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119. Curriculum for Master's Degree Programmes at Paris-Lodron University of Salzburg

Curriculum "Applied Geoinformatics" Version 2016

Table of Contents

In its session on 08.03.2016 the Paris Lodron University of Salzburg Senate formally approved the curriculum for the master's degree programme in Applied Geoinformatics finalised by the Geography and Geoinformatics curriculum committee at the University of Salzburg in its 02.12.2016 meeting in the version that follows.

The legal basis for the curriculum is the 2002 Federal Act on the Organisation of Universities and their Studies (Universities Act 2002 – UG), Federal Law Gazette No. 120/2002, and the section of the Statutes of the University of Salzburg pertaining to university studies.

§ 1 General Provisions

(1) The number of ECTS points necessary to complete a degree in the master's programme in Applied Geoinformatics is 120. This corresponds to four semesters of study.

(2) Graduates of the master's programme in Applied Geoinformatics hold a Master of Science degree (abbreviated MSc).

(3) In order to be admitted to the master's programme in Applied Geoinformatics, students must hold a bachelor's degree in an equivalent or related field from an accredited Austrian or foreign institute of higher education (cf. UG2002 §64 para. 5).

(4) If a student's bachelor's degree is not deemed equivalent to an acceptable extent, the student may be required to complete additional work up to 45 ECTS points; these requirements must be satisfied by the end of the master's programme. Only the Rectorate or a member of staff at the University of Salzburg designated by the Rectorate is authorised to make a determination of equivalency.

(5) All graduation requirements to be fulfilled by students have been assigned ECTS points. One ECTS point equals 25 hours of study, which corresponds to the average number of hours required to achieve the expected learning objectives. An academic year consists of 1500 hours, corresponding to 60 ECTS points.

(6) Students with disabilities and/or chronic illnesses will not be subject to any form of discrimination in their studies. The University is committed to the basic principles laid out in the UN Convention on the Rights of Persons with Disabilities and Austrian non-discrimination laws as well as the policy of positive action.

§ 2 Overview of the degree programme and professional skills

(1) Overview of the degree programme

The discipline of Geoinformatics offers highly sought-after qualifications well founded in concepts and technologies of geospatial computing, tied into inter- and multidisciplinary application domains.

The knowledge and skills acquired throughout the programme's modules are based on the common grounding of spatial sciences and a 'Digital Earth' perspective, based on concepts typically acquired during undergraduate Geography, Surveying, Environmental Studies, Cartography or Planning programmes.

The 'Applied Geoinformatics' MSc aims at the building of advanced competences in geospatial data acquisition and data management, data analytics and simulation as well as interactive communication. Graduates are expected to interface with different spatially oriented application domains, contribute to solving problems across societies, economies and environments as well as leading teams assigned pertinent tasks.

(2) Professional skills and competences (Learning Outcomes)

Geoinformatics has been established as a methodology-oriented, cross-disciplinary subject based on spatial concepts and approaches. Such 'spatial view' competences are invaluable

within any subject-specific context whilst widely applicable across domains such as planning, resource management, logistics, mobility, marketing, nature and environmental protection, and security. Graduates will be confident in using key interfaces pertinent to spatial information processing.

Graduates with a Master's degree in "Applied Geoinformatics" are able to answer research questions, including the development of hypotheses, definition of objectives, selection of methods, implementation of workflows, collection, analysis and interpretation of data as well as a written and oral communication and interpretation of outcomes in a decision support context.

The study programme provides application-oriented knowledge based on relevant theories and methods. Discipline-specific ways of thinking, analytical skills and techniques as well as problem-solving competences are developed in core areas of Geoinformatics, especially in:

- Geospatial data acquisition and visual / cartographic communication;
- Data modelling and spatial data management;
- Data analytics across the spectrum of Geoinformatics: georeferenced data and data streams; in-situ, remote and mobile sensing; statistics;
- Spatial analysis, as well as dynamic system simulation;
- Standards for architectures of open and distributed systems and spatial data infrastructures;
- Development of geospatial applications.

Graduates of the ‘Applied Geoinformatics’ programme will be able to independently plan and manage complex projects and applications in Geoinformatics as well as to cooperate on projects in spatial data infrastructures. The aim is to support and enhance decision-making in all application domains of Geoinformatics.

The study programme is scientifically based, provides a broad range of academic analysis and research methods, and prepares students for a doctoral degree programme.

