

## **THE NEW CHALLENGES FOR THE HIGHER EDUCATION OF GEODESY IN UACEG – SOFIA**

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### **Abstract**

*Report presents the essence, structure and content of the new academic curriculum of major Geodesy at the Faculty of Geodesy at the University of Architecture, Civil Engineering and Geodesy (UACEG) - Sofia, developed in conjunction with the new state requirements for acquiring higher education degree Master of Science in majors of the regulated profession Engineer in Geodesy, Cartography and Cadastre in professional field Architecture, construction and geodesy, Decree № 303 of November 9, 2015. It emphasizes the main challenges facing the academic curriculum in terms of recent trends in higher education in EU.*

**Key words:** *academic curriculum, state requirements, regulated profession, geodesy, cartography, cadastre*

### **1. INTRODUCTION**

The University of Architecture, Civil Engineering and Geodesy (UACEG) was founded as a Higher Technical School in 1942. UACEG is traditionally on first place in the Bulgarian University Ranking System for Professional field Architecture, Construction and Geodesy.

Currently the UACEG consists of 5 faculties – Architecture, Structural Engineering, Hydraulic Engineering, Transportation Engineering and Geodesy.

The degree programme of Geodesy (at Faculty of Geodesy – UACEG) is the successor of one of the first two degree programmes (Construction Engineering and Land Surveying), launched in 1942 with the foundation of the first higher technical school in Bulgaria. The Faculty of Geodesy was established as a separate unit in the structure of the school in 1951/1952 with two degree programmes: Land Surveying and Land Management. Later, the degree programme of Land Surveying was renamed to Geodesy, Photogrammetry and Cartography. In 1992 these two programmes were merged into Geodesy.

Since 1942 more than 4500 Geodesy graduates are taking part in the exploration of the territory and natural resources of Bulgaria, in designing its maps, in constructing its cities, roads and industrial enterprises, creation and maintenance of the cadastral system and other geodetic activities.

From academic year 2016/2017 the degree programme of Geodesy is a major (specialty) of the regulated profession Engineer in Geodesy, Cartography and Cadastre which necessitated the development of new academic curricula.

### **2. LEGAL FRAMEWORK USED**

The legal framework used to draw up a new academic curriculum for the major Geodesy in UACEG is: Ordinance on State Requirements for the acquisition of higher education of education-qualification degree Master of Science in majors of the regulated profession Engineer in Geodesy, Cartography and Cadastre in professional field Architecture, Civil Engineering and Geodesy.

The Ordinance on State Requirements for the acquisition of higher education of education-qualification degree Master of Science in majors of the regulated profession Engineer in Geodesy, Cartography and Cadastre in professional field Architecture, Civil Engineering and Geodesy (in the next we will use the term “Ordinance”) is:

- Adopted by Council of Ministers Decree No. 303 on November 13, 2015;
- Promulgated in State Gazette No 88 on November 13, 2015;
- Effective from the academic year 2016/2017.

The Ordinance defines the state requirements for the acquisition of higher education in majors of the regulated profession Engineer in Geodesy, Cartography and Cadastre.

Higher education in majors of the regulated profession Engineer in Geodesy, Cartography and Cadastre is acquired in a higher education institution, which has received accreditation under the Higher Education Act in accordance with the requirements of the Ordinance.

The training and its results correspond to level 7 (Master) of the National Qualification Framework adopted by Council of Ministers Decree No 96 from 2012 and lead to the acquisition of a Master of Science degree.

The forms of training in majors from the regulated profession Engineer in Geodesy, Cartography and Cadastre are full-time and part time.

The training should ensure the acquisition of specific minimum knowledge, skills, competencies in the field of Geodesy, Cartography and Cadastre.

The training of students for the acquisition of higher education in the regulated profession Engineer in Geodesy, Cartography and Cadastre must last for not less than 10 semesters with a course of not less than 4200 academic hours, not less than 500 hours of practical training and lead to the acquisition of a minimum of 300 ECTS credits.

