CARTOGRAPHY - GEOINFORMATICS DOCTORAL PROGRAM

Head of Program: Prof. László Zentai

FÖL/3/1 Map design and editing (Mátyás Márton)

6 credits, theoretical, optional, non-repeatable

The very first experiences already showed that the subject of map editing and design is chosen by professionals who graduated from various programmes and in very different periods. Several among them are recently graduated cartographers who attended this subject with a significant number of class hours and thus became familiar with both the theory and practice of computer-assisted map editing and design. Others were also once students of our department, but at that time—and since then—they have had no opportunity to come into contact with the new technology. Still others likewise completed their studies with us, but are currently working in another, though related, field, and in reality have not had the possibility to further expand their broad theoretical, yet more limited practical knowledge at their workplace. There are also those who possess very limited theoretical and practical cartographic knowledge, since they did not graduate from our programme; however, due to the nature of their current workplace, they feel the need to acquire deeper knowledge in this field as well. They usually work in some area of the geosciences or environmental protection.
It seemed hopeless to compile teaching material or a series of lectures that could satisfy all members of this heterogeneous group equally. It is also natural that the same level of performance cannot be expected from interested individuals with differing educational backgrounds. This is the reason why we compile "personalised" teaching material packages, differing from one another, which can be mastered and discussed not through lectures but through consultations.

FÖL/3/2 Thematic cartography (Krisztina Irás)

6 credits, theoretical, optional, non-repeatable

1. The System of Expressive Forms in Thematic Cartography
    1.1 Objective Regularities
    1.1.1 The Expression of Quality and/or Quantity
    1.1.2 The Expression of Discrete and/or Continuous Phenomena
    1.1.3 The Expression of Static and/or Dynamic Characteristics
2. Methods of Cartographic Representation
    2.1 Graphic Regularities – The Type and Definition of Representation
    2.1.1 Analytic Forms of Representation
    2.1.2 Complex-Analytic Forms of Representation
    2.1.3 Synthetic Forms of Representation
3. The Type and Definition of Representation
4. The Significance of Associative Capacity
5. Aesthetics, Art, and Harmony in Contemporary Cartography

FÖL/3/3 Map projections in GIS 1 (János Györffy, Krisztián Kerkovits)

6 credits, theoretical, optional, non-repeatable

- The most common units of measurement used on maps.
- Planar, spatial, and surface (especially spherical and ellipsoidal) coordinate systems.
- The relationship between latitude and longitude defined on the geoid, height above sea level, and ellipsoidal coordinates; geodetic datums and basic transformation possibilities between reference surfaces.
- Transformation between coordinate systems of reference surfaces (direct and inverse geodetic problems on the sphere and the rotational ellipsoid, auxiliary geographic coordinates); spherical projections.

- Projection distortions; Tissot's theory of distortion.
- Common true projections used in topographic cartography. Frequently used conformal projections for mapping the countries of Europe.
- Definition of coordinate systems in a GIS environment; defining a custom projection.

FÖL/3/4 Research on the history of cartography (Zsolt Győző Török)
6 credits, theoretical, optional, non-repeatable

The aim of the seminar is to provide effective support for solving the map-historical problems that frequently arise in doctoral research by addressing both the theoretical and practical–methodological questions involved in the study of historical map material.

- Old Maps and Map History in the 18th–19th Centuries
- Map History and the History of Cartography in the Development of Map Science
- Reproduction, Facsimile, Catalogues, and Empirical Map Histories
- Hungarian Map History
- Methodology and Research Methods. Archiving Maps. Cartobibliography and Catalogues
- Postmodern History of Cartography: Brian Harley
- Critical Cartography: Changes in the Social Context of Cartography and Their Consequences

FÖL/3/5 Fundamentals of Cartographic Modelling (Zsolt Győző Török)
6 credits, theoretical, optional, non-repeatable