(3) Importance and relevance of the degree for society, the scientific community and the labour market

Graduates of the Master's programme in "Applied Geoinformatics" develop a focus on methodological and technical areas of expertise, thus emphasizing career perspectives in public administration (e.g. spatial data infrastructures and geoinformatics services and application development, as well as in application domains such as in spatial planning, regional management, mobility, environment and nature conservation) and in business across a broad spectrum of industries. The study programme covers all areas of geospatial data collection and data management, spatial analytics, communication of results and decision support, interaction with of spatial information, as well as aspects of general management.

§ 3 Structure of the programme

The master’s programme in Applied Geoinformatics comprises 7 modules with a total number of 90 ECTS points. This includes 12 ECTS points assigned for elective courses and a mandatory internship. The master’s thesis incl. an ePortfolio and Master’s exam is worth 30 ECTS points.

	ECTS
856M11 – Propedeutics and Elective courses (12)	15
856M12 – GIScience: Theory and Research Methods	6
856M13 – Methods in Geoinformatics	18

856M14 – Spatial Analysis and Modeling	6
856M15 – Geo Application Development	12
856M16 – Spatial Data Infrastructures	12
856M17 - I3 Project	12
Electives, cf.§6 – see 856M11	
Master thesis (incl ePortfolio and Master's exam)	30
Internship	9
Total	**120**

Within the master's programme in Applied Geoinformatics two compulsory seminar type courses in modules [856M12] and [846M14] have to be completed.

Throughout the programme a personal portfolio ('ePortfolio') has to be maintained. It contains individual presentations of materials resulting from coursework and internships. The portfolio is developed in a suitable digital online format, e.g. as a website or blog.

§ 4 Course Types

The programme contains the following course types:

Lecture (VO) provides an overview of a subject or one of its sub-areas and its theoretical approaches and presents different teachings and methods. The contents are mainly presented in lecture style. Attendance is not mandatory but highly recommended.

Lab / Practical (UE) serves the acquisition, testing and optimization of practical skills and knowledge in the field of study or one of its sub-areas. Course participation is continuously assessed and attendance is mandatory.

Excursion (EX) supports experiential and applied learning outside of classrooms and is focussed on active learning through contact with real world phenomena and experiences. Course participation is continuously assessed and attendance is mandatory.

Pro-seminar (PS) is a scientifically oriented course in preparation for seminars. Students acquire fundamental knowledge and skills for scientific research through practical as well as conceptual work. Course participation is continuously assessed and attendance is mandatory.

Seminar (SE) is a graduate level scientific course. It serves the acquisition of advanced expertise as well as the discussion and reflection of scientific topics based on active participation of the students. Course participation is continuously assessed and attendance is mandatory. The focus of each seminar will be outlined in the course description (e.g. supervision seminar, empirical seminar, project seminar, interdisciplinary seminar, ...).

Interdisciplinary Project (IP) integrates approaches, concepts and methods from various disciplines for holistic problem solving across disciplines, including practical as well as conceptual synergies. Course participation is continuously assessed and attendance is mandatory.

§ 5 Required courses and plan of study

The following table contains a list of modules and courses in the master's programme in Applied Geoinformatics. The semester structure serves as a recommendation designed to ensure that the order in which courses are taken builds on a sequence of knowledge acquisition and that the workload of 60 ECTS points in an academic year is not exceeded. If there are no stated prerequisites, modules and courses can however be taken in any order in accordance with requirements outlined in §12.

Detailed descriptions of the modules including the knowledge, methods and competences to be acquired can be found in Annex I: Module descriptions.

Master's degree programme in Applied Geoinformatics								
Module	**Course**	**SHrs**	**Type**	**ECTS**	**Semester with ECTS**			
					I	**II**	**III**	**IV**
(1) Compulsory Modules								
856M11 - Propedeutics and Electives								
Electives. Short Intensive Programs ('Summer Schools'). Subjects recommended in the orientation interview				12	10	2		
Orientation and Introduction		1	UE	1	1			
Scientific Methods and Writing		1	PS	2	2			
Subtotal 856M11		2		15	13	2		
856M12 - GIScience: Theory and Research Methods								
Lectures in GIScience		2	VO	2		2		
GIScience: Theory and Concepts		2	SE	4			4	
Subtotal 856M12		4		6		2	4	
856M13 - Methods in Geoinformatics (select 3)								
Advanced Remote Sensing		4	PS	6	6			
Multivariate Statistics | Spatial Statistics | Geostatistics		4	UE|PS	6		6		
Geovisualization and Advanced Cartography		4	PS	6		6		
Geodata Acquisition			UE|PS					
Spatial Simulation			PS					
Location Based Services			UE|PS					
Additional options identified by CK			UE|PS					
Subtotal 856M13		12		18	6	12		
856M14 - Spatial Analysis and Modelling								
Methods in Spatial Analysis		2	PS	2	2			
Analysis and Modeling		2	SE	4		4		
Subtotal 856M14		4		6	2	4		
856M15 - Geo-Application Development								
Basics of Software Development		2	VO	3	3			
Practice: Software Development		2	PS	3	3			
Application Development		3	IP	6		6		
Subtotal 856M15		7		12	6	6		
856M16 - Spatial Data Infrastructures								
Design of Geospatial Data Models		2	VO|PS	3	3			