The curricular content of the compulsory groups of study subjects in the separate curricula of the academic curriculum and their minimum workload in the Ordinance is presented in Table 1.

| <b>Compulsory groups of study subjects according Ordinance on State Requirements</b> | <b>Min. number of academic hours</b> |
|--------------------------------------------------------------------------------------|--------------------------------------|
| Humanities, Social, Economic and Legal Sciences                                      | 120                                  |
| Natural Sciences, Mathematics and Informatics                                        | 210                                  |
| Land Surveying and processing of geodetic measurements                               | 300                                  |
| Geodesy                                                                              | 300                                  |
| Applied Geodesy                                                                      | 150                                  |
| Geoinformatics                                                                       | 120                                  |
| Photogrammetry and image processing                                                  | 180                                  |
| Remote Sensing                                                                       | 120                                  |
| Cartography and Cartographic modeling                                                | 150                                  |
| Topographic and Thematic mapping                                                     | 150                                  |
| Cadastre and Property management                                                     | 150                                  |
| Land-use and Urban planning (including regulations)                                  | 120                                  |
| Grading                                                                              | 120                                  |
| <b>Total:</b>                                                                        | <b>2190</b>                          |

**Table 1.** Compulsory groups of study subjects in the academic curriculum and their minimum workload in the Ordinance.

Practical training is done through training practices and Pre-Diploma training.

The training in majors of the regulated profession Engineer in Geodesy, Cartography and Cadastre ends with Diploma Thesis submission and defence.

Students who have fulfilled their obligations under the academic curriculum developed in accordance with Ordinance, and successfully defended a Diploma thesis, receive a Master of Science in Higher Education with a professional qualification Engineer in Geodesy, Cartography and Cadastre.

### **3. WHAT IS REGULATED PROFESSION?**

Regulated profession is a professional activity or a group of professional activities included in the list of regulated professions in the Republic of Bulgaria, which is of public importance and/or is essential for people's life and health and access to which is subject to the laws, regulations or administrative provisions regarding:

- possession of a specific professional qualifications, or
- capacity, or
- membership in a professional organization that works to maintain the high level in the professional field, for the implementation of which it has received special recognition by the state.

For the regulated profession Engineer in Geodesy, Cartography and Cadastre all of the above conditions are presented.

### **4. MAIN ACCENTS IN THE STATE REQUIREMENTS ACCEPTED**

Training must ensure the acquisition of knowledge about:

- Determination of the shape and dimensions of the Earth, geodetic methods and measuring instruments; Main geodetic networks and their associated coordinate, elevation and gravimetric systems; The theory of earth potential and geodynamics;
- Types of geodetic surveys;
- Probability-statistical methods for processing geodetic measurements;
- Spatial objects and the creation of databases with them, data structures, CAD systems and their application for geodetic activities and spatial planning;
- Methods of planning, photogrammetric capture, processing, analysis and interpretation of digital images and signals, reduction and transformation of raster information into vector; Methods for creating and evaluating a digital territory model;
- Methods of analysis, interpretation and use of thematic information through Remote sensing;
- Methods for the investigation of deformations of engineering sites, facilities and risk processes;
- General theory of map projections, deformations and their applications;
- Cartographic imaging and research methods; Drawing, shaping and Issuing topographic and thematic maps;
- The Cadastral System in the Republic of Bulgaria and the technical activities for its creation and maintenance;
- Regulations and administrative procedures in the field of Geodesy, Cartography and Cadastre, investment design and spatial planning.