1. **Cartographic Representation – Concepts and Tasks**
2. **Map Graphics as a Sign System**
   2.1 The Structure of the Map Sign System
   2.2 Graphic Variations of Signs
   2.3 Logical Conditions of Map Graphics
   2.4 Minimum Dimensions of Graphic Representation
   2.5 Fundamentals of Map Graphics and Perception
3. **Basics of Color Theory**
4. **Tools of Cartographic Representation**
   4.1 The Point
   4.2 The Line
   4.3 The Area
   4.4 The Symbol
   4.4.1 Types of Symbols
   4.4.2 Arrangement of Symbols and the Nature of Information Transmission
   4.5 The Diagram
   4.6 Tone/Shading
   4.7 Writing (Letters and Numbers)
5. **Formation of the Analog Map Model**
   5.1 Parts of the Map
   5.2 Map Scale
6. **Formation of the Digital Map Model**
   6.1 Concepts and Tasks
   6.2 Fundamentals of Data Modelling
   6.3 Spatial Data Modelling in Geoinformatics
   6.4 Formation of Digital Object Models
   6.5 Formation of Digital Cartographic Models
7. **Generalization**
   7.1 The Need for Generalization
   7.2 The Nature (Types) of Generalization
   7.3 The Concept of Generalization

FÖL/3/6 Optimal projections of geographic maps 1 (János Györffy, Krisztián Kerkovits)
6 credits, theoretical, optional, non-repeatable

- Map projection distortions and distortion criteria.
- Precursors of variational-type projection optimization in geocartography (perspective plane projections with optimal distortion, the Behrmann problem).
- The Euler–Lagrange differential equation and its application in projection theory.
- True plane, conic, and cylindrical projections of the sphere and the rotational ellipsoid with minimal distortion.

FÖL/3/7 Output-oriented digital cartography 1 (László Zentai)
6 credits, theoretical, optional, non-repeatable

- Introduction to Digital Cartography
- The PostScript Page Description Language
- Output Devices (Color Printers)
- Elements of Color Separation
- Film Output / Imagesetting
- Web Cartography

FÖL/3/8 Digital filtering methods in GIS (István Elek)
6 credits, theoretical, optional, non-repeatable

- Basic Concepts: The Electromagnetic Spectrum; Pixel, Resolution, Color Depth; RGB Color Model, HSI Color Model; Histogram, White Balance; Practical Exercise: Developing Color-Manipulation Programs
- Data Acquisition Tools
- Raster Data Structures
- Mathematical Foundations of Image Processing
- DFT, FFT
- Theory of Sampling
- Statistical Methods
- Raster–Vector Conversion

FÖL/3/9 Map-based animations on the Web (Jesús Reyes)
6 credits, theoretical, optional, non-repeatable

1. Introduction
   1.1 Internet and Web
   1.1.1 Historical Overview and General Characteristics
   1.1.2 Brief Description of the HTML Language
   1.2 Multimedia on the Web
   1.2.1 Raster- and Vector-Based Graphics
   1.2.2 Image, Audio, and Video Formats on the Web
2. Web Animations**:**
   2.1 The Past and Present of Web Animation Production (A Brief Historical Overview)
   2.2 Raster- and Vector-Based Animations
   2.3 GIF Animations:
   2.3.1 Properties of the GIF Format, Advantages and Disadvantages
   2.3.2 Possible Applications in Cartography
   2.3.3 Overview of GIF Animation Software
   2.4 Macromedia Flash Technology:
   2.4.1 Description
   2.4.2 Using the Flash Software
   2.4.3 Cartographic Applications of Flash

2.5 Examples of Cartographic Animations Found on the Web
2.6 The Future of Cartographic Animation Production

FÖL/3/10 Writing of foreign geographical names (Gábor Gercsák)
6 credits, theoretical, optional, non-repeatable

- Transcription and Transliteration
- Onomastic Errors, Inconsistencies, and Traditional Forms
- Hungarian Geographical Names in English-Language Publications
- Translation of Hungarian Geographical Names in English Texts and Maps
- Non-Hungarian Geographical Names in Hungarian and Foreign Languages
- Spelling and Grammar of English-Language Geographical Names
- Geographical and Personal Names in Hungarian and English Expressions

FÖL/3/11 Geological mapping (Gáspár Albert)
6 credits, theoretical, optional, non-repeatable

- The Geological Map and Its Use
- Topographic Fundamentals; Cartographic Requirements for Base Maps
- Geological Mapping: Basic Conditions, Preparation, and Fieldwork
- Application of Remote Sensing Materials in Geological Mapping
- 2-D Thematic Content of Geological Maps
- 3-D Thematic Content of Geological Maps
- 4-D Thematic Content of Geological Maps
- Map Compilation and Generalization
- Methods of Representing Geological Maps: The Symbol Method and the Area Method
- Digital Geological Maps, Geoinformatics, and Map Production