OpenGIS: Standards, Architectures and Services	2	VO|PS	3		3		
SDI Services Implementation	3	IP	6			6	
Subtotal 856M16	7		12	3	3	6	
856M17 - Interdisciplinary/Integrated/Interactive Project							
Project (topics vary)	7	IP	12		1	11	
Subtotal 856M17	7		12		1	11	
Total for compulsory modules	43		81	30	30	21	0
(2) Electives lt. § 6							
See 856M11							
(3) ePortfolio	1						1
(4) Internship	**9**					**9**	
(5) Master thesis	**28**						**28**
(6) Master's exam	**1**						**1**
Total	**82**		**120**	**60**		**60**	

§ 6 Elective module catalogues and/or bundled elective modules

(1) Within the framework of ‚joint study programmes', or, with approval by the responsible body, to facilitate topical focus areas instead of modules [856M13] and/or [856M17] courses with a defined connection to the study programme objectives according to §2 can be completed and recognized.

(2) A topical focus on the subject ‚Object-Based Image Analysis' (OBIA) can be established by completing courses identified by the responsible body in the amount of 30 ECTS within modules [856M13] to [856M17]. Upon request this topical focus subject can be documented in the master certificate / final transcript of studies.

(3) The responsible body can identify and define additional focus subjects based on demand and according to available course offerings.

§ 7 Elective courses

(1) In the master's programme in Applied Geoinformatics students are to complete elective courses totalling 12 ECTS points (according to module 856M11). These elective courses are designed to further the acquisition of additional professional skills and strengthen individual areas of focus within a student's course of study. They can be completed at any accredited postsecondary institution.

(2) Should the courses chosen as electives for 12 ECTS points have a demonstrable connection to this master's programme, the electives can constitute a supplementary certificate in a specific area (*Wahlfachmodul)*, which is recorded on the master's degree certificate.

§ 8 Master's thesis

(1) The master's thesis serves to demonstrate that students have acquired the ability to perform independent academic research in the area of [name of the area] according to current academic research methods and standards.

(2) The topic of the master's thesis should be chosen in such a way that it is reasonable and appropriate for completion of the thesis within six months (cf. UG2002 §81 para. 2).

(3) The topic of the master's thesis must be taken from a module in the master's curriculum. The student may suggest a topic or choose from a number of topics provided by one of the available thesis advisors.

(4) It is to be noted that both the student's work on the topic and advisor's work with the student are governed by Austrian copyright law, Federal Law Gazette No. 111/1936 (cf. UG2002 §80 para. 2).

(5) Extensive thesis topics jointly researched and developed by more than one student are admissible as long as individual's contribution and results are well documented and can be separately and independently assessed.

§ 9 Internship

(1) As part of the master's programme in Applied Geoinformatics, students must complete a compulsory internship related to the programme comprising 6 weeks, which is comparable to full-time employment and corresponding to 9 ECTS points. The internship should enable students to use the knowledge and skills they have gained during their studies so far.

(2) The internship is generally to be completed outside of the University in an institution pre-approved by the responsible body. Pre-approval of the internship and the selected institution is required and must be granted by the responsible body.

(3) Should it not be possible to complete the internship outside the University, students may in exceptional cases complete an internship by participating in research projects at the University, as far as this is possible and as far as this receives approval from the responsible body.

(4) Students with disabilities and/or chronic illnesses will be supported in the completion of their internship by the University (Office of the Rectorate for Disability & Diversity). Should the requirements of potential internships be rendered impossible to fulfil due to architectural and/or structural barriers, students with disabilities and/or chronic illnesses will be given the opportunity to complete this part of the curriculum in a different form.

(5) An internship certificate issued by the host institution and serving as a basis for recognizing a completion of this requirement has to document these items:

1. Institution and location where the internship has been completed.
2. Timeframe / duration and workload (hours per week) of the internship.
3. Description of assigned tasks and responsibilities.
4. Written assessment of internship by supervisor at host institution.