Training must ensure the acquisition of skills about:

- Structuring, exchanging and analysing spatial data in Geo(graphic) and other Information systems, creation of digital models for data exchange between information systems;

- Management of geodetic and cartographic activities;
- Elaboration and implementation of planning schemes and plans, as well as projects in Investment design - part Geodesy;
- Development of agricultural land development projects;
- Application of geodetic and photogrammetric methods, operation with tools, topographic maps, geodetic photographs and measurement processing;
- Processing of geodetic measurements, analysis and interpretation of the results;
- Processing of digital images and methods for obtaining spatial information by photogrammetric technologies;
- Obtaining of thematic information by means of distance research methods;
- Design and creation of precise engineering geodetic networks for investigation of deformations of objects, facilities, risk processes, etc.;
- Creating and choosing a map projection, setting its parameters; examining deformations of a map projection;
- Designing, creating and working with topographic and thematic maps and others cartographic works and examination of their accuracy;
- Implementation of technical and administrative activities for creation and maintenance of the Cadastral System; Real estate valuation;
- Management and control of geodetic, cartographic and cadastral activities.

Training must ensure the acquisition of competencies about:

- Making optimal decisions when choosing methods and tools for conducting geodetic measurements;
- Use of Geographic Information Systems (GIS) for spatial data analysis; Design of Geo-information Systems and Object-Oriented Databases;
- Organization and carrying out of photogrammetric surveys; Classification and Interpretation of images by distance research methods;
- Organization and implementation of construction supervision under the part Geodesy of construction sites in the investment design; Preparing expert reports and reports;
- Organizing the activities for drawing up, editing and shaping thematic, general geographic, study maps, atlases, globes and relief maps;
- Organizing and carrying out activities for: creation, maintenance and applications of the Cadastral System; Estimates of real estate;
- Organization and management of projects in the field of Geodesy, Cartography and Cadastre;
- Development of concepts for spatial development, planning and spatial planning.

## **5. STRUCTURE AND CONTENT OF THE NEW CURRICULUM**

The new academic curriculum of major Geodesy part of regulated profession Engineer in Geodesy, Cartography and Cadastre is compiled on the basis of the world trends in education in the field of Geodesy, Cartography and Cadastre as well as the requirements of the Geodesy and Cartography Act and the Cadastre and Land Register Act.

International organizations setting standards in education in Geodesy, Cartography and Cadastre whose current aspects and trends are taken into account:

- International Federation of Surveyors – FIG;
- International Cartographic Association – ICA;
- International Association of Geodesy – IAG;
- Council of European Geodetic Surveyors – CLGE.

Training takes place in two university levels of education – full-time and part-time.

The full-time university level of education of major Geodesy part of regulated profession Engineer in Geodesy, Cartography and Cadastre, Degree Master of Science in professional field 5.7 - Architecture, Civil Engineering and Geodesy provides a duration of study 10 (ten) semesters. Of these, nine semesters are teaching, and the latter is for the Diploma submission and defence. In the last semester (IX semester) the students specialize in one of the following specializations: Geodesy, Geo-information Systems, Applied Geodesy, Photogrammetry and Remote Sensing, Cadastre and Real Estate Management, Cartography and GIS.

The part-time university level of education of specialty Geodesy part of regulated profession Engineer in Geodesy, Cartography and Cadastre, Degree Master of Science in professional field 5.7 - Architecture, Civil Engineering and Geodesy provides a duration of study 12 (twelve) semesters. Of these, eleven semesters are teaching, and the latter is for the Diploma submission and defence. In the last semester (XI semester) the students specialize in one of the mentioned above six specializations for full-time level of education.

The academic curriculum contains 124 subjects, structured as follows:

- Compulsory (excluding specializations): 51 (41 %)
- Compulsory on subject by student's choice: 7 (5.5 %)
- Compulsory (from specializations): 29 (23 %)
- Compulsory on subject by student's choice (from specializations): 28 (23 %)
- Practical and Pre-Diploma Trainings: 9 (7.5 %)

Forms for examining students knowledge and skills are written exams and an on-going (continuous) assessment.

The academic curriculum provides 69 grades, from which:

- Exams: 46 (66.7 %);
- Continuous assessment: 23 (33.3 %).

