Second-cycle studies programme with hours/week in three semesters [15 weeks]

Field of education: Geodesy and Cartography, **specialization** Spatial Information Systems

No	Course	Sem. I				Sem. II				Sem. III			
	l - lecture, e - exercices, p - project, E - exam	l	e	p	ECTS	l	e	p	ECTS	l	e	p	ECTS
	General courses												
1	Selected issues of economy law	1			1								
2	Human rights					1			2				
3	Geodetic and Cartographic Law									1	1		2
4	Specialist foreign language										2		1
5	Mathematics		2		3								
6	Selected Topics of Mathematics and Numerical Methods /E	1	2		4								
7	Geophysics	1	1		2								
8	Selected Topics of Physical Geodesy and Geodynamics			1	2								
9	Digital image processing			2	2								
	Profiled courses												
10	Standards in Geographic Information	1			2								
11	Spatial Data Infrastructure	1			2								
12	Cartographic Modelling /E	1		2	3								
13	Photogrammetric Technologies /E	2		2	4								
14	Geostatistics	1		1	2								
15	GIS Technologies	1		1	3								
16	Facultative class 1					1		1	2				
17	Facultative class 2					2			1				
18	Facultative class 3					2			1				
19	Facultative class 4					2			1				
	Specialization courses												
20	Spatial Databases Design /E					1		2	4				
21	Programming in GIS							2	2				
22	GIS Software					1		1	3				
23	Providing Access to Spatial Data /E					1		1	3	1		1	2
24	Spatial Analyses and Modelling					1		2	4	1		2	2
25	Remote Sensing Data Sources for GIS /E					2		2	5				
26	GIS Applications							2	2		2		2
27	Diploma Seminar											2	1
28	Diploma Thesis												20
	TOTAL	10	5	9	30	14	0	13	30	3	5	5	30

Courses descriptions

	General courses	
	Selected issues of economy law	1. Basic information on economic law 2. Sources of law, including the economic law 3. Legal entities. an individual and a legal person, methods of their creation and their legal capacity. 4. The principles of representation of legal persons. 5. Basics principles of obligation. Contracts as a source of obligations. The principle of freedom of contracts. Modes of concluding a contract, in particular in the economy. 6. The principles of fulfillment of contractual obligations. Consequences of non-performance or improper performance of the contract. 7. Taking up and running a business. The concept of the entrepreneur. Forms of runnning and requirements for starting a business. 8. Economic freedom and its limitation 9. Registration of running of an individual entrepreneur in the Central Register of Economic Activity, Polish Classification of Economic Activity 10. Company law. Principles of establishing companies. Register of Entrepreneurs of the National Court Register 11. Partnerships and capital companies – main features

	Geodetic and Cartographic Law	Lecture: Tasks of the organs of the geodetic and cartographic service. State geodetic and cartographic repository – management, sharing, fees, licenses. Submission of geodetic and cartographic works. Coordination of utilities network projects. Protection of geodetic controls. Geodetic works in closed areas. Technical standards applicable in surveying. Rules for completing technical reports. Professional qualifications in the field of geodesy and cartography. Exercises: Preparation of a geodetic work application. Preparation of a fee calculation document for materials for the submitted geodetic work, drawing up a license for the above-mentioned geodetic and cartographic materials. Preparation of a technical report for the submitted work and the content of the technical report for a specific assortment of surveying work. Preparation of an application for authentication of geodetic materials resulting from surveying work. Preparation of a notice of completed surveying work. Preparation of an application for coordination of the utilities network project.
	Specialist foreign language	Achieving the B2+ level of knowledge of a foreign language by expanding the specialist vocabulary related to geodesy and cartography and improving other skills that will enable students to communicate freely in a foreign language, prepare effective presentations and write an abstract of a master's thesis, report or texts in a foreign language useful in their professional work.
	Mathematics	Functions of complex variable: function derivative, Cauchy-Riemann equations, holomorfic function. Integration of complex function, Cauchy integral theorem, Cauchy integral formula, Laurent series, residual of the complex function and its application for the computation of integrals. Basic equations of mathematical physics. Partial differential equations of the first and second order and their classification. Differential equations of the string and of the thermal conductivity. Fourier method of the separation of variables. Integration and ultra-tight (deep) integration.