As part of their internships, students can gain the following qualifications (among others):

- Ability to put the theoretical knowledge acquired in the field of study into practice in a professional context
- Acquaintance with different scenarios in which theoretical concepts can be used
- Acquisition of soft skills such as teamwork, communication skills, planning and organisational skills in a professional context.
- Familiarity with professional environments of Geoinformatics applications

§ 10 Study abroad

Students in the master's programme in Applied Geoinformatics are recommended to spend a semester of study abroad. This semester abroad should ideally be scheduled in the second or third semester of study. Course credit transfers for the courses completed at the university abroad will be granted by the responsible body. Documents needed for the assessment of transfer courses are to be provided by the student.

Steps will be taken to ensure that the semester abroad can be completed without causing a delay in a student's course of study when the following conditions are met:

- at least 30 ECTS credits are earned in each semester of study abroad
- the content of the courses completed during the period of study abroad is not identical to courses already completed at the University of Salzburg
- confirmation by formal notification in writing before beginning the study abroad period of which courses and/or exams planned to be taken abroad are transferable to the University of Salzburg

In addition to field-specific knowledge and skills, students stand to gain the following qualifications by studying abroad:

- acquisition and consolidation of field-specific knowledge in a foreign language
- acquisition and consolidation of general foreign-language skills (comprehension, conversation, etc.)
- acquisition and consolidation of organisational skills gained by independently navigating the bureaucracy and organisational structure of a university abroad as well as daily challenges of student life abroad
- becoming acquainted with international student exchange programmes and broadening one's perspectives in one's own field of study
- acquisition and consolidation of intercultural communication skills

Students with disabilities and/or chronic illnesses will be assisted in their search for a study abroad opportunity and in planning for their semester abroad by the Office of the Rectorate for Disability & Diversity.

§ 11 Allocation of places in courses with a limited number of participants

(1) The maximum number of participants in the master's programme in Applied Geoinformatics for the following course types is limited as follows:

Lectures (VO)	no limit
Pro-seminars (PS) and Labs (UE)	25 (or adjusted to number of available work places / instruments)
Seminars (SE)	16
Interdisciplinary Projects (16)	16

(2) In instances in which courses with a restricted number of participants are oversubscribed, priority of enrolment will be given to students for whom the course is an obligatory part of their curriculum.

(3) Students in the master's programme in Applied Geoinformatics will be assigned priority places in courses based on the total number of ECTS credits they have earned in the programme so far. If multiple students registering for a particular course have earned the same number of ECTS credits, the available places in this course will be allocated based on the following criteria in the order listed below:

- a student was on the waiting list in the course in the previous academic year
- a student has completed a greater number of courses and/or exams
- a student has completed a greater number of semesters in the programme of study
- random draw selection

Available places will be allocated to students from other programmes using the same criteria in the above stated order.

(4) For students participating in international exchange programmes, additional places constituting at least ten percent of the maximum number of participants in each course will be made available. These places will be allocated randomly.

§ 12 Admission requirements for exams

The admission requirements for the following exams are as follows:

Course / Module:	**Prerequisite for:**
‚Orientation and Introduction' in [856M11]	All exams in modules [856M12] through [856M17]
All non-IP courses in modules [856M15] and [856M16]	Courses with type IP in modules [856M15] and [856M16], respectively
Completion of at least 30 ECTS within MSc „Applied Geoinformatics"	Courses with type IP in module [856M17]

§ 13 Examination regulations

All courses with the exception of type VO require course attendance and are continuously assessed. Lectures (VO) are assessed based on a single written or oral exam at the end of the course. All modules listed in §5 can be assessed through module or individual course exams (or combinations thereof) under the discretion of course instructors, nonwithstanding stated continuous assessment requirements.

The supervisor of the final master thesis confirms the successful completion of the ePortfolio requirement.

§ 14 Master's examination [before examining committee]

(1) The master's programme in Applied Geoinformatics concludes with a master's examination rated 1 ECTS credit before an examining committee.

(2) Candidates must have successfully completed all of the required courses, the compulsory internship, ePortfolio and the master's thesis in order to be eligible to take the master's examination.

(3) The master's examination before an examining committee starts with a presentation and defense of the master thesis, followed by an examination in two subjects suggested by the candidate.

(4) The master's examination subjects are drawn from modules 856M12 to 856M16, exam subjects correspond to module names.

§ 15 Effective date

The curriculum comes into force 1 October 2016.

