating the main components of LBS including positioning, modelling and presentation, various aspects of ongoing research are presented. Fundamental questions of LBS, including technical, economical and legal frameworks are discussed. Development of the LBS project by applying the theoretical input into a live LBS application. A main element of LBS is applying methods of multimedia to cartography. Thus the theory, the methods and the programming of such services is key. Learning to know the fundamentals and principles of cartographic data handling in the context of multimedia cartography as well as digital cartography in general is therefore element of this module.

The following topics are covered within the lectures:

- Components and applications of location based services
- Indoor and outdoor positioning methods and constraints
- Modelling location based services
- Interfaces and cartographic presentation
- Legal, economic and technological constraints of location based services and multimedia cartography
- Theories and applications of multimedia cartography
- GeoCommunication
- Interactivity and animation in multimedia cartography applications
- Information-graphics in the domain of location based services and multimedia cartography
- Contemporary programming methodologies and frameworks

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- understand the relations of lbs and multimedia cartography to associated fields;
- understand the fundamentals in location based services and multimedia cartography;
- understand key criteria's for developing cartographic research projects in the context of location based services;
- and multimedia cartography;
- implement appropriate interfaces for location based services and multimedia cartography;
- analyse legal constraints and intellectual property issues for lbs and multimedia cartography;
- evaluate appropriate visualization methods for lbs and multimedia cartography;
- create lbs and multimedia cartography applications using contemporary programming languages and frameworks.

**Teaching and Learning Methods:**

The module is structured in lectures, exercises and project work. The lectures provide in particular the theoretical foundation of location based services, multimedia cartography and associated fields like communication, graphic design and application programming.

Within the exercises, the students have the ability to apply the learned theories and foundations to real word applications in the context location based services and multimedia cartography. The exercises are carried out individually under supervision

Each student has to accomplish three different short projects. Each of the projects focuses on the whole picture from the initial idea to a prototype application and puts the individual steps applied during the exercises together. Until the end of the semester the students have to write a report covering the three different project topics, the applied methods and methodologies as well as about the chosen approach to solve the lbs or multimedia cartography problem. At the end of the semester the students can give oral presentations summarizing their project works in order to receive expert feedback.

The exercises as well as the project work are carried out individually under supervision. Feedback to each student is given by e-mail and by face-to-face discussions during the contact hours.

**Media:**

TUWEL e-learning platform, presentations, script, pc-lab, hand-out, exercise sheets

**Reading List:**

Cartwright et al (2007): *Multimedia Cartography*. Springer.

Chun, L (2014): *Principle and Application Progress in LBS*. Springer.

Gartner, G. et al (2015): *Progress in LBS*. Springer.

Krisp, J (2013): *Progress in LBS*. Springer.

**Responsible for Module:**

Georg Gartner, georg.gartner@tuwien.ac.at

**Courses (Type of course, Weekly hours per semester), Instructor:**

Location-based Services (Lecture with integrated exercises VI, 3 SWS)

Gartner G, Retscher G, Rehl K

Multimedia Cartography (Lecture with integrated exercises VI, 2 SWS)

Gartner G, Porras Bernardez F

Programming Cartographic Tasks (Lecture with integrated exercises VI, 2 SWS)

Ledermann F

## Module Description

### BV300029: Cartographic Publishing

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	summer semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam of 120 min (100%). The students have to answer to the exam questions with own formulations partially they have to sketch issues or circumstances. No auxiliary materials are permitted within the written exam.

The written exam measures the student's ability to understand basic concepts of web-mapping application and geo-media techniques. In particular, the understanding, applying and analysing the internet and press as relevant outlets of the cartographic communication processes, to formally apply these concepts using contemporary programming languages and frameworks and apply graphical design rules for visualizing spatial data.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Knowledge as presented by the Cartography M.Sc. module 'Cartographic Foundations' is recommended.

#### Content:

This module deals with contemporary ways to disseminate cartographic products. Thus a focus is geo-media techniques. By evaluating the main components of geo-media techniques including DTP, Press and PrePress, typography and design, raster image edit-ing various aspects of ongoing research are presented. The Internet is a key media for disseminating cartographic products, thus a focus of this module is dealing with web-mapping, thus learning to know the fundamentals and principles of cartographic data handling in the context of internet cartography.

The following topics are covered within the lectures:

- Graphic data handling
- Desktop Publishing
- PrePress
- Digital Printing Methods
- Typography
- Graphical Design
- Raster image processing

- Maps in the Internet
- Map Galleries
- Interactive Maps
- Client-based Scripting and Markup Languages
- Graphics and Interactivity
- Contemporary programming methodologies and frameworks

### **Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- understand the internet and press as relevant outlets of the cartographic communication process;
- analyse key criteria for developing geo-media and web-mapping projects;
- apply contemporary programming languages to develop web-mapping applications;
- create components and relations of contemporary geo-media techniques and web-mapping projects.