	Selected Topics of Mathematics and Numerical Methods **/E**	The main purpose of the course is to give students theoretical and practical knowledge on the selected methods of random signals analysis. The course will present mathematical background and describe algorithms of empirical data analysis, both in the time and frequency domain. The course will begin with a short introduction to the theory of probability, random variables and their parameters. Next, given is description of the random signals with special attention paid to the properties of stationarity and ergodicity. The basic characteristics of the signals are introduced: mean value and variance, probability density, autocorrelation and power spectral density (PSD) functions, then the joint characteristics: joint probability density, cross correlation and the cross power spectral density (CPSD). The data analysis algorithms will include the classical methods, based on the digital Fourier transform, and the parametric methods focusing on the autoregressive (AR) modeling of time series. The last part of the course is devoted to the application of the linear Kalman filter to the time domain analysis of discrete data. It begins with definition of the linear dynamical system using the state-space formulation, then the filtering equations are derived. The project part of the course includes application of the computer programs for analysis of empirical data.
	Geophysics	The purpose of this course is to give the students a basic knowledge on the folowing subjects: The Earth as a planet. Internal structure of the Earth. Isostasy – postglacial rebound. Plate tectonics: oceanic rifts, subduction zones, orogens, transform boundary. Rheology. Seismology: seismic waves, seismic wave propagation, Richter scale. Earth's magnetic field: parameters, units, constituents, geodynamo hypothesis. Magnetic surveying: magnetic anomalies. Geomagnetic poles, equator and coordinates (calculation of). Paleomagnetism, polarity reversals. Magnetosphere, magnetic storms and solar activity. Hydrological cycle, physical properties (density, optical, acoustic) of oceanic water. Physical oceanography: thermocline, waves, currents, deep-water circulation, oceanic tides. Basic of fluid dynamics. Particular attention is paid to the interactions between geophysics and geodesy. That includes those geophysical theories and models which are used in geodetic practice, as well as the geodetic observations and models which can support geophysical research.

	Selected Topics of Physical Geodesy and Geodynamics	Gravimetric measurements - construction of a gravimeter, preparation for measurement (calibration, adjustment) - calculation exercise: determination of the gravimetric factor from measurements on a calibration basis. Gravimetric measurements - Development of a gravimetric measurement with the calculation of the tidal correction - calculation exercise: preparation of the results of a gravimetric span measurements with relative method. Gravimetric measurements - development of measurement results: calculation of the field correction, calculation of reductions and gravimetric anomalies - calculation exercise: preparation of a map of free air anomalies and the full Bouguer anomaly. Tidal deformations - determination of the deformation of the earth's crust caused by tidal phenomena, static and dynamic tidal model - computational exercise: determination of the deformation of the earth's crust in the neu system for a specific point in a given period. Non-tidal deformations - determination of deformations caused by non-tidal phenomena (atmosphere, hydrology or anthropogenic and local factors) - computational exercise: determination of the Earth's crust deformation in the neu system for a specific point. Implementation of the EVRF2007 system - determination of the increments of geopotential number with the use of real gravimetric measurements and geopotential models - accuracy analysis - computational exercise: determining the increments of geopotential features for a selected leveling line, reduction to zero tide. The phenomenon of isostasy and its importance for the implementation of the geodetic network - computational exercise: modeling of the isostatic effect on the basis of the GNSS time series (Fennoscandia). Gravity field of simple geometric solids - elements of geophysical interpretation - computational exercise: modeling of gravity field anomalies resulting from anomalies of subsurface formations. Elements of the gravity field in connecting the natural (related to the plumb line) and geodetic (related to the normal line) coordinate system - computational exercise: reduction of traverse elements from the tacheometric system to the geodetic system related to the GNSS network.
	Digital image processing	1. Registration and development of a digital image 2. Digital image recording formats. 3. Lossy and lossless image compression methods. 4. Basics of image processing in Matlab (Computer Vision System Toolbox TM) 5. Basics of image processing in Python 6. Preprocessing (Matlab) and automatic image vectorization (ArcGIS) 7. Detection and analysis of text on images using the function Optical Character Recognition (OCR) 8. Clustering algorithms and the basics of machine learning for digital image classification. 9. Contextual processing: removing noise from an image through selected low-pass filters and detection characteristic elements of the image through high pass filters 10. Basics of mathematical morphology. 11. Basics of image texture analysis: fractal analysis, GLCM, granulometric analysis.