FÖL/3/12 Chapters on Geographic names (András Dutkó)
6 credits, theoretical, optional, non-repeatable

- Basic Concepts in Toponymy
- Natural and Artificial Geographical Names
- United Nations Efforts for Standardization of Geographical Names
- Historical Hungarian Geographical Names in the Carpathian Basin and Beyond
- History of Official Geographical Names in Hungary
- The Geographical Names Committee
- Writing Systems – Transliteration of Geographical Names Across Different Scripts, Transcription, Transliteration
- Issues in the Hungarian Orthography of Geographical Names

FÖL/3/13 Hungarian topographic maps since the First Military Survey to 1950 (Annamária Jankó, László Zentai)
6 credits, theoretical, optional, non-repeatable

A systematic study of the First (1763–1787), Second (1806–1869), Third (1869–1887), and Fourth (1896–1914) Military Surveys, as well as Hungarian military topographic mapping between the two World Wars: examining their geographic coverage, the organizations responsible for the surveys, scale, projection, sheet division, legend, and the analysis of both surveyed and derived scale series, as well as the history of map preservation. Presentation and comparative analysis of the different map variants produced by these surveys.

FÖL/3/14 Hungarian cartography 1528-1709 (Katalin Pilhál, Zsolt Győző Török)
6 credits, theoretical, optional, non-repeatable

- Sources of Maps of Hungary and Transylvania and the Channels of Data Flow
- Variation, Change, and Expansion of the Toponymic Content of Maps Between 1528 and 1709
- Techniques of Early Map Printing

FÖL/3/15 Application of map-based informatics in earth sciences (Gáspár Albert)
6 credits, theoretical, optional, non-repeatable

- Content-Level Classification of Databases; Relationships
- Technical Classification of Databases; Data Types
- Internal Inhomogeneity of Thematic Databases
- Internal and Inter-Database Harmonization of Thematic Databases
- Structure and Design of Geoinformatics Databases
- Functional Toolkit of Geoinformatics Tools
- Application of Geoinformatics in Derived Maps
- Analytical Use of Geoinformatics
- 3D Geoinformatics
- Cartography-Supporting Capabilities of Geoinformatics
- Web GIS
- The Relationship Between Map Databases and Cartographic Maps
- Case Studies

FÖL/3/16 Cartography in the History of science (Zsolt Győző Török)
6 credits, theoretical, optional, non-repeatable

1. Views on the Emergence of Cartography Science
2. Beginnings of Theoretical Cartography
   2.1 Antiquity
   2.2 The Middle Ages
   2.3 From the Renaissance to the First Half of the 17th Century
3. The Emergence of Cartography as a Subdiscipline
   3.1 From the Mid-17th Century to the End of the 18th Century
4. The Development of Cartography into a Science
   4.1 Direct Prehistory – From the Early 19th Century to the 1860s
   4.2 Constitution of Cartography Science (1860–1930)
   4.3 The First Phase of Cartography Science Establishment (1930–1950)

FÖL/3/19 Satellite navigation systems (Béla Kovács)
6 credits, theoretical, optional, non-repeatable

1. Street Network-Based Geoinformatics Systems
2. Natural Resource-Based Geoinformatics Systems
3. Property Register-Based Geoinformatics Systems
4. Utility Register-Based Geoinformatics Systems
5. National Geoinformatics Applications in Agriculture
   5.1 Database, Methods, and Results for the Establishment of the Land-Use Zoning System
   5.2 Implementation Framework: The National Agri-Environmental Program (NAKP)
   5.3 Core Model: The Sensitive Natural Areas (ÉTT) System
   5.4 Characterization of Protected and Sensitive Natural Areas
6. Regional and Local Geoinformatics Applications
   6.1 Agricultural Water Management Geographic Information System
7. Human-Focused Geoinformatics Applications

FÖL/3/20 Cartographic paradigms (Zsolt Győző Török)
6 credits, theoretical, optional, non-repeatable

The Development of the Theory of Cartographic Discipline and Current Issues; Competing and Parallel Paradigms in the Scientific Theories of Digital Cartography

- Philosophy and History of Science – Questions of Scientific Development. Kuhn and Paradigms. Sociology of Knowledge
- The Emergence of Cartography as an Independent Science
- Modern Cartography: Empiricism, Positivism, Value-Neutrality as Ideology
- Definitions of Map and Cartography. General and/or Thematic Maps?
- Cartographic Communication, Scientific Visualization
- The Technological Revolution: Digital Cartography and Cognitive Possibilities
- Paradigm Shift and Social Context. The Future of Cartography