### **Teaching and Learning Methods:**

The module is structured in lectures, exercises and project work. The lectures provide in particular the theoretical foundation of cartographic publishing in particular geo-media techniques and web-mapping as well as associated fields web-based programming.

Within the exercises, the students have the possibility to apply the learned theories and foundations to real word applications in the context web-mapping and geo-media techniques. The exercises are carried out individually under supervision

Each student is encouraged to accomplish two different short projects. Each of the projects focuses on the whole picture from the initial idea to a web-mapping application and puts the individual steps applied during the exercises together. Until the end of the semester, the students can write a short report for each project, covering the applied methods and methodologies as well as about the chosen programming frameworks to accomplish a web-mapping application. At the end of the semester, the students give oral presentations summarizing their project work. The student's project handling teaches them to create web-mapping applications with geo-media techniques using contemporary programming languages and is therefore a helpful preparation for many questions of the written exam.

The exercises as well as the project work are carried out individually under supervision. Feedback to each student is given by e-mail and by face-to-face discussions during the contact hours.

### **Media:**

TUWEL e-learning platform, presentations, script, pc-lab, hand-out, exercise sheets

### **Reading List:**

Cartwright et al (2007): *Multimedia Cartography*. Springer.

Dykes, J. et al (2005): *Exploring Geovisualization*. Elsevier.

Kraak, M.J. et al (2002): *Web Cartography*. Taylor & Francis.

MacEachren, A. M. (1995): *How Maps Work: Representation, Visualization and Design*. The Guilford Press.

Peterson, M. (2003): *Maps and the Internet*. Elsevier.

### **Responsible for Module:**

Georg Gartner, georg.gartner@tuwien.ac.at

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geo-Mediatechniques (Lecture with integrated exercises VI, 2 SWS)

Ortag F

WebMapping (Lecture with integrated exercises VI, 2 SWS)

Ledermann F

## Module Description

### **BV300030: Applied Cartographic Research and Development**

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	summer semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

This module is completed with a written project report (approx. 20 pages) as the module exam. The written project report consists of a project documentation and a scientific paper review.

The project documentation shows the students ability to manage a cartographic research project from the initial idea to the final product. In particular, specific characteristics of the cartographic domain different project management approaches have to be considered. The scientific paper review part shall put the project documentation into an overall scientific framework. The scientific paper part covers the student's capability of writing scientifically correct research papers by using the advanced methods and methodologies. The quality of the paper shows the students ability of evaluating and applying key criteria for developing and writing research papers.

#### **Repeat Examination:**

Next semester: Yes

End of the semester: No

#### **(Recommended) Prerequisites:**

Knowledge of fundamental cartographic principles is recommended.

#### **Content:**

This module covers advanced scientific writing and presentation methods and cartographic project management, thus is dealing with components of research-driven cartography. The Cartographic seminar includes the selection of a contemporary research topic of a current cartographic problem, scientific referencing of cartographic literature, structuring, writing and presenting. The Cartographic Project deals with learning to know the fundamentals and principles of project management in the context of cartography.

The following topics are covered within the lectures:

- Scientific sources in cartography
- Literature inquiries
- Advanced scientific writing and presenting
- From the problem to the publication
- Cartographic project management
- Cartographic project planning

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- understand scientific papers and research projects as relevant outlets of cartographic research;
- apply the advanced methods of scientific writing and presenting;
- evaluate scientific papers and presentations in the domain of cartography;
- evaluate contemporary project management methods and methodologies according to a intended cartographic project.

**Teaching and Learning Methods:**

The module is structured in lectures and project work. The lectures provide in particular the theoretical foundation of advanced scientific writing and presentation methods as well as the basics of project management and project planning considering the characteristics in cartography.

Until the end of the semester, the students have to write a report for each project. Within the first project part, the students gain the ability to prove the learned theories and foundations by writing a scientific correct paper, which covers a cartographic problem based on a topic provided by the cartographic research agenda. Within the second project, the students can prove their competence in project planning and management skills. The projects are carried out individually under supervision. Feedback according to the projects is given to each student by e-mail or by face-to-face discussions during the contact hours.

**Media:**

TUWEL e-learning platform, presentations, script, pc-lab, hand-out, exercise sheets

**Reading List:**

Cartwright et al (2007): *Multimedia Cartography*. Springer.

Dykes, J. et al (2005): *Exploring Geovisualization*. Elsevier.