§ 16 Transitional provisions

(1) Students enrolled in the curriculum for the Master's Programme of Study in Applied Geoinformatics at Paris Lodron University of Salzburg 2013 Version, Mitteilungsblatt – Sondernummer, no. 65, issued 27. Juni 2013) when this curriculum comes into force have until 30.09.2016 to complete the programme in which they are enrolled.

(2) Students subject to a different curriculum may during any period of registration decide to change into this curriculum. An irrevocable written declaration is to be submitted to the Office of Admissions (Studienabteilung), should a student wish to change curricula.

Annex I: Module descriptions:

Module Description 856M11

Module title	Propedeutics and Electives
Module code	856M11
Total workload	15 ECTS
Learning Outcomes	Students are adjusting to the requirements of the MSc AGI programme based on their respective (and different) first degrees. Based on admission interviews, students receive recommendations to compensate any deficiencies from their undergraduate studies, particularly in the areas of informatics / computing as well as basic GIS skills, basic spatial literacy and cartographic competences, fundamental understanding of spatial sciences and general quantitative methods. Typically, bachelor level courses will build the needed entry level competences for subsequent modules. Students not requiring any remedial courses are encouraged to either use this module for acquiring additional geoinformatics methods competences (see module 856M13), or for other electives complementing their overall study programme. In addition, students enhance their general orientation in scientific methods and scientific writing in a dedicated class, as a preparation for supervised and independent work in advanced classes. Coursework aiming at adjusting prerequisites will secure coverage of knowledge according to [*add reference to BSc Geography*]: - Foundations of Geoinformatics: CF3, CF4, CF5-1,4,5, DA4, DM1-4, GD12, OI51-2, GS3 - Cartography and Visualization: GD1-5, GD10, CV2, CV3, CV4-1, CV6-1-3, DN2
Module content	According to chosen remedial / elective courses. Plus: orientation re professional outlook and career development. Planning and design of one's individual course of study, including specific methodology and / or domain emphases. Personal SWOT analysis and translation of outcomes into action. Written communication in science. Structuring of documents according to media and target audience. Scientific writing in English language. Adequate use and referencing of sources, empirical evidence and pertinent tools. Elementary research design. Professional ethics.
Courses	Specific courses taken by students will vary widely, depending on either a need for remedial coursework or complementary electives developing an emphasis in a methodology or domain. Two courses are obligatory within this module: - UE Orientation and Introduction - PS Scientific Methods and Writing - Electives
Type of exam	Defined through specific courses taken; for 'Orientation and Introduction' the outcomes from personal interview and consultation as well as prior skills tests are assessed on a binary fail/pass scale. 'Scientific Methods and Writing' is assessed based in individual assignments through teacher and optionally peer assessment of individual coursework and portfolio entries.

Module Description 856M12

Module title	GIScience: Theory and Research Methods
Module code	856M12
Total workload	6 ECTS
Learning Outcomes	Participants in this module can describe the highly dynamic nature of the evolving field of Geographic Information Science or GIScience in short. Students can work scientifically in the broader field of GIScience and communicate in an interdisciplinary manner with other fields based upon generic scientific as well as GIScience-specific skills and competencies. Students acquire competences both in GIScience theory including its epistemology and in Geoinformatics applications fields. They are able to use theory in application contexts (CF1-CF7). Geospatial technologies support a wide variety of uses in society. Students can evaluate technological and scientific trends and whether they may provide opportunity or threats for our society.
Module content	The lecture / lecture series shall provide a broad overview over the fields of GIScience and Geoinformatics while complementing the content of other compulsory classes in this program. The seminar shall make participants sensitive to scientific questions in general and when using Geographic Information in particular. Secondly, it will comprehensively discuss the body of knowledge in a relatively new field called Geographic Information Science or GIScience in short. GIScience is based upon the understanding that basic and applied research must be reflected within society. Seminar papers shall analyse the role of GIS and Geoinformatics applications in their social context considering the ideas and practices that have emerged among GIS users, demonstrating how they reflect the material and political interests of various societal groups. The seminar also discusses the impact of new GIS technologies on the discipline of geography and evaluates the role of Geoinformatics and GIScience within the wider transformations of a post-industrial society. Students should get acquaintance with application fields as well as with cutting-edge literature by leading scholars. The seminar provides the foundations for a critical rethinking of GIS and opens up scientific debates in the form of structured discussions.
Courses	A combination of a lecture series and a GIScience seminar: - VO|KO Lectures in GIScience - SE GIScience: Theory and Concepts
Type of exam	Written or oral exams which certify a broad and intellectually sound understanding of the content. Judgement of active participation in seminal discussions, oral and written seminar papers.