FÖL/3/21 Map-based animations on the web 2. (Jesús Reyes)

6 credits, theoretical, optional, non-repeatable

- Vector-Based Animations**:** Overview; Presentation of Vector Formats Used on the Web; Advantages Compared to Raster Applications; Their Application in Cartography and Geoinformatics
- Software for Creating Vector Animations: The Macromedia/Adobe Flash Technology**:** Historical Overview; Preparation of Vector Files for Use in Animations
- Overview of the Software**:** Workspace, Formats, Commands; Using Flash for Web Animation Production; Cartographic Applications of Flash
- Examples of Cartographic Animations Found on the Web
- The Future of Cartographic Animation Production
- Creating Your Own Animation

FÖL/3/22 Map design and editing II (Globes) (Mátyás Márton, Zsuzsanna Ungvári)

6 credits, theoretical, optional, non-repeatable

The Construction of Terrestrial and Celestial Globes is a highly specialized cartographic task. Historically, various processing approaches posed specific challenges in projection design and/or toponymic layout for cartographers attempting to complete such tasks. Consequently, compared to the large number of general geographic or country-colored ("political" or administrative) maps, maps of physical geography (or relief) and political-color globes appeared only in very limited numbers. This is even more pronounced for globes featuring thematic cartographic content. The aim of the course is to explore and discuss the issues of this specialized field and to introduce modern methodologies.

FÖL/3/23 Output-oriented digital cartography 2. (László Zentai)

6 credits, theoretical, optional, non-repeatable

Practical Demonstration of Software Types Used in Computer Cartography, Execution and Practice of Typical Tasks**.** Software**:** OCAD, CorelDraw, MapInfo

FÖL/3/25 The art of map printing – development of printing technologies (Katalin Pilhál)

6 credits, theoretical, optional, non-repeatable

Throughout history, numerous technical and technological "innovations" have been developed for the mass reproduction of cartographic documents. Technological changes have always influenced contemporary mapmaking, making knowledge of historical map printing techniques important for evaluating historical maps today. The development of map printing transformed the map into a significant tool for information dissemination. The specific research topic for investigation is determined in consultation with the student enrolling in the course.

FÖL/3/26 Map projections in GIS 2 (János Györffy, Krisztián Kerkovits)

6 credits, theoretical, optional, non-repeatable

- Distortion characteristics of projections with an ellipsoidal base surface.

- True projections based on an ellipsoidal surface.
- More common ellipsoidal variants of transverse and oblique-axis projections, with special emphasis on the topographic cartographic projection systems formerly and currently used in Hungary.
- Imaginary projections of the rotational ellipsoid as applied in topographic cartography.
- Possibilities for transformation between map coordinate systems.
- Applications of complex function theory in projection theory; transformations between conformal projections using complex power series.

FÖL/3/27 Optimal projections of geographic maps 2 (János Györffy, Krisztián Kerkovits)
6 credits, theoretical, optional, non-repeatable

- Imaginary projections of the sphere with minimal distortion.
- The concept of the ideal and the best cartographic projection.
- Fundamentals and major results of minimax-type projection optimization; Chebyshev's theorem.
- Applications of complex function theory in projection theory; approximation of minimal-distortion conformal projections using simpler complex functions.

FÖL/3/28 The GIS background of 3D geological modelling (Gáspár Albert)
6 credits, theoretical, optional, non-repeatable
The subject gives an overview about the general methodological tasks and questions of 3D geological modelling from the point of view of a GIS. It deals with the overview of the types of geological data, the technical parameters of the systematic sorting of these data, and the perspectives of different data management in the resulting information systems. It discusses the 3D visualization of the geological data in the context of the data content of the resulting information system and the purpose of the modelling.The subject includes 2 hours per week (lecture), which can be substituted by block sessions. Practical sessions are also included with industrial modelling software. The subject can be attended by the students of the Doctoral School of Earth Sciences.

Main topics:
- Concepts of 3D geological modelling.
- The "scale" of a 3D model, and the coherence of the spatial reference of geological data.
- Hierarchical management of data, and the source of primary data.
- The uniform management of different sub-systems (maps, borehole-logs, geophysical datasets), witch contain primary data.
- Classification of modelling methods, based on geometry (irregular/regular).
- The transfer of data between different types of models, concerning the distortion of data.
- Visualization of the 3D model on papers an in the virtual space; the requirements of the visualisation.