Kraak, M.J. et al (2002): *Web Cartography*. Taylor & Francis.

MacEachren, A. M. (1995): *How Maps Work: Representation, Visualization and Design*. The Guilford Press.

Peterson, M. (2003): *Maps and the Internet*. Elsevier.

**Responsible for Module:**

Georg Gartner, georg.gartner@tuwien.ac.at

**Courses (Type of course, Weekly hours per semester), Instructor:**

Course (Type of course, Weekly hours per semester), Instructor:

Seminar on Cartography (Lecture VO + Project PT, 2 SWS)

Gartner G

Project Map Creation (Project PT, 3 SWS)

Schmidt M



## Required Studies Dresden (3. Semester)

## Module Description

### **BGU30061: Georelief and Cartography – Morphogenetic and Environmental Understanding**

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester
<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
10	300	180	120 (90 EX, 30 VO)

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination is taken by a project work (100%). The project work consists of a written project report (approx. 25 pages) and a project presentation (20 min.).

The report measures the student's ability to understand, describe and apply concepts, applications and approaches of cartographic Georelief visualizations, using navigation hints within the alpine environment as well as methods for collecting data and transfer them to a cartographic product like a thematic map.

The project presentation assesses the communicative competence in presenting a scientific topic to an audience. Furthermore, it gives the opportunity for iterative questions of increasing complexity as well as to commit oneself to the student's knowledge base, which leads to a realistic estimation of the achieved competences during the module.

#### **Repeat Examination:**

Next semester: No

End of the semester: Yes

#### **(Recommended) Prerequisites:**

Knowledge as presented by the Cartography M.Sc. modules Cartographic Foundations and LBS and Multimedia Cartography.

#### **Content:**

The principal objective is to enhance the geo-thinking through a detailed presentation of an exemplary alpine landscape in close relation to methods and realizations of its cartographic depiction. Important educational targets are:

- Introduction into the dynamic natural and cultural environment of the Alpine study region and corresponding maps and geo-data (incl. satellite imagery)
- Wayfinding and navigation (including use of LBS) in an alpine environment and mountain dangers
- Recognize local geo-features within a wider geographical context (Eastern Alps)
- Topography and practical orientation within varying landscapes
- Field mapping using traditional and electronic data capturing methods
- Thematic mapping in high mountain regions

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- understand local geo-features within a wider geographical context (Eastern Alps);
- understand topography and orientate within varying landscapes;
- apply methods for mountain-risk-analysis with geoinformation systems;
- create field-maps and collect geodata using GPS, total stations etc.;
- create advanced thematic maps;
- create cartographic products of alpine landscape considering the dynamic, natural and cultural environment of the alpine region.

**Teaching and Learning Methods:**

The module combines on-site lectures, day excursions and practical in-situ training. Most of the education is done in the field and in direct contact to the features under discussion. 11 complete days of field work comprising lectures and practical work. Documentary films on landscape genesis serve as discussion basis. In-depth lectures will be given after the excursion during the semester at TUD. Individual work on the project report needs to be done after return. The student's individual projects are to be presented after the excursion.

**Media:**

OPAL E-Learning platform, presentations, handouts, films, literature

**Reading List:**

Pfiffner, O.A. (2014): *Geology of the Alps*. Wiley Blackwell.

Anderson, R., Anderson S. (2012): *Geomorphology*. Cambridge University Press.

Imhof, E. (2007): *Cartographic relief presentation*. Esri Press.

Harvey, A. (2012): *Introducing Geomorphology: A Guide to Landforms and Processes*. Dunedin Academic Press.

Buchroithner M. (2014): *Excursion Guide for Alpine Field School*. Institute for Cartography, TU Dresden.

**Responsible for Module:**

Dirk Burghardt, dirk.burghardt@tu-dresden.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Georelief and Cartography – Morphogenetic and Environmental Understanding (Lecture VO, 2 SWS)

Burghardt D, Prechtel N

Georelief and Cartography – Morphogenetic and Environmental Understanding (Excursion EX, 6 SWS)

Burghardt D, Prechtel N

## Module Description

### BGU30059: Mobile Cartography

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
10	300	225	75

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam (50%) and a project work (50%). The written exam duration is 120 min. The students have to answer to the exam questions with their own formulations, partially they have to sketch issues or circumstances. No auxiliary materials are permitted within the written exam.

The written exam measures the students' ability to understand the basic concepts of mobile cartography and automated generalisation. In particular to compare different generalisation algorithms, the concepts of representing spatial features in various ways depending on the visualization medium and the scale as well as understanding the complete information flow for/on mobile devices and their constraints. The verification of knowledge and understanding of related theories and methods for data capturing, mobile UI design, positioning and sensor, context and adaptation, generalization operators, algorithms and generalization processes is included in the written exam.