The distribution of the assessments by semesters (full-time university level of education) is presented in Table 2.

| <b>Assessments<br/>(without Practical and Pre-<br/>Diploma Trainings)</b> | <b>Semester</b> |           |            |           |          |           |            |             |           |
|---------------------------------------------------------------------------|-----------------|-----------|------------|-----------|----------|-----------|------------|-------------|-----------|
|                                                                           | <b>I</b>        | <b>II</b> | <b>III</b> | <b>IV</b> | <b>V</b> | <b>VI</b> | <b>VII</b> | <b>VIII</b> | <b>IX</b> |
| Exams                                                                     | 4               | 5         | 5          | 4         | 6        | 6         | 3          | 6           | 5         |
| Continuous assessment                                                     | 2               | 2         | -          | 4         | -        | 2         | 2          | 2           | 2         |
| <b>Total per semester</b>                                                 | <b>6</b>        | <b>7</b>  | <b>5</b>   | <b>8</b>  | <b>6</b> | <b>8</b>  | <b>5</b>   | <b>8</b>    | <b>7</b>  |

**Table 2.** Distribution of academic hours by subjects

The distribution of the academic hours by subjects is presented in Table 3.

| <b>№</b> | <b>Subjects</b>                              | <b>%</b>     |
|----------|----------------------------------------------|--------------|
| 1.       | Compulsory courses - Fundamental             | 11.8         |
| 2.       | Compulsory courses - General Engineering     | 4.7          |
| 3.       | Compulsory courses – Special Training        | 27.6         |
| 4.       | Compulsory courses – Specializations*        | 23.6         |
| 5.       | Elective courses - Fundamental               | 4.7          |
| 6.       | Elective courses – Specializations*          | 20.5         |
| 7.       | Practical Trainings and Pre-Diploma Training | 7.1          |
|          | <b>Total</b>                                 | <b>100.0</b> |

*\* For all specializations together*

**Table 3.** Distribution of academic hours by subjects

The distribution of the lecture and exercises/seminar hours by type of classes is presented in Table 4.

| <b>№</b> | <b>Classes</b>       | <b>%</b>     |
|----------|----------------------|--------------|
| 1.       | Lectures             | 33.2         |
| 2.       | Exercises/Seminars   | 34.6         |
| 3.       | Practical Trainings  | 17.0         |
| 4.       | Pre-Diploma Training | 15.2         |
|          | <b>Total</b>         | <b>100.0</b> |

**Table 4.** Types of classes inclusive average values for all specializations

The new academic curriculum content (in academic hours) of the compulsory groups of study subjects according to Ordinance on State Requirements (without specializations) with comment on implementation is presented in Table 5.

| <b>Compulsory groups of study subjects acc. Ordinance on State Requirements</b> | <b>Min. academic hours</b> | <b>Academic hours acc. Curriculum</b> | <b>Comment on implementation</b> |
|---------------------------------------------------------------------------------|----------------------------|---------------------------------------|----------------------------------|
| Humanities, Social, Economic and Legal Sciences                                 | 120                        | 210                                   | Exceeds with 75 %                |
| Natural Sciences, Mathematics and Informatics                                   | 210                        | 645                                   | Exceeds with 307 %               |
| Land Surveying and processing of geodetic measurements                          | 300                        | 360                                   | Exceeds with 20 %                |
| Geodesy                                                                         | 300                        | 450                                   | Exceeds with 50 %                |
| Applied Geodesy                                                                 | 150                        | 210                                   | Completed                        |
| Geoinformatics                                                                  | 120                        | 120                                   | Exceeds with 40 %                |
| Photogrammetry and image processing                                             | 180                        | 240                                   | Exceeds with 33 %                |
| Remote Sensing                                                                  | 120                        | 120                                   | Completed                        |
| Cartography and Cartographic modeling                                           | 150                        | 180                                   | Exceeds with 20 %                |
| Topographic and Thematic mapping                                                | 150                        | 180                                   | Exceeds with 20 %                |
| Cadastral and Property management                                               | 150                        | 240                                   | Exceeds with 60 %                |
| Land-use and Urban planning (including regulations)                             | 120                        | 240                                   | Exceeds with 200 %               |
| Grading                                                                         | 120                        | 120                                   | Completed                        |
| <b>Total</b>                                                                    | <b>2190</b>                | <b>3450</b>                           | <b>Exceeds with 57.5 %</b>       |