FÖL/3/29 New technologies in webcartography (Mátyás Gede)
6 credits, practice, optional, non-repeatable

The course covers the general characteristics of web mapping APIs, as well as the capabilities and limitations of the most well-known open-source APIs. Students are expected to be familiar with raster map data sources such as TMS, WMS, and georeferenced standalone images, as well as client-side vector data formats including GeoJSON and vector tiles. The exam also includes knowledge of freely available geocoding, routing, and other geospatial services, along with their integration into interactive web maps. Students must possess both practical and theoretical knowledge of the Leaflet web mapping and the Cesium.js virtual globe JavaScript APIs, including their advantages, limitations, and practical applications demonstrated through examples.

- Introduction to web mapping APIs. General concepts and objectives.

- Open-source web mapping APIs. The most well-known options, advantages, and limitations. Leaflet.
- Raster map data formats: TMS, WMS, georeferenced images.
- Raster data sources: typical providers and their availability.
- Client-side vector data formats: GeoJSON, vector tiles, and their use.
- Geocoding services: freely available options and their integration into web maps.
- Routing services: overview of open routing services and their integration.
- Other geospatial services: POI search, spatial analysis, and other useful services for web maps.
- Cesium.js virtual globe API: functions, advantages, limitations, and practical examples.

Literature:

- Farkas, Gábor: *Establishing the Foundations of a General-Purpose Web GIS Client*.
- Paul Crickard: *Leaflet.js Essentials*.
- Leaflet API Reference.
- CesiumJS Tutorial and Reference.
- Gede, Mátyás: *The OpenLayers 5 API*.

FÖL/3/30 High precision GNSS measurements (Béla Kovács)

6 credits, practice, optional, non-repeatable

- The theory and practice of extreme precision GNSS measurements
- Measurement planning
- Real-time and post-processed sub-cm GNSS measurements
- Theory of error and corrections
- Signal jamming
- Pseudolite measurements
- Measurements at weak satellite signal enviroment

Literature:

- Rizos C, M Higgins, S Hewitson: *New Global Navigation Satellite System Developments and Their Impact on Survey Service Providers and Surveyors.* Article of the Months October, 2005

FÖL/3/31 Cognitive cartography and geovisualization (Zsolt Győző Török)

6 credits, practice, optional, non-repeatable

The importance of representation in scientific visualization. The process of vision and the visual image in the brain. Cognitive maps and spatial cognition: orientation, wayfinding, navigation. Geovisualization of spatial information: networks, semantic relations, abstract spaces. Multi-level, multiple, temporal and interactive displays. The measurement of the effectiveness of geovisualization (UX). Eye tracking research and higher-level human cognitive functions. Design and implementation of a cognitive cartographic research project.

FÖL/3/32 Thematic maps in GIS (Pál Márton)

6 credits, theoretical, optional, non-repeatable

Preparing and editing thematic maps in a GIS environment requires essential knowledge of data sources, general methods of data processing and visualization, the capabilities of geographic information systems, as well as the planning, implementation, and documentation of a project.

- Types of thematic maps and applicable graphic methods
- GIS and maps
- Data types, data processing, base maps, databases
- Map production – projections, digitization, editing
- Topology

- Map production – data visualization
- Color theories
- Alternative data visualization methods
- Characteristics of print-ready maps
- Geospatial databases on the internet
- Planning a GIS project
- Practical exercises

Literature:

- Klinghammer, I. – Papp-Váry, Á.: *Thematic Cartography* (lecture notes, 1975)
- Klinghammer, I. – Papp-Váry, Á.: *Our Earth Reflected in Maps*
- Klinghammer, I. – Pápay, Gy. – Török, Zs.: *History of Cartography*
- Györffy, János: *Cartography and Geoinformatics II: Map Projections*
- Elek, István: *Introduction to Geoinformatics*
- Elek, István: *Geoinformatics Exercises*
- Tyner, J.: *Map Design*
- Slocum, T. – McMaster, R. – Kessler, F. – Howard, H.: *Thematic Cartography and Geographic Visualization*
- Dent, B. – Torguson, J. – Hodler, T.: *Cartography: Thematic Map Design*

FÖL/3/33 Renaissance Cosmography and Cartography (Zsolt Győző Török)