The project work covers the writing of a project report (approx. 25 pages) documenting their programmed application which was carried out during the practical course work. The written report measures the student's competence of developing a mobile application from the initial idea to a prototype. This includes evaluating of user-interface design methodologies, generalisation operators, algorithms, generalisation workflows and contemporary programming languages and frameworks.

#### Repeat Examination:

Next semester: Yes

End of the semester: Yes

#### (Recommended) Prerequisites:

Knowledge as presented by the Cartography M.Sc. modules Cartographic Foundations, LBS and Multimedia Cartography as well as Cartographic Theories and Applications.

#### Content:

The course provides an overview of theories, methods and application for information delivery and cartographic presentation on mobile devices. The course structure reflects the complete processing chain and visualization pipeline starting with data capturing and integration, followed by scale dependent data modelling until adaptive information presentation on small screens. In addition theories and methods for automated generalisation and multiple representations will be presented. Lecture topics concerning mobile cartography in detail:

- Introduction to mobile cartography with definitions, platforms, applications and research challenges

- Mobile user interface design
- Icon and map design for small screens
- Positioning techniques, sensors and geosensor networks
- User generated content
- Navigation, context and adaptation
- Field based evaluation methods
- Methods for interactive and automated generalisation.

### **Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- understand the complete information flow on mobile devices, considered data capturing and integration, scale dependent data modelling until adaptive information presentation;
- capture and integrate geodata to mobile devices;
- apply context modelling and user modelling with geodata on mobile devices;
- apply and evaluate concepts and algorithms for generalisation of 2D- and 3D-geodata;
- create multiple representation of geodata on mobile devices;
- create on-demand and on-the-fly generalization applications with geodata on mobile devices;
- create mobile applications (e.g. navigation, way finding, orientation, tourist maps).

### **Teaching and Learning Methods:**

The module is structured in lectures and the practical course work on the students' individual projects. The lectures provide in particular the theoretical foundation of mobile cartography and automated generalisation and associated fields like communication, graphic design and application programming.

Within the practical course work, the students gain the ability to apply acquired knowledge of theories and foundations to real world applications in the context of generalisation and mobile cartography, i.e. programming a map based mobile application (weather forecast app, event calendar, campus finder etc.). The presentation of each programmed application will be discussed with the whole group, which gives the opportunity to try to get to the bottom of the applied concepts and methodologies. Until the end of the semester, the student has to write a project report covering the development issues of the programmed application. The practical course work is carried out individually under supervision. Feedback to each student is given by e-mail and by face-to-face discussions during the contact hours.

### **Media:**

OPAL E-Learning platform, presentations, hand-outs, exercise sheets

### **Reading List:**

Burghardt, D., Duchene, C., Mackaness, W. (2014): *Abstracting Geographic Information in a Data Rich World. Methodologies and Applications of Map Generalisation*. Springer.

Duckham, M. (2013): *Decentralized Spatial Computing. Foundations of Geosensor Networks*. Springer.

Gartner, G., Cartwright, Peterson, M. (2008): *Location Based Services and TeleCartography (I+II)*. Springer.

Gartner, G., Ortag, F. (2012): *Advances in Location-Based Services*. Springer.

Meng, L. Zipf, A., Winter, S. (2008): *Map-based Mobile Services*. Springer.

### **Responsible for Module:**

Dirk Burghardt, dirk.burghardt@tu-dresden.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Mobile Cartography (Lecture VO, 2 SWS)

Burghardt D

Mobile Cartography (Exercise UE, 3 SWS)

Hauthal E

## Module Description

### BGU30058: Subject-specific GIS Applications and Case Studies

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
10	300	225	75

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

An oral examination of 20 minutes duration takes place in the end of the semester and a project report is to be prepared of approx. 25 pages. The practical outcome of this report, which consists of programme code plus documentation, is the proof, that algorithms and sample programmes have been understood, and practical programming skills have been developed for self-programming algorithms and small customised software solutions. Consequently, grades assigned to the report bear a 50% weight in the rating, whilst the other 50% reflect the results of the oral examination. The oral examination ensures that the students understand the concepts and needs for GIS applications in a specific field.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Introduction to geo-information systems and basic programming knowledge are required.

#### Content:

Any major project demands for avoidance of time-consuming interactive data testing, analysing and transformation. In most cases interactive work flows can be formalised and automated. Customised development using existing APIs of GIS software can boost innovative solutions, quality and speed. Consequently, the module...