	Profiled courses	
	Standards in Geographic Information	Lectures: 1. Concepts of standard and norms. Objectives and tasks of standardization. 2. The subject, structure, and organization of standardization in GI. OGC standards, ISO standards. 3. Standards formalism, ISO / TS 19103 specification - UML language and ISO 19109 - rules of application schemas. 4. Selected issues from the ISO 19100 series standards: - describing the position (ISO 19107, ISO 19125-1, ISO 19111 and ISO 19112); - temporal scheme (ISO 19108); - data quality (ISO 19157 and ISO 19158); - cataloging methodology (ISO 19110); - metadata (ISO 19115); - XML language - GML (ISO 19136 and ISO 19139). 5. Rules for the use of standards in specific applications.
	Spatial Data Infrastructure	Lectures: The rules of construction of european and national Spatial Data Infrastructure (SDI), the INSPIRE idea and choosen implementing documents. Standardization of geospatial data and services: ISO, CEN and PN standards. Basic definitions: feature class and collection, web service, harmonization, consistency, interoperability. Types and OGC standards of geospatial web services, its applications. Structure of SDI in Poland, the rules of building, the leading organisations. The law acts: transposition the UE law documents to Polish law Order, technical documents of GUGiK (Head Office of Geodesy and Cartography) concerning the reference and thematic databases and cartographic vizualizations. Recources of reference and themtatic data: conceptual models, standards, structures, LoDs, applications. Geoportal.gov.pl as a national SDI access point, its functionality. Metadata - definitions, standards, editors and problem of validation.

	Cartographic Modelling /E	Geographic data: DLM (digital landscape model) and DCM (digital cartogrphic model). Basics of the topographic data model. Properties of DLM and DCM models and their practical application. Conceptual models in topographic and thematic databases. Methods of analysis and generalization of geographic information. ISO 19100 series standards for modeling geographic information. Processing of geographic data. Spatial analyzes performed on vector and raster data. Surface modeling. Interpolation methods. TIN model, GRID model. Modeling of the relief surface. Network analyzes. Transformations of spatial data. Basic principles of using databases in cartography. Multimedia techniques in cartographic presentations: multimedia means of expression, software, formats of graphics, animations, sounds and video images, compression algorithms, principles of designing and implementing multimedia compositions. Basics of cartographic visualization of geographic information on the Internet. The specificity of sharing spatial and multimedia data on the Internet, rules of website editing, designing online cartographic publications, designing and configuring geoinformation services, issues of functionality of Internet publications.
	Photogrammetric Technologies /E	1. Demand for geoinformation data. The influence of solar lighting and the atmosphere on photographing the Earth's surface 2. Aerial digital camera. Large format cameras. Perspectives; Medium format cameras; Oblique cameras; Direct georeferencing (in flight) - advantages and limitations 3. The quality of present aerial photos. Lens, orthoscopy; Internal camera / photo orientation. Camera calibration. Calibration certificate. 4. The market for aerial photography.
		Country coverage with aerial photos. State archive of photos. 5. Satellite imaging in the optical range. VHRS systems. VHRS systems - spatial resolution; HRS systems - data openness policy. Constellations of nanosatellites – temporal resolution 6. Airborne laser scanning. Design of area imaging by ALS ; The form of the results, content, formats. Basics of data georeferencing (terrain control network, stages of georeferencing, quality indicators). Coloring the point cloud. Basic products. 7. Digital terrain models. Sources of elevation data. Types of models, structure, basic standardization parameters. Derivative products from DTM. Comparison of ALS point cloud and image data (image matching). Standards and state of country coverage with elevation models 8. Microwave interferometry (InSAR). Airborne and satellite InSAR systems. Single pass and repeat pass interferometry. Global coverage of altitude data from InSAR satellite systems. 9. Digital orthophotomap. Process of processing from aerial photos. Standardization parameters. Photo parameters vs. orthophoto parameters. True-ortho, "oblique" ortho. Orthorectification of satellite images. Orthophotomap as a source of topographic databases supply. Standards and state of country coverage with digital orthophotomap. 10. Terrestrial laser scanning. Mobile multisensory systems. Principle of operation of a terrestrial scanner and its application. The principle of integration of MMS and MLS sensors systems. Applications of MMS systems. 11. 3D modeling of buildings. Review and evaluation of data sources, multi-source data. 3D modeling standards, CityGML. 12. BSL. Low-altitude photogrammetry. Platforms. Legal regulations; Measurement systems, imaging systems; Elaboration of UAV data. Typical products; Imaging from UAV platforms vs. aerial photography from manned airplanes.