6 credits, theoretical, optional, non-repeatable

The term 'cosmography' was applied from the fifteenth century to a wide range of various levels of scholarly activities ranging from astronomy to popular natural history. The changing meaning of the concept reflected different interpretations, but cartography, the representation of knowledge in visual form was always substantial in Renaissance European cosmography. The seminar's focus is on the visual nature of Renaissance cosmography and cartography, and it actually explores the early history of scientific representation and visualization. The classical tradition. Ptolemy's rediscovery and Jacopo Angeli's translation. Berlinghieri's geography and Ptolemaic maps. The beginning of map printing and commercial cartography in Florence. German cosmographies: Waldseemüller, Apianus, Münster. Johannes Honter, a Transylvanian humanist. Renaissance court cosmography in Europe: maps, symbols, emblems. Measurement and representation. Explorations and navigation. Cosmographical diagrams and regional maps, from fortification to astrology. 17-18th century cosmography and its crisis. Science and representation: the map in the Enlightenment.

FÖL/3/34 Cartographic Information Processing & School Cartography (Jesús Reyes)

6 credits, theoretical, optional, non-repeatable

1. **Introduction**: Geographic Information Science. Composition of the Geographic Information Science knowledge. Background and Chronology of the Development of Geographic Information Science. Analog and Digital Cartography.

2. **Geographical and Cartographic Information:** Concepts, Attributes. Space and Time in Geography and Cartography. Temporality and Space. Spatial, Geographical or Geospatial Information. Coordinate Systems. Main Reference Systems. Data and Information.

3. **Cartographic Data Models**: Vector and Image models. Object Oriented Modelling. Diffuse Models, Time and Three-Dimensional Models.

4. **Cartographic, geometric and projective transformations**: Coordinate transformations between reference and projection systems; Cognitive transformations (Generalization). Vector and Matrix Models. Graphical Variables and Representation of Cartographic Information.

5. **Geometry and Topology in Vector Systems**: Implicit Spatial Relationship between objects. Geometry in Vector Models. Graph Theory.
6. **Historical Cartography and Spatial Analysis**: Examples and Surveys.
7. **Geographical Names:** their role within Geographic and Cartographic Information (use and analysis).
8. **The Field of School Cartography**: scenarios and applications
9. **School Cartography and educational projects**: geoinformation for citizenship education
10. **Cartographic Education in the Information Era**: Laboratory Practice with some current school cartography projects
11. **Planning and making of school cartography projects**: team work 1.
12. **Planning and making of school cartography projects**: team work 2.
13. **Presentations of projects and discussions**

Literature:

- Araujo de Almeida, R.: Cartographic education for school teachers and children: current and future challenges. Proceedings of ICC 2009. Santiago de Chile: ICA, 2009.

  https://icaci.org/files/documents/ICC_proceedings/ICC2009/html/nonref/29_6.pdf

- Almeida, R. D. and Araujo de Almeida, R.: Theoretical Approaches and future prospects of School Cartography in Brazil. Revista Brasileira de Cartografia. N 64/6: 833-844, 2012. http://www.seer.ufu.br/index.php/revistabrasileiracartografia/article/view/43824

- Di Maio, A.C. and Veiga, L.A.K.: Brazilian Cartographic Olympiad Project. In: 27th International Cartographic Conference (ICC) - Maps Connecting the World. Proceedings. Rio de Janeiro, RJ, 23 a 28 de agosto de 2015. https://icaci.org/files/documents/ICC_proceedings/ICC2015/papers/23/280.html

- Di Maio, A.C. et al. Collective construction and sharing of information and products from the Brazilian Cartographic Olympiad: data acquisition, access and availability. In: 12th Annual International Conference on Global Studies: Business, Economic, Political, Social and Cultural Aspects. Athens: ATINER, 2018.

- Grafarend, E.W., You, R., Syffus, R.: Map projections Cartographic Information Systems. Heidelberg: Springer Verlag, 2006.

- Iliffe J., Lott, R.: Datums and Map Projections for Remote Sensing, GIS and Surveying, 2nd edition, Caithness, UK: Whittles Publishing, 2000.