**Table 5.** Course content of the compulsory groups of study subjects (without specializations) with comment on implementation

The total number of academic hours is 4245 and the distribution by lectures and exercises/seminars is presented in Table 6.

| Type of study subjects    | Lectures and Exercises/Seminars | %          |
|---------------------------|---------------------------------|------------|
| Fundamental               | 840                             | 20         |
| Profiling and Specialized | 2835                            | 67         |
| General Engineering       | 330                             | 8          |
| Sport                     | 240                             | 5          |
| <b>Total</b>              | <b>4245</b>                     | <b>100</b> |

**Table 6.** Distribution of academic hours by lectures and exercises/seminars

The total number of Practical training hours is 504.

The new academic curriculum for major Geodesy at the Faculty of Geodesy at the University of Architecture, Civil Engineering and Geodesy corresponds to the state requirements for acquiring higher education at the Master's degree in majors from the regulated profession Engineer in Geodesy, Cartography and Cadastre in the professional field Architecture, Construction and Geodesy.

## 6. THE CHALLENGES

At present, graduates of degree programme Geodesy have the right to obtain qualifications (legal capacity) for activities on – Geodesy, Cartography, Cadastre and Investment Design – part Geodesy and Applied Geodesy. These qualifications are in accordance with the provisions of the Geodesy and Cartography Act, the Cadastre and Land Register Act and the Law on the Chambers of Architects and Engineers in Investment Design.

This predetermines sophisticated and focused academic curriculum content (average 30 academic hours per week) and number of ECTS credits 324 (instead of the minimum required 300).

Training should provide in-depth fundamental training combined with profiling in the field of Geodesy, Cartography and Cadastre. For this reason the structure of the academic curriculum follows the following philosophy (for full-time university level of education):

- 1<sup>st</sup> and 2<sup>nd</sup> academic year (semesters I – IV) - Fundamental subjects;
- 3<sup>rd</sup> and 4<sup>th</sup> academic year (semesters I – IV) - Profiling subjects;
- 5<sup>th</sup> academic year (semester IX) - Specialized subjects;
- 5<sup>th</sup> academic year (semester X) - Diploma Thesis submission and defence.

The distribution in academic years and semesters between Fundamental/ Profiling/Specialized subjects, for the compulsory groups of study subjects specified in the Ordinance on the Minimum State Requirements and the General Engineering Disciplines is presented in Table 7.

| Academic year                                                  | 1 |    | 2   |    | 3 |    | 4   |      | 5  |   |
|----------------------------------------------------------------|---|----|-----|----|---|----|-----|------|----|---|
| Semester                                                       | I | II | III | IV | V | VI | VII | VIII | IX | X |
| <b>Compulsory groups of study subjects according Ordinance</b> |   |    |     |    |   |    |     |      |    |   |
| Humanities, Social, Economic and Legal Sciences                |   |    |     |    |   |    |     |      |    |   |
| Natural Sciences, Mathematics and Informatics                  |   |    |     |    |   |    |     |      |    |   |
| Land Surveying and processing of geodetic measurements         |   |    |     |    |   |    |     |      |    |   |
| Geodesy                                                        |   |    |     |    |   |    |     |      |    |   |
| Applied Geodesy                                                |   |    |     |    |   |    |     |      |    |   |
| Geoinformatics                                                 |   |    |     |    |   |    |     |      |    |   |
| Photogrammetry and image processing                            |   |    |     |    |   |    |     |      |    |   |
| Remote Sensing                                                 |   |    |     |    |   |    |     |      |    |   |
| Cartography and Cartographic modeling                          |   |    |     |    |   |    |     |      |    |   |
| Topographic and Thematic mapping                               |   |    |     |    |   |    |     |      |    |   |
| Cadastral and Property management                              |   |    |     |    |   |    |     |      |    |   |
| Land-use and Urban planning (including regulations)            |   |    |     |    |   |    |     |      |    |   |
| Grading                                                        |   |    |     |    |   |    |     |      |    |   |
| General Engineering disciplines                                |   |    |     |    |   |    |     |      |    |   |