- exemplifies a need for automation in various geo-applications like, for instance, consistency checks, route and time demand calculation, segmentation, treatment of incomplete data, processing of dynamic phenomena;
- demonstrates concepts of automation;
- provides solutions for selected spatial problems, for which no built-in software solution exists;
- introduces types and organisation forms of programme libraries delivered with GIS software;
- offers and discusses sample codes and methods;
- guides individual developments.

#### Intended Learning Outcomes:

Upon completion of the module, students are able to...

- remember exemplary use cases of automated geo-processing;

- understand the necessity of automation in the work with geo-data;
- analyse spatial problems in order to find an appropriate modularisation;
- understand provided algorithms and code samples of lower complexity;
- design small customised software solutions;
- develop their own codes.

### **Teaching and Learning Methods:**

Within lectures the students get introduced to solutions for selected spatial problems of higher complexity, for which no built-in software solution exists within standard GIS software. Examples will mostly be taken from accomplished projects (case studies) and will comprise various fields of application. Furthermore, the student gets an introduction into types and structures of programme libraries of the software used (i.e. ArcObjects, ArcPy-Interface) and into methods of accessing these libraries in the scope of custom developments. In the exercises, the programming of algorithms and small customised software solutions is done by the students individually in a computer lab. After some guided practical programming with extensive comments on all steps, the students shall finally develop their own programmes of limited size and complexity. Such development will start under supervision and will build upon previous presentations of theory and examples. Within the report the students must individually complete and document the development. The report is to be prepared during self-study hours. The programming tasks will be put under an umbrella topic, which will presumably vary from year to year. The thematic links between the tasks encourage communication between the participants.

### **Media:**

OPAL E-Learning platform, presentations, hand-outs, exercise sheets

### **Reading List:**

ESRI. *ArcGIS Resources. Online Help for Developers.* [http://resources.arcgis.com/en/help/arcobjectsnet/conceptualhelp/index.html#/Developing\\_with\\_ArcGIS/0001000001ww000000/](http://resources.arcgis.com/en/help/arcobjectsnet/conceptualhelp/index.html#/Developing_with_ArcGIS/0001000001ww000000/)

Guttag, J. V. (2013): *Introduction to Computation and Programming Using Python*. Cambridge (MA): MIT Press.

Longley, P. A., Goodchild, M. F. Maguire, D. J. Rhind, D. W. (Eds.) (2005): *Geographical Information Systems: Principles, Techniques, Management and Applications*. Wiley & Sons.

Prechtel, N. (2003): *Selected Problems and Solutions for Drainage Modelling and Handling in a GIS. Kartographische Bausteine: 21 (101-109)*. Dresden: Institut für Kartographie.

### **Responsible for Module:**

Dirk Burghardt, [dirk.burghardt@tu-dresden.de](mailto:dirk.burghardt@tu-dresden.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Subject-specific GIS Applications and Case Studies (Lecture with integrated exercises VI, 5 SWS)

Prechtel N



## Module Description

### BGU30057: Remote-Sensing-based Environmental Mapping

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	120	30

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of an oral exam (100%) of 20 min duration. The oral exam is a means to measure the students' ability to understand, describe and apply and analyse multi remote sensor data, classification methods for airborne and space borne imagery, existing methods to multi scale monitoring and evaluate different types of spatial analysis for environmental mapping. This includes the required knowledge about foundations of radiometry and remote sensor systems, pixel-based and object-based image analysis as well as applications related to local and global scales.

The oral exam gives the opportunity for iterative questions of increasing complexity as well as to commit oneself to the students' knowledge base, which leads to a realistic estimation of the achieved competences during the module.

#### Repeat Examination:

Next semester: Yes

End of the semester: Yes

#### (Recommended) Prerequisites:

Basic skills in remote sensing and GIS with special emphasis on applications in international cooperation.

#### Content:

The module provides information on sensor characteristics and on basic as well as advanced methods of environmental remote sensing with special regard to the analysis of multi-level space- and airborne digital imagery. Applications of regional to global environmental mapping are presented and discussed, in detail:

- Foundations of radiometry and remote sensor systems
- Libraries of spectral signatures of land and ocean surfaces
- Pixel-based and object-based image analysis
- Case studies in local to global scales

#### Intended Learning Outcomes:

Upon completion of the module, students are able to...

- understand and classify airborne and space borne imagery based on hybrid approaches;
- assess land cover change and its dynamics;
- apply existing and to develop new strategies for multi-scale monitoring;
- integrate remote sensing environmental mapping with geoinformation systems;

- analyse multi-sensor remote sensing data;
- evaluate various types of spatial analysis towards environmental mapping.