- Kerski, J.J.: Geo-awareness, geo-enablement, geotechnologies, citizen science, and storytelling: geography on the world stage. Geography Compass 9/1:14-2 6, 2015. http://dusk.geo.orst.edu/Pickup/Esri/Kerski-Geog-Compass.pdf

- Kerski, J.J. Understanding our changing world through web-mapping based investigation. Journal of Research and didactics in Geography (J-READING), 2, 2, Dec., 2013, pp. 11-26 DOI: 10.4458/2379-02 2013.

  http://www.j-reading.org/index.php/geography/article/view/39/60

- Kraak, M., Ormeling, F.: Cartography, visualization of geospatial data. London: Prentice Hall, 2003.
- Lemmens, M.: Geo-information Technologies. Heidelberg: Springer Verlag, 2011.
- National Research Council. 2006. Learning to Think Spatially. Washington, DC: The National Academies Press. https://doi.org/10.17226/11019.
- Slocum, T. A., McMaster, R.B., Kessler, F.C. & Howard, H.H.: Thematic Cartography and Geographic Visualization. Second Edition. Upper Saddle River: Pearson Prentice Hill, 2004.
- Taylor D. R. F. (Ed.): Cybercartography: Theory and Practice. Amsterdam: Elsevier, 2005.
- Thrower Norman J. W.: Maps and Civilization. Cartography in Culture and Society. Chicago: University of Chicago Press, 2008.

FÖL/3/35 International overview of the science and practice of cartography 1. (László Zentai)
6 credits, theoretical, optional, non-repeatable (two semesters; description below)

FÖL/3/36 International overview of the science and practice of cartography 2. (László Zentai)
6 credits, theoretical, optional, non-repeatable

- **Introduction**: Cartography as science, a short overview on the development of cartography
- **Institutions of cartography:**
    - International Cartographic Association
        - Commissions
        - Working groups
    - Sister societies:
        - FIG (International Federation of Surveyors)
        - ISPRS (International Society for Photogrammetry and Remote Sensing)
        - IGU (International Geographical Union)
        - CLGE (Council of European Geodetic Surveyors)
        - GSDI (Global Spatial Data Infrastructure Association)
        - IAG (International Association of Geodesy)
        - IHO (International Hydrographic Organisation)
        - IMIA (International Map Industry Association)
        - ISHM (International Society on History of Cartography)
    - Other organisations
        - UNI GIS
        - Agile (Association of Geographic Information Laboratories in Europe)
        - EU Inspire directive
        - International Orienteering Federation
- **International umbrella organisations in GI Science:**
    - International Science Council, GeoUnions
    - UN GGIM (United Nations Global Geospatial Information Management)
    - UNGEGN (United Nations Group of Experts on Geographical Names)
    - UN Sustainable development goals
    - Marine cartography
    - Cartography in NATO
- **National Mapping Agencies**:
    - Hungarian national mapping authorities (civil and military)
    - Federal Agency for Cartography and Geodesy (Germany)
    - Ordnance Survey (United Kingdom)
    - USGS (US Geological Survey)

    - National Geographic Institute (France, Spain)
    - Swisstopo (Switzerland)
    - Other examples (Austria, Russia, Japan, Australia, Brazil)
- **Private companies in cartography and GI Science**
    - Global on-line map services:
        - GoogleMaps
        - HERE Maps
        - BingMaps
        - MapQuest
        - ViaMichelin
        - YahooMaps
        - TomTom
        - Yandex
        - BaiduMaps
        - OpenStreetMap
    - Cartographia Ltd (Hungary)
    - ESRI
- **Publications in cartography and GI Science**
    - Hungarian and university repositories
        - MTMT, the Hungarian Scientific Bibliography
        - Edit, the ELTE repository
        - ODT (Hungarian Doctoral Council and the Hungarian Doctoral Data Base)
    - Scientific journals:
        - Geodézia és Kartográfia
        - International Journal of Cartography
        - The Cartographic Journal
        - Cartography and Geographic Information Science
        - International Journal of Geographical Information Science
        - Cartographica
        - International Journal of Maps
        - Journal of Location Based Services
        - Kartographische Nachrichten
        - Geodesy and Cartography
        - ePerimetron
        - Imago Mundi
    - Scientometry in cartography
        - refereed journals
        - citations
        - Scimago
    - Cartographic and GI Science conferences:
        - International Cartographic Conference
        - Geospatial World Forum
        - UN regional workshops

FÖL/3/37 Hyperspectral imaging and field spectroscopy (András Jung)

6 credits, theoretical, optional, non-repeatable

Hyperspectral imaging (HSI) combines scanning or non-scanning imaging with spectroscopic techniques. Technical developments in the last decades have brought the capacity of HSI to provide spectrally, spatially and temporally detailed geodata. The latter crucially relates to rapid data acquisition, favoured by hyperspectral snapshot technologies and spectral mobile mapping devices. Furthermore, the development of miniaturized hyperspectral sensors has fostered their applications

with lightweight unmanned aerial vehicle (UAV) platforms. HSI sensor technology and applications with 3D reconstruction capacities are of high interest in spatial sciences (geosciences, agriculture, ecology, etc.). This course helps better understand and integrate the available technologies, theories and practical use.