Module Description 856M13

Module title	Methods in Geoinformatics
Module code	856M13
Total workload	18 ECTS
Learning Outcomes	Students therefore will be able to immediately apply the respective methods in project-oriented work and take methodological responsibilities in working groups and complex workflows. Depending on individual choices, students will: - Design and implement advanced geovisualisation interfaces for use-case oriented media, devices and user experiences [DM5-3, DN2-4, GS3-3]. - Decide on adequate Remote Sensing data sources and workflows across available passive and active sensors. - Apply the Object-Based Image Analysis (OBIA) paradigm to the extraction of features and monitoring of change across remote sensing application domains. - Select and implement advanced geodata acquisition processes using e.g. photogrammetry, LiDAR, in-situ and mobile sensors, crowdsourcing and UAV platforms, including real-time data streams [DN1-6, components from GD]. - Prepare and support decisions through (geo-)simulation [DA5-3,4, GC]. - Choose and apply spatial- and geo-statistical methods to analyse multidimensional and multivariate data sets to explain and model complex relations and processes [CF6, AM7, AM8, AM9-2,4, GC2-4]. - Manage information extraction from large ('big') data sets, including flow of data, DBMS aspects and pattern analysis [AM10].
Module content	Students are offered a selection of core geoinformatics methodologies like remote sensing, geovisualisation or data analysis, sharpening personal competence profiles in combination with choices in electives, IP courses, seminar and thesis topics. All courses have a strong practice orientation, combining conceptual foundations with a view towards applications. Depending on courses, chosen content will vary and include combinations from: Remote Sensing – field and mobile data acquisition. Advanced sensors. Hyperspectral and Microwave analysis. Radiometric correction. OBIA with transferable rules and app development. | Geovisualisation – use case analysis and UX design. Design of flexible and responsive interfaces. Navigation of perspective views. | Data and process analysis – advances spatial statistics and pattern analysis. Geostatistics. Big data analysis. Process simulation with individual based vs aggregate/lumped approaches. | …
Courses	All courses are taught as practicals, fostering problem-oriented and experiential learning through individual or group assignments. - Advanced Remote Sensing - Multivariate Statistics | Spatial Statistics | Geostatistics - Geovisualization and Advanced Cartography - Geodata Acquisition - Modeling Geographical Systems, Spatial Simulation - Location Based Services, Big Data Analytics
Type of exam	Teacher and peer assessment of individual assignments, optionally presentations and portfolio entries, plus overview tests.

Module Description 856M14

Module title	Spatial Analysis and Modelling
Module code	856M14
Total workload	6 ECTS
Learning Outcomes	This core area of Geoinformatics builds advanced translation skills from application domain problems towards conceptual reframing and structuring, and into the analytical methods and toolsets of Geoinformatics. Based on this knowledge of operational methods, complete workflows representing complex processes are modeled and represented in structured frameworks for spatial decision support across domains. Students will: - Be able to map conceptual spatial relations (topological and geometrical) to the body of analytical methods. [AM2-1, AM3-6, AM4-4] - Recognize the value of different metrics in the spatial as well as attribute domains (e.g. fuzzy algebra). [AM3-1] - Describe shape characteristics of spatial features as well as complex landscape structures with the aim of diagnosing change. [AM3-3] - Identify, select (including SQL clauses) and statistically describe spatial features based and their distance to and/or topological relations with a target feature. [AM2-2,3, AM4-1,3] - Estimate values of a continuous (real or thematic) surface based on sample points through interpolation methods. [AM3-5] - Select adequate interpolation methods (based on characteristics of surface theme, measurement level, sample density) and assess quality of results. [AM6-2] - Derive characteristics of continuous surfaces as a basis for advanced models. [AM6-1, AM3-2] - Develop and adequately parameterized basic models of surface runoff, groundwater dynamics, visibility, solar irradiation and diffusion / spreading over inhomogeneous surfaces. [AM6-3,4,5] - Apply topological relations for combination of spatial themes (overlay analysis), derive and implement weighting schemes. [AM4-2] - Find best routes (paths) across fields and networks. [AM11-3,4,6] - Allocate areas and features to service centres, distinguish from ('optimal') location analysis. [AM11-7, AM12-1,4] - Choose classification and regionalization methods according to specific requirements and contexts. - Design, implement and validate complex workflows and process models built from individual methods and operations. [AM5-6,78] - Move from data analysis to generation of context-specific information and the creation of higher level domain knowledge. [AM1-1,2]
Module content	Topological relationships (Egenhofer). Map Algebra. Distance metrics. Spatial query operators. Fuzzy metrics and algebra. Shape and landscape metrics. Interpolation methods (trend surface, IDW, … and cross reference to statistical methods like Kriging). Surface descriptors. Spatial models with gravity and radiative mechanisms. Cost surface modeling. Network: Dijkstra algorithm. Vector and raster overlay, incl. weighted overlay and AHP. Allocation and location analysis. Nodal and homogeneous regionalization. Process model building. Spatial decision support strategies.
Courses	Through a combination of a practical class including extensive lab components with an advanced seminar, students develop broad competences across the spectrum of analytical methods (optionally including