	Geostatistics	Lectures: 1. Introduction to spatial statistics, measurement scales. 2. Basic statistics - central tendency statistics, dispersion statistics, correlation coefficient. 3. Spatial autocorrelation and heterogeneity, the concept of a matrix of weights and the principle of selection. 4. Global and local measures of spatial autocorrelation. 5. Measures of spatial concentration - Lorenz curve and Gini index. 6. Regression and spatial regression - basic concepts and stages of model construction. 7. Selected models of spatial regression. 8. Spatial panel models. 9. Basic concepts of geostatistics - semivariance, semivariogram. 10. Geostatistical methods of data interpolation. 11. Introduction to data mining methods. 12. Selected examples of geostatistics applications. Exercises: Projects involving the analysis of spatial data with the use of geostatistical methods, performed in various GIS class software, as well as statistical programs: 1. Study of spatial dependencies with the use of basic statistics of central tendency and dispersion, various global and local measures of spatial autocorrelation and spatial concentration using the Gini index. 2. The use of spatial regression to investigate the relationship between selected phenomena. 3. The use of geostatistical interpolation methods to create probability maps of the occurrence of a selected phenomenon
	GIS Technologies	Lectures: 1. Basic terminology related to Special Information Systems: ordering of concepts. Evolution of the definition and conceptual scope of SIS. 2. How to understand in the context of SIS: technologies, information technologies and IT technologies. Technology and technique. 3. Basic techniques used in SIS (e.g. data visualization, spatial analysis, saving spatial data in a database, spatial data transformation, automation). 4. Introduction to multi-criteria analyses - methodology, selected approaches and tools. 5. SIS techniques supporting the activities of geodetic and cartographic companies.6. Examples of projects implemented in Poland including public tenders. Project: Implementation of a project based on a local revitalization program of a selected urban municipality (development of small road infrastructure). Obtaining spatial information made available on the municipality's website and adapting it to a pre-created database with selected Topographic database BDOT data, with the appropriate attributes necessary to create simple network analyses, based on both data sources. Simple multi-criteria spatial analyses in a mixed approach (boolean and fuzzy functions) to chart a path between two points. The use of tools to visualize path profiles in 2D and 3D.
	Facultative class 1 - Review of contemporary surveying techniques	The principles of operation of selected measurement systems and the conditions for the use of individual measurement techniques in measurement implementation procedures and methods of determining displacements will be presented. A report will be made on the measurements made by videotachimeter. During the project implementation, the student will use the GNSS signal generator 1. statistical analysis of the measured time series 2. filtering with the use of a moving average and a median filter in a given filtering window 3. Fourier analysis of recorded time series 4. making appropriate charts 5. execution of the report
	Facultative class 1 - Advanced use of Matlab in geodetic and carto	The principles of operation of selected measurement systems and the conditions for the use of individual measurement techniques in measurement implementation procedures and methods of determining displacements will be presented. A report will be made on the measurements made by videotachimeter. During the project implementation, the student will use the GNSS signal generator 1. statistical analysis of the measured time series 2. filtering with the use of a moving average and a median filter in a given filtering window 3. Fourier analysis of recorded time series 4. making appropriate charts 5. execution of the report
	Facultative class 2 - Spatial data mining	Introduction to Spatial Data Mining. Data preprocessing and spatial data enrichment. Non-classical logics, including fuzzy logic. Rough sets and reducts. Decision trees. Association rules. Spatial concentration analyses. Spatio-temporal trends. Text mining and Twitter spatial data analysis. Big Data. Distributed databases. Distributed data processing

	Facultative class 3 - BIM in investment management	Lectures: BIM Standards and Initiatives; BIM Guides and Execution Planning; Uses of BIM; Levels of BIM; Impact of BIM; The Evolution to Object-Based Parametric Modeling; Parametric Modeling of Buildings; Creating a model based on a point cloud; BIM Environments, Platforms, and Tools Overview of the Major BIM Design Platforms; BIM for Owners and Facility Managers; BEP, Scope of Design Services; BIM Use in Design Processes; BIM for Contractors; Processes to Develop a Contractor Building Information Model; Construction Analysis and Planning; Integration with Cost and Schedule Control and Other Management Functions.