  

|  |                                |
|--|--------------------------------|
|  | Fundamental subjects           |
|  | Profiling subjects             |
|  | Specialized subjects           |
|  | Diploma Submission and Defence |

**Table 7.** Distribution between Fundamental/Profiling/Specialized subjects by academic years and semesters (for full-time university level of education)

Meanwhile training practices are taking place (the main at the end of the respective summer semester - II, IV, VI, VIII in real conditions in the university's training bases), as well as Pre-Diploma practice in state or municipal structures or leading companies.

The academic curriculum preserves the so-called General Engineering disciplines such as: Basics of Structural Engineering, Basic Water Engineering Course, Highways, Roads and Railways and Urban Territory Planning.

The academic curriculum takes into account and includes software products from leading companies such as: Autodesk, ESRI, Pitney Bowes Software, Adobe, Microsoft, Corel Corporation, Intergraph, Leica, Topcon, Sokkia and own developments in the field of Geodesy, Cartography and Cadastral.

A specific objective of the academic curriculum is to acquire knowledge and skills to automate geodetic production and data collection for the territory. This has been achieved by involving Microsoft Visual Studio Community and creating applications in the environment of commercial software (mainly for Autodesk and ESRI products), open source software (mainly for QGIS, Postgres/PostGIS and Open Layers) and own applications for processing geodetic measurements and data collection for the territory.

For the purpose all students and lecturers have free and unlimited access to relevant commercial or open source software.

The main prerequisites for the distribution of learning content are:

- Acquire knowledge, skills and competences required by the Bulgarian legislation for taking up positions, related to geodesy, cartography and cadastre in the state and municipal administration and the relevant services requiring higher education in these fields;
- Acquire knowledge, skills and competences in accordance with Bulgarian laws and international standards, as well as enough practical and pre-diploma trainings;
- European directives on standards for spatial information (for example Inspire) requires training to ac Engineer in Geodesy, Cartography and Cadastre which covers more than 80 % of the required knowledge, skills and competences to work on these standards;
- Implementation of the new Bulgarian Geodetic System 2005, the renovation of State Topographic maps, the creation and maintenance of the cadastral map and cadastral registers and the accurate mapping of Bulgarian state and other borders require thorough knowledge, skills and competences;
- Improve the level of key competences and skills, with particular regard to their relevance for the labour market;
- Teaching methods based on student-centred active learning and assessment.

A key issue to be addressed is the technological upgrading with equipment for terrestrial and aerial laser scanning, Unmanned Aerial Vehicle and Augmented Virtual Reality.

## **7. CONCLUSION**

The regulated profession Engineer in Geodesy, Cartography and Cadastre is a priority for the State authority because there is an objective necessity of training highly qualified specialists for the purposes of the economic and social development of the Republic of Bulgaria. The main geodetic and cartographic activities, as well as the creation, management and use of the Cadastre and the Property Register are a direct commitment of the State. For these reasons, the new curriculum developed provides for the acquisition of additional knowledge, skills and competencies related to:

- Collecting and publishing spatial data for objects of the territory (spatial data providers);
- Creation and maintenance of an up-to-date model of the cadastre according to the latest trends in the field of technology;
- Provision of services with spatial information and cadastral data;
- Implementation of new information technologies according to the latest trends in the field of geoinformatics.

The new academic curriculum will assist in the preparation and implementation of highly qualified engineers to apply the knowledge, skills and competences they have acquired in different sectors in the country and abroad.