	spatial statistical and remote sensing methods), as well as a deeper understanding and critical appreciation of results through application experience of selected methods and their parameterization contexts. - PS Methods in Spatial Analysis - SE Analysis and Modeling
Type of exam	Assessment of individual lab assignments plus overview test. Presentation of seminar (project) paper with peer and teacher assessment.

Module Description 856M15

Module title	Geo-Application Development
Module code	856M15
Total workload	12 ECTS
Learning Outcomes	Participants in this module will gain a well-structured understanding of software development from a software engineering (SWE) perspective, enabling them to work as geospatial experts in development teams and to successfully communicate with software developers. Based on the foundations of programming and development, students acquire competences in at least two development environments and languages, enabling them to design simple software programs, to customize existing applications, and to automate basic workflows. This includes practical skills in geo-application development in the areas of web applications, mobile applications, or desktop analytical applications. Having completed this module, students are able to carry out basic development tasks on a variety of platforms and architectures with an emphasis on understanding and translating demands from typical geospatial application domains. This key competence is developed and verified through a development project in one of the selected IPs. Students will be able to: - Design and carry out software projects in accordance with standardized and structured SWE processes [DA7-1, DA7-2, DA6-1, DA6-3] - Select the appropriate programming or scripting language according to the specific goals of a software project [DA5-4 , DA6-3 , DA7-1, DA2-4] - Apply their basic knowledge of modeling software systems for communication between different stakeholders in a SWE project [DA1-2, DA1-5, DA2-4, DA6-2] - Programmatically access external code libraries and Application Programming Interfaces (APIs) of commercial off-the-shelf (COTS) and open source software in their own programs to achieve their goals [DA7-2, DA1-5, DA6-3] - Develop software programs to pre-process and analyze spatial data (read, manipulate, store, visualize, classify) that are available in a variety of formats (CSV, ShapeFiles, GML, KML, raster formats etc.) [DA7-1, DM1-2] - Integrate data from service-oriented architectures (SOA), including OGC Web Services (OWS) into their software programs through service-based data access [DA7-2] - Read and understand the documentation of software libraries - Create user interface components in selected development environments [DA6-2] - Batch analysis tasks in the application domains of GIS and remote sensing [DA6-3], - Develop geo-applications for different platforms (desktop, web, mobile, …) and application domains (GIS, remote sensing) [DA7-2, CV5-1, CV4-5]
Module content	Principles of software engineering. Procedural and object-oriented programming principles. Approaches to modeling software systems using UML. Service-oriented Architectures. OGC Web Services (OWS). Client-side and server-side scripting languages (e.g., JavaScript, Python, or similar). Object-oriented programming vs. scripting. Server-side OO programming and scripting (e.g. JSP, Python, PHP, or similar). Programmatic database access. Program development for

	spatial data pre-processing. APIs in commercial off-the-shelf (COTS) and/or open source software.Web Mapping. Web GIS. Batch processing for GIS and remote sensing analysis and classification tasks. Basic GUI design.
Courses	Through a combination of an introductory lecture and a lab exercise as well as an IP (selectable from different application domains) including extensive practical components, students develop broad competences across the spectrum of application development methods on different platforms and programming languages (at least two) as well as different application domains (optionally including remote sensing applications). - VO Basics of Software Development - PS Practice: Software Development - Selectable IPs: o IP Application Development (web|mobile|desktop) o IP Application Development (remote sensing applications)
Type of exam	Assessment of individual lab assignments plus overview test. Presentation of focus topic with peer and teacher assessment. Major development project in one of the selected IPs.