	Facultative class 4 - Machine Learning	1. Introduction to the class. Basic information on unmanned aerial vehicles 2. Legal provisions regarding the use of UAV aviation law 3. Review of photogrammetric UAV platforms and RGB, NIR, multispectral, hyperspectral, LIDAR sensors 4. Planning and development of photogrammetirc missions with the use of UAV 5. Processing of photogrammetric data obtained from the UAV 6. Regulations in the field of geodesy and cartography regarding the use of data from UAV platforms 7. Presentations of exemplary geodetic works using UAV data
	Facultative class 4 - UAV Technologies	Lectures: 1. Introduction to Machine Learning, basic concepts 2. Supervised and unsupervised learning 3. Classification 4. Regression 5. Cluster analysis: hierarchical, k-means, c-means, Kohonen networks 6. Supervised methods: kNN, least distance, maximum likelihood, decision trees, random forests, SVM, Bayes classifier 7. Artificial neural networks: neuron model, multilayer perceptron 8. Training of multilayer perceptron, mathematical model of a neuron 9. Deep neural networks, convolutional neural networks 10. Practical aspects of Machine Learning application in remote sensing 11. Typical problems in Machine Learning: small amount of data, unreliable data, unrepresentative data, overfitting, etc. 12. Methods of increasing model accuracy: extending a set of image features, knowledge transfer from related problems, combined methods 13. Machine learning in time series applications: trend curve fitting, outlier detection, prediction by analytical methods and deep networks (LSTM) 14. Competitive learning and other new trends in Machine Learning, examples of Machine Learning applications in remote sensing and related fields
	Specialization courses	
	Spatial Databases Design	Lecture: Repetition and consolidation fundamental knowledge of relational databases. Introduction to analytical methods of information systems design. Conceptual modeling. UML language and selected ISO standards in spatial data modeling. Cartographic presentation model. Principles of creating professional project documentation of geoinformation system. Features and functions of software supporting design processes (CASE software). Analysis of selected models of spatial databases, especially those available within the Polish national Spatial Information Infrastructure. Methods of recording spatial data in selected GIS programs (e.g. ArcGIS, Geomedia) and spatial databases (e.g. Oracle Spatial). Methods of using external databases by GIS software. Methods of harmonizing spatial databases within the framework of the Polish national Spatial Information Infrastructure (IIP). Project: Designing an information system using a spatial database. Performing requirements analysis. Developing use case and business process models. Designing a database conceptual, logical and physical models. Using selected CASE tool. Creating a database prototype within selectde RDB system (Oracle or PostreSQL). The project should use fragments of data models from the national IIP. Creation of as-built documentation.
	Programming in GIS	Projects involving the analysis and writing of scripts of increasing complexity: 1. Introduction to Python - creating lists, loops, functions, reading data from text files, saving data to text files. 2. Calculating attribute values using Python scripts in ArcGIS. 3. Basics of spatial analysis - Arcpy module. 4. Creating Python geoprocessing tools in ArcGIS. 5. Processing raster data in Python in ArcGIS. 6. Calculating attribute values using Python scripts in QGIS. 7. Python tools development in QGIS, using the ScriptRunner plugin. 8. Creating geoprocessing tools in Python in QGIS. 9. Raster data processing in Python in QGIS. 10. Creating own plugins based on Python scripts in QGIS. The scope of the algorithms taken into account results from the analysis of the market needs in terms of the demand for automation of the performed processing.

	GIS Software	Lectures: Software as off-the-shelf or Custom Low-Code Development product. COTS software: advantages and disadvantages. NDI software: advantages and disadvantages. Free and open software. Computer-aided software engineering (CASE). Free and open software: types of licenses. Introduction to free and open software. GIS in the cloud. Web-based mapping software -Leaflet, MapTiler, ESRI Server. Examples of the practical application of GIS. Exercises: 1: Building geoprocessing workflows (iterations, variables, submodels). 2: Creating a Leaflet.js mapping app. 3: Building a static website for viewing and analyzing GeoTIFF's in the browser. 4: Differences Between ArcGIS and QGIS. 5. The Introduction to MapInfo Pro or Geomedia. 6. Deploying ArcGIS Pro on Microsoft Azure. 7. Individual project.
	Providing Access to Spatial Data	Internet publications: the specificity of sharing spatial data on the Internet, tools and methods of publishing cartographic presentations. Principles of website editing, designing websites (webmastering), issues of the usability of internet publications, W3C standards. Classification of spatial data services (web services): browsing, searching, integrating. OGC standards. The functionality and configuration of the map server environment. Designing a geoinformation service (WebGIS): database organization, presentation editing, configuration of the sharing service, user application design.