**Teaching and Learning Methods:**

The module is focusing on lectures together with interactive discussion. The theoretic framework and application-oriented perspectives are presented and discussed by an integrated approach of teaching and teamwork with students. Case studies are analysed in detail and application-oriented multi-thematic knowledge is communicated by a participatory teaching approach.

**Media:**

OPAL E-Learning platform, presentations, hand-outs

**Reading List:**

Jones, H.G. & Vaughan, R.A. (2010): *Remote Sensing of Vegetation: Principles, Techniques, and Applications*. Oxford University Press.

Lillesand, T.M., Kiefer, R.W., Chipman, J.W. (2008): *Remote Sensing and Image Interpretation*. 6th ed. Wiley & Sons.

Sabins, F.F. (2007): *Remote Sensing: Principles and Interpretation*. 3rd ed. Waveland Press.

**Responsible for Module:**

Elmar Csaplovics, [elmar.csaplovics@tu-dresden.de](mailto:elmar.csaplovics@tu-dresden.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Remote-Sensing-based Environmental Mapping (Lecture VO, 2 SWS)  
Csaplovics E

## Module Description

### BGU30050: Geodata Infrastructures

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a written exam with a duration of 90 min (100%). The students have to answer to the exam questions with their own written formulations. No auxiliary materials are permitted within the written exam. The written exam measures the student's ability to understand theories and methods of Geospatial Data Infrastructures. Some questions will address the student's ability to assess geoinformation services in multiple aspects. Furthermore, case studies are given where the students have to theoretically elaborate on how they would model and present geodata and develop a geoinformation service on a specific device.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Good knowledge and practical skills in GIS applications, basic knowledge in computer science and programming.

#### Content:

The module provides an overview about organizational and technical aspects of Geodata Infrastructures (GDI), about regulations and frameworks, about foundations of interoperability for geoinformation and related research.

The lecture topics are:

- Concepts of Geospatial Data Infrastructures
- Data infrastructure frameworks
- Object-relational geospatial databases
- Spatial Data Infrastructures applications
- Technical components of GDI
  - geospatial data repositories
  - metadata catalogues
  - access services
  - technical standards
- European SDI (INSPIRE)

**Intended Learning Outcomes:**

Upon completion of the module, students...

- have comprehensive knowledge about current GDI developments and foundations;
- are able to design and develop geoinformation services and to publish geodata in GDIs;
- are able to use and assess related tools and methods for setting up geoinformation services;
- can apply context modelling and user modelling with geodata on mobile devices.

**Teaching and Learning Methods:**

The module is structured in lectures and exercises. The lectures provide the theoretical foundation of GDI. There are guided exercises carried out in supervised groups. Within this practical course work the students will set a GI service (e.g. Map Services). The geoinformation services implemented by the students can be presented and discussed with all students in order to receive feedback from the lecturer.

**Media:**

OPAL E-Learning platform, presentations, hand-outs, exercise sheets

**Reading List:**

Bernard, L., Mäs, S., Müller, M., Henzen, C., Brauner, J. (2014): *Scientific Geodata Infrastructures: Challenges, Approaches and Directions*. International Journal of Digital Earth. 7(7):613-633.

Masser, I. (2010): *Building European Spatial Data Infrastructures. 2nd Edition*. Redlands, CA: ESRI Press.

<http://inspire.jrc.ec.europa.eu>

**Responsible for Module:**

Lars Bernard, lars.bernard@tu-dresden.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geodata Infrastructures (Lecture with integrated exercises VI, 3 SWS)

Bernard L, Mäs S

## Module Description

### BGU30051: Laser Scanning and DTM Generation

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	120	30

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

A written exam of 90 min takes place at the end of the semester. By answering the questions the student should verify that they have gained the required knowledge about the complete DTM processing workflow starting from airborne laser scanning techniques over data pre-processing and georeferencing to DTM generation with quality control. The exam contains questions in which they have to give valid definitions, explain concepts and theoretically implement and evaluate case studies.

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Basic knowledge in geo-information science, relevant practical computer skills.

#### Content:

The module provides an overview on laser scanning and DTM generation techniques, including theoretical background, sensor technology, measurement systems, algorithms and data processing methods as well as application examples. Special focus will be put on aspects of accuracy and reliability of 3D information.

Lecture topics in detail:

- Airborne laser scanning, DTM generation, 3D city models, bathymetry, biomass estimation
- Digital airborne cameras, DTM generation from stereo imagery, advanced image matching techniques
- Direct georeferencing techniques

#### Intended Learning Outcomes:

Upon completion of the module, students are able to...