Module Description 856M16

Module title	Spatial Data Infrastructures
Module code	856M16
Total workload	12 ECTS
Learning Outcomes	A spatial data infrastructure (SDI) comprises technology, standards, policies, organisational/legal aspects, human resources and related activities to integrate, exchange, process, maintain and preserve geospatial data and information. Students will: - Be able to describe the main components of SDIs and know key objectives, benefits and current state-of-the-art of such initiatives [OI5-1]. - Understand the conceptual strategies, organizational requirements and legal frameworks for leveraging the advantages of open geographic data infrastructures [DA3-3, GS1]. - Recognize the importance of standardized data models to store, analyse and manipulate geographic phenomena. - Be able to explain the role of metadata for spatial data sharing across distributed networks [GD12]. - Be able to describe the existing spatial data sharing policies including intellectual property rights, security issues, privacy issues, Open Government data initiatives [GS5-4, OI5-6]. - Be able to explain the Service Oriented Architecture (SOA) concept together with its underlying publish-find-bind principle. - Know internationally accepted geographic- and IT standards (OGC, OASIS & ISO) and apply these in practical projects [OI5-1]. - Be able to understand, design and implement geodata models according to standardised approaches [CF3-CF6]. - Be able to publish geodata and geoprocessing services over the web: map services, data services (editing, search, image service), and analytical services. - Be able to define the interoperability needs beyond technical issues like direct access and industry standards on a legal, semantic and organizational level [OI5-2]. - Understand the principles and techniques of spatial data organization and apply these principles and techniques to design and build spatial databases [DM2, DA4]. - Based on these concepts, the students will learn how to utilize open, shared GIS resources to design and use Open GIS data structures, workflows and processes leveraging information repositories.
Module content	**Conceptual foundations:**Geographic information - reference model, spatial schema, temporal schema, spatial referencing; spatial relationships, functions and operations; Interoperability (syntactic, semantic and technical); distributed IT architectures (private/public cloud, Internet of Things etc.); spatio-temporal information integration; spatial data infrastructure concepts (service-orientation; publish-find-bind principle; semantic web). **Technological Foundations**: Geospatial data modelling (UML, GML); application schema; GI Ontologies; domain bridging data Integration; Geospatial Data Management (Simple feature access, 13249-3 Information technology - SQL Multimedia and Application-Part 3); Spatial DBMS: Oracle Spatial, MSSQL Spatial, Postgres/PostGIS, ESRI ArcSDE etc.; geospatial network-service architectures (view, download, discovery & registry, web processing and security services); Communicating with WebGIS; GI applications services using COTS and open-source solutions; private/public cloud-computing platforms; data & metadata repositories; Big GI data & Geospatial Eventing.

	Standards and Regulations for Interoperability: ISO/TC211 19100 standards series, Open Geospatial Consortium; Legal acts: Laws on SDIs, Environmental INSPIRE, Public Sector Information INSPIRE Directives; privacy and security issues. **Initiatives:** Open Government Data; GSDI-Global Spatial Data Infrastructure, GEOSS-Global Earth Observation System of Systems
Courses	VO|PS Design of Geospatial Data Models VO|PS Open GIS: Standards, Architectures and Services IP: SDI Services Implementation
Type of exam	Written exams for the lectures. IP: hands-on project work with strong motivation from real world problems; detailed documentation according to corresponding standards; Evaluation of the approach to challenge in the course of the project as well as the final results.

Module Description 856M17

Module title	I3: Interdisciplinary/Integrated/Interactive Project
Module code	856M17
Total workload	12 ECTS
Learning Outcomes	As a capstone project, students develop, test and validate the competences required for 'putting it all together'. Acknowledging the differences between 'the whole and its many parts', challenges from completing a major project through all its stages are successfully dealt with. From problem analysis, conceptualization, workflow design and data acquisition to schema implementation, analyses, validation and communication of essential outcomes, all major phases of a project are practiced. In particular, skill sets for collaborative work and structuring of larger projects are developed. Based on impulse elements and structured inputs in the domains of project management, presentation techniques, moderation / facilitation and controlling / supervision, a project reflecting the key elements of practice-oriented work flows will qualify students to function in teams and to start organizing tasks and challenges into structured projects. In addition, by being familiar with standard project management and communication steps, graduates will confidently accept responsibilities within major project environments. At the same time, this experience will be a major contribution to successfully develop and complete the master thesis.
Module content	Problem analysis. Assessment of user / customer / target group needs and requirements. Design and planning of workflows towards deliverables. Data integration. Full project management cycle including use of PM methods (e.g. logical framework matrix), tool set and strategies. Communication and intervention planning with users / customers. Distributed responsibilities within a team. Communication and presentation techniques aligned with overall project workplan. Quality assurance and reporting of deliverables.
Courses	IP I3 Project
Type of exam	Teacher and peer assessment of entire process leading up to project presentation and report (typically done in small work groups).

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