	Providing Access to Spatial Data 2	Lectures: 1. Providing access to spatial data in relation to the INSPIRE Directive, legal regulations, scope of shared data, methods of sharing 2. Geoinformation metadata part. 1 - legal bases, metadata as a necessary component of INSPIRE, basic definitions 3. Geoinformation metadata, part. 2 - metadata profiles, national metadata profile, examples of industry metadata profiles 4. XML and XSD language, basics of syntax, validation of XML documents, use of XML in INSPIRE 5. Geoinformation network services - legal basis, basic definitions, standards used in building network services 6. Search Service (CSW) and metadata catalogues 7. WMS service, WMS service interface 8. WFS service, WFS service interface, ATOM service 9. GML language, basics of language, role in INSPIRE, mapping XML to GML 10. Creating WMS and WFS services using GeoServer 11. Review of geoportals in terms of the scope of shared spatial data. Exercises: 1. Creating metadata according to different profiles and their validation - practical use of different metadata editors 2. Comparison of the possibility of using geospatial services (WMTS, CSW, WMS, WFS) in free and commercial GIS software 3. Building raw queries according to OGC standards for WMS and WFS servers 4. Conversion of spatial data to GML in accordance with the interoperability and sharing in relation to the INSPIRE 5. Getting to know GeoServer - server configuration, publishing spatial data using WMS and WFS, testing created services, asking queries to running network services using GIS software and bypassing the service client, using the service interface to view / download data Part of the design exercises will be performed with the use of e-learning.
	Spatial Analyses and Modelling	Lecture: Introduction to spatial analysis and modeling, basic concepts, definitions. Multi-criteria analyzes, methodology of analyzes; WLC and OWA method, risk level, criteria compensation. A review of practical applications in the field of land suitability analysis. Methodology of solving tasks in the field of land suitability analyzes in the case of determining contradictory goals. Multi-criteria comparative analysis - an example of the bypass variants analysis. Designing optimal connections on a specific surface area; the concept of cost-weighted 'distance', area of relative and cumulative costs. Analyzes using DTM data and land cover model, including site visibility analysis. Modeling of the phenomenon of erosion; USLE model. Landscape analyzes, landscape structure indicators. Study of time changes analysis. Generating various scenarios and forecasts. The role of spatial analysis and modeling in the decision-making process and in solving current problems and meeting socio-economic needs.

		Decision support systems, expert systems, knowledge bases; knowledge-based analyzes and multi-source data, information, aggregation of knowledge, information from various sources, numerical and approximate inference. The problem of assessing the quality of the results of spatial analyzes; importance of input data quality, error propagation, sensitivity analysis, risk level assessment. Sample projects: 1: Multi-criteria analyzes of land suitability for a specific investment (application of fuzzy logic tools). Review of data sources for the criteria of spatial analyzes from the point of view of the investor or local government unit. WLC methodology, determination of weights, including the use of the AHP method. Solving tasks in the field of land suitability analyzes in the case of identifying conflicting goals. Choosing the optimal location for investment with the use of cost mapping technology and determining the optimal connection with selected objects of the existing technical infrastructure. Building and testing the universality of the geoprocessing model for the described methodology of spatial analyzes. 2: Analysis based on knowledge and multi-source data; numerical reasoning within the decision support system; extension with elements of accuracy analysis and uncertainty modeling. 3: The task of modeling the erosion or the assessment of natural groundwater susceptibility to pollution. Building a geoprocessing model, evaluation of modeling results depending on the accuracy / detail of the source data.
	Spatial Analyses and Modelling 2	Lectures: 3D GIS. Structure and sources of 3D data. LIDAR data as a data source for 3D GIS objects. Algorithms of 3D spatial analysis and their potential application; automation of the processing and analysis process. Solar cadastre, solar potential of roofs of buildings and structures. The concept of networks and topology in network analysis. Network analysis - network features, data sources for network building, overview of network analysis types and scenarios, geoprocessing models and scripts. Comparative analysis, analysis of changes. Examples of applications in the field of advanced spatial analysis and modeling. Project: 1. Overview of the possibilities of creating 3D objects. 2. The use of tools of 3D spatial analysis to assess the attractiveness of the view and assess the impact of the skyscraper on the surroundings. 3. Development of a methodology for transforming 2D to 3D data on the example of selected elements of technical infrastructure. 4. Solar cadastre. Building a geoprocessing model to determine the solar potential of roofs in ArcGIS Desktop / ArcGIS Pro environment. 5. Determining the optimal locations of e.g. city bike stations with the use of network analysis tools. 6. Optimization of determining the range of e.g. school districts in a selected commune with the use of network analysis tools. 7. Automation of the assessment of the progression of vegetation succession to agricultural areas.