- understand the principles and potentials of different DTM generation techniques;
- understand airborne, mobile and terrestrial laser scanning techniques;
- assess the quality of laser scanner products;
- apply image matching techniques and judge the quality of their results;
- find the suitable technique and system configuration for 3D data acquisition tasks;
- evaluate the potential of photogrammetry and laser scanning in various application fields.

**Teaching and Learning Methods:**

The module is structured in lectures and exercises. The lectures provide the theoretical foundations of laser scanning and photogrammetric DTM generation. A set of exercises put the theoretical knowledge into practice. The guided computer lab exercises carried out in supervised small groups. Some exercise parts are performed by the students individually.

**Media:**

OPAL E-Learning platform, presentations, hand-outs, exercise sheets, software programs

**Reading List:**

*ISPRS Journal of Photogrammetry and Remote Sensing: Special Issue on Airborne Laser Scanning* (Eds. A. Wehr and U. Lohr), Vol-ume 54, Issue 2-3, July 1999.

Mostafa, M., Hutton, J. (2001): *Direct Positioning and Orientation Systems. How Do They Work? What is the Attainable Accuracy?* Proceedings 2001 ASPRS Annual Meeting Photogrammetric Week 2011 (Ed. Dieter Fritsch) .

Papers on semi-global matching (<http://www.ifp.uni-stuttgart.de/publications/phowo11/index.en.html>)

Vosselman, G., Maas, H.-G. (2010): *Airborne and Terrestrial Laser Scanning. Whittles Publishing. CRC Press*, 336 pages.

**Responsible for Module:**

Hans-Gerd Maas, [hans-gerd.maas@tu-dresden.de](mailto:hans-gerd.maas@tu-dresden.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Laser Scanning and DTM Generation (Lecture with integrated exercises, 2 SWS)  
Maas H. G., Westfeld P.

## Module Description

### BGU30060: 3D Virtual Landscapes

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester

<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
5	150	120	30

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of this module consists of a project work and an oral exam. The project work is proven by a project report of approx. 25 pages, which must be prepared individually. The project report is done partly during self-study hours and partly during contact hours. The project report consists of defined model contents associated by a comprehensive documentation on methods and techniques used and the quality achieved. This measures the students' ability to choose suitable input data and implement 3D virtual landscape models.

Within an oral exam of 20 minutes duration, the students have to demonstrate to what degree they have understood the principles of 3D geo-content generation, model assembly and the underlying workflow. Furthermore, they should recall applications of virtual 3D landscape models. The final grade is calculated as the unweighted average of the report (50%) and the oral exam (50%).

#### Repeat Examination:

Next semester: Yes

End of the semester: No

#### (Recommended) Prerequisites:

Introduction into geo-information systems, theory of geo-visualisation on a graduate level.

#### Content:

Geo-data sources serving the generation of virtual 3D models in terms of geometric and visual surface properties are progressively available. The generation of a virtual landscape model, however, is no standard process. Different use context and related design options of representations of existing or past environments will be presented. Central is an introduction to a comprehensive workflow leading from established geo-data sources (e.g. aerial imagery, digital terrain model) to a textured 3D model. Upgrades of heterogeneous primary data to a 3D model will be treated not only in theory, but essential processing steps will have to be performed by each participant.

Consequently, the module...

- presents concepts of virtual 3D landscape models;
- exemplifies different use context and implications on the model design;
- shows potential input data sources;
- discusses consistency demands within and among input sources;
- offers a comprehensive workflow as an example;
- demonstrates collaborative use of different software products;
- guides practical implementation.

**Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- remember applications of virtual 3D landscape models;
- consider the range of design options;
- choose suitable input data for 3D landscape models;
- understand necessity of quality and consistency control;
- produce 3D content of moderate complexity, and
- implement 3D content into a simple model.

**Teaching and Learning Methods:**

The students get involved with 3D models of real environments. Existing individual experience of the participants, be it through virtual globes, gaming, or other applications, will be used in order to discuss design, complexity, and appropriateness of such models. The lecture will demonstrate collaboration of different inputs as well as necessity and modes of processing. Lecture and exercise contents will be interlocked. Hands-on training will concentrate on a few selected processes as consistency testing, small 3D object design and geo-object fusion into a model. Practical work starts with a visual 3D landscape implementation project under supervision. The completion of this project must be done during self-study hours. Theoretic considerations, practical experiences, and self-evaluation of the results form mandatory parts of a documentation as part of the project report submission.