Main topics

1. Basics of radiometry
2. Hyperspectral remote sensing
3. Spectral data chain
4. Non-imaging spectroscopy
5. Imaging spectroscopy
6. Field spectroscopy
7. Snapshot hyperspectral imaging
8. Spectral field campaigns
9. Spectral sampling
10. Spectral libraries
11. Platform technologies and AI
12. UAV based imaging spectroscopy
13. Airborne sensors
14. Spaceborne sensors
15. Spectral mapping and applications

FÖL/3/38 Drone based remote sensing in the Earth Science practice (János Mészáros)

6 credits, theory, optional, non-repeatable

FÖL/3/39 Science Communication in Geography and Geosciences (Zsolt Győző Török)

6 credits, theoretical, optional, non-repeatable

The course deals with the popularization of research results in geography and Earth sciences, as well as issues of science communication. Students will become familiar with communication theories and model projects, gaining practical experience in effective communication. The course reviews informal communication issues relevant to a research career and certain phases of the scientific publication process, with particular attention to interdisciplinary fields.

In addition to traditional forms and channels of science popularization (popular articles, lectures, exhibitions, demonstrations, radio, and television), special emphasis is placed on exploring opportunities offered by new media (scientific blogs, serious games) and virtual reality (interactive presentations). Among non-traditional platforms, the course examines grassroots initiatives (e.g., meet-ups), as well as the specifics of science cafés and science art.

The course demonstrates the effective application of narrative methods in both textual (studies) and visual storytelling (presentations, exhibitions). After studying and analyzing international and domestic examples and best practices, students will create a digital story presenting the results of their own research or of a transdisciplinary nature.

FÖL/3/40 Pattern recognition and machine learning (Angela Lausch)

6 credits, theoretical, optional, non-repeatable

The module provides basic knowledge of concepts, principles, models and techniques of pattern recognition, geospatial modelling and prediction and machine learning for datasets from the fields of ecology and geoinformation.

Specific content topics:

- Introduction to the importance of data science and machine learning methods for pattern recognition and evaluation of "BIG Data" in surveying and geoinformatics.
- Integration of geodatabases, databases in modelling
- Analysis of relationships, connections and patterns through network analysis - bibliographic networks, social networks, networks of geodata
- Introduction to the trait/trait variation approach (properties/property changes of survey and geospatial data as well as remote sensing data as a basis for modelling and predicting patterns and processes.
- Quantitative spatial structure analysis (landscape and surface metrics) of geodata
- The Data Mining Process - Conceptual Model of Data mining (CRISP-DM)
- Pattern recognition and modelling: task understanding, data understanding, data visualisation, data structures, data types (simple-highly complex data)
- Data preparation (missing values, outliers, normalisation)
- Predictive modelling: models/learning functions, model training and prediction
- Learning functions (regression models, classification models, graphical models): Decission Tree, Random Forest, Bayes Classifiers, Regression, k-nearest neighbours, SVM, Neural Networks, EM Algorithms),
- Modelling similarities, neighbours, cluster modelling
- Fitting the model to data, recognising and avoiding model overfitting, (cross-validation, learning curves, controlling model complexity).
- Criteria for a good model, visualisation of the performance of models (assessment criteria, ROC curves, lift curves, dashboards, etc.)

FÖL/3/41 Remote Sensing Sensors (András Jung, Zsófia Varga)

6 credits, practice, optional, non-repeatable

In this PhD course, students become familiar with the tools and methods of remote sensing. They gain insight into both imaging and non-imaging data collection. Practically, they learn multispectral, thermal, and LiDAR data acquisition techniques (field and UAV-based) and the processing of these data. Students are also introduced to the practical and research applications of super-resolution satellites. Upon completion of the course, students will be able to select and carefully apply the remote sensing technologies and methods necessary for their independent scientific research.