	Remote Sensing Data Sources for GIS	Lecture: 1. Remote sensing data catalogues and services, operating and designed platforms and hubs for data acquisition and processing in Poland and around the world (e.g. EarthExplorer, Copernicus / DIAS, Planet, GoogleEngine). 2. Various image products available on websites, metadata. 3. Levels of processing of the shared optical data. 4. Methods of satellite data processing in terms of obtaining thematic information: classification algorithms, image segmentation and post-processing. 5. Automation of the satellite data processing in commercial and open software. 6. Updating databases using remote sensing data.

		7. The use of hyperspectral, thermal and radar data in research and monitoring of the environment and agriculture landscape. 8. Problems of multi-source and multi-sensor data fusion. Exercises: 1. Detailed familiarization with the various optical high resolution products; critical geometric and informational evaluation of orthophoto products (airborne and satellite) available in Poland and in the world in terms of their use in the preparing and updating of spatial databases (using aerial orthophoto, QB and Landsat or Sentinel2) 2. Advanced methods of satellite data processing in terms of obtaining thematic information (classifications, segmentation and post-processing) and its use in the development and updating of spatial databases. Developing an information coverage using various classifiers and updating the selected database 3. Automation of identification of selected forms of land cover and their changes in multi-time analyzes. 4. Development of database structures for raster data and automation of the satellite image processing. 5. Acquiring thematic information for monitoring the natural environment as a result of processing hyperspectral, thermal or radar images. Sample projects: SAR data processing in order to obtain the "water" thematic layer, thermal data processing for the study of the urban climate / locations of potential algae blooms / study of climate change, processing of hyperspectral data to monitor the condition of plants / water quality.
	GIS Applications	1. Detailed knowledge of topographic and general geographic databases in Poland, the ability to evaluate and select products, availability and possibilities of their applications for the needs of local government units, the ability to assess the information potential of topographical databases in INSPIRE. 2. Review and familiarization with the products of the digital terrain model. Critical geometric and attribute assessment of DEM products available in Poland and around the world; comparison of different data models, processing and analysis of DEM for specific applications and the quality of derived products. 3. Review and familiarization with industry databases in Poland and Europe; acquisition sources, institutions responsible for maintaining databases. Area and thematic ranges of databases: geology / geomorphology, hydrography, forests, environmental; geometric and thematic assessment of specific databases; analysis of the possibilities and design of the use of industry databases for various applications, including in planning new investments, monitoring changes and managing the area, environmental threats.
	GIS Applications 2	Overview of selected SIP applications in Poland and in the world. Getting to know various implementations and use of SIP through study visits, workshops and presentations of institutions such as: Agency for Restructuring and Modernization of Agriculture - Department of Reference Databases and Field Controls, Central Office of Geodesy and Cartography - Documentation Center, Marshal's Office of the Mazowieckie Voivodeship (Department of Digitization, Geodesy and Cartography), State Forests, and selected private companies, incl. ASTRI POLSKA with experience in designing and implementing GIS technology in crisis management, Cenatorium - using GIS technology in the economy and real estate trade. Overview of applications and solutions using GIS technology in the world in the context of innovative implementations. Presentation based on sources from international literature. Critical analysis of source texts. Basics of GIS project management, including selected approaches, e.g. SCRUM, PRINCE, or after Tomlinson. Implementation of the task "GIS project management" of a simulated industry order in accordance with the selected project management methodology. Building own portfolio in the field of GIS implementation.
	Diploma Seminar	Methodology of scientific work, guidelines for writing scientific texts and thesis. Putting a scientific thesis, the ability to verify it, selection of appropriate research methods, methods of presenting results. Review of literature sources, selection and analysis of literature related to the topic of the thesis. General overview of issues in the field of geodesy and cartography, including related topics with diploma theses undertaken as part of the SIP specialization, as well as accompanying issues, in particular in the field of intellectual property and copyright. Preparation and delivery of presentations presenting important stages of the implementation of the diploma thesis.