**Media:**

OPAL E-Learning platform, presentations, hand-outs, exercise sheets

**Reading List:**

ESRI. *ArcGIS Resources. Online Help for Developers*. [http://resources.arcgis.com/en/help/arcobjectsnet/conceptualhelp/index.html#/Developing\\_with\\_ArcGIS/0001000001ww000000/](http://resources.arcgis.com/en/help/arcobjectsnet/conceptualhelp/index.html#/Developing_with_ArcGIS/0001000001ww000000/)

Gutttag, J. V. (2013): *Introduction to Computation and Programming Using Python*. Cambridge (MA): MIT Press.

Longley, P. A., Goodchild, M. F. Maguire, D. J. Rhind, D. W. (Eds.) (2005): *Geographical Information Systems: Principles, Techniques, Management and Applications*. Wiley & Sons.

Prechtel, N. (2003): *Selected Problems and Solutions for Drainage Modelling and Handling in a GIS. Kartographische Bausteine: 21 (101-109)*. Dresden: Institut für Kartographie.

**Responsible for Module:**

Dirk Burghardt, [dirk.burghardt@tu-dresden.de](mailto:dirk.burghardt@tu-dresden.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

3D Virtual Landscapes (Lecture with integrated exercises VI, 2 SWS)

Prechtel N



## **BGU0MTCA15RK: Master's Thesis**

## Module Description

### BGU0MTCA15: Master's Thesis

<b>Module Level:</b>	<b>Language:</b>	<b>Duration:</b>	<b>Frequency:</b>
Master	English	one semester	winter semester
<b>Credits:*</b>	<b>Total Hours:</b>	<b>Self Study Hours:</b>	<b>Contact Hours:</b>
30	900	900	0

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The Master's Thesis is a scientific elaboration within a time period of six months. The students work on specific complex research questions in cartography and develop solutions of their own by applying the scientific background acquired during their studies.

By means of a written thesis the students explain the chosen approach and demonstrate their ability to precisely analyse the proposed method and to put it into the scientific context. The students should verify that they are able to investigate in a self-contained manner a new scientific topic related to cartography. This includes in detail, depending on the topic, the search and review of literature, topic-related methods and concepts, the development of theoretical concepts, methodologies, methods, to implement related algorithms, to apply them to specific problems, to analyse and to assess the results, and to develop and derive conclusions.

The written thesis is accompanied by a Master's Thesis Colloquium of 60 min in total (presentation and discussion). In the oral presentation, the students shall verify that they are able to give a presentation on a self-contained investigated scientific subject in front of a larger audience in order to demonstrate the ability to communicate found solutions and scientific content in a clear way. In addition, students shall verify that they are able to discuss and defend their own work in front of a scientific audience.

Different forms of assessment (written and oral) are necessary, because different competencies are verified by this. The Master's Thesis must be submitted in written form, by which mainly thematic and methodical competences as well as competencies to structure a written scientific document and to properly reference related work are verified. In contrast, the Master's Thesis Colloquium must be held in oral form. Via the presentation and defence (interactive scientific discussions with the scientific audience), the overarching understanding of the thesis topic, self-competencies and soft-skills such as skills of presentation, didactics and rhetoric can be verified. The grade is determined by weighted mean of the Master's Thesis (80 %) and the Master's Thesis Colloquium (20 %).

#### Repeat Examination:

Next semester: Yes, with new topic.

#### (Recommended) Prerequisites:

Required, required-elective and elective modules of the first 3 semesters.

#### Content:

This module is offered by all partners (all four collaborating universities, TUM, TUW, TUD, UT). The universities propose suitable topics from their subject area, mostly an aspect of one of their research projects. They support the students in the acquisition of the scientific skills to investigate broadly an aspect of a subject area and based on that to answer a problem in the corresponding area with the use of scientific methods. Under guidance students familiarize themselves with an area in cartography. They obtain a problem in that area which is still quite general, i.e. not yet specified concretely. They have to investigate and

evaluate different approaches to solve the problem, and then decide for one path which is then to be executed.

**Intended Learning Outcomes:**

After the elaboration of the master's thesis the graduates know how to...

- rapidly become acquainted with a specific and complex subject area in cartography;
- embed a scientific problem in a scientific and technical environment;
- identify all important aspects of those parts in cartography which are necessary for finding a solution;
- develop algorithms and methods for solving problem-specific tasks based on the scientific background acquired during their studies;
- analyse and to evaluate the results;
- present the relevance and context of the topic, the scientific questions, the methodologies employed for their solution, the results and discussion in a professional, well-structured written report;
- properly reference related work;
- present their results to a scientific audience.

**Teaching and Learning Methods:**

Self-study, regular discussions with the supervisor.

**Media:**

Not applicable.

**Reading List:**

To be researched independently according to the scope of work.

**Responsible for Module:**

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**Courses (Type of course, Weekly hours per semester), Instructor:**