The Role of Surveying within the University Curricula for Training Terrestrial Measurement and Cadastre Engineers

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SUMMARY

The activity of the terrestrial measurement and cadastre engineer in the field of Geodesy consists mainly in performing works of surveying, tracing or topographic tracking. Also, we could say that the activity of technical cadastre, of recording or application, has a significant topographic content.
This paper analyses the weight of topography in the training curricula of the mentioned specialists, with its components, spread, as you will see, over all four years of university education. Also, the paper presents the content of the courses, in order to reveal how we conceive the didactic presentation (the didactic methods used will be also presented), in the end resulting the whole range of studied problems.
The development of the total topographic station obviously simplifies the work of the topographer, the stations being more and more efficient, so that the role of the topographer will soon resume to carrying around the prism; and thus the paper discusses this very aspect: given the circumstances, to what extent is the classic study of topography necessary? The authors support maintaining education in its current, complete format, considering that the complete training of field specialists cannot be reduced to using a device, even a very efficient one, without knowing the essence of the profession.

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MOTTO

"We are finding that surveying education curricula is dictated by the norms of practice in each country. Different discipline areas from one country to another conduct the various elements of the profession…So we must look at and analyze the past, present, and conceivable future education models, their problems and the various potential solutions to these problems". **Julian "Jud" ROUCH**, **Summary of models of surveying curricula around the world,** www.fig.net/pub/proceedings/prague-final-papers/papers/rouch-fin.pdf

1. INTRODUCTION

The 2005-2006 academic year brings most of the changes in the organization and functioning of the Romanian technical higher education, since 1990. Romania has signed the Bologna Statement, on June 19th, 1999, thus committing itself to insert the objectives within the priorities of the Romanian higher education. Romania has created the legal frame needed to restructure the upper education on two levels, the implementation of the new structure being carried on beginning with the academic year 2005-2006. The academic training is developed on cycles of studies: undergraduate education – 4 years, graduate Master's degree – 1-2 years, Doctoral studies – 3 years. Thus, engineering was changed from 5 to 4 years of studies. Implementing the Bologna Agreement is a priority objective of the current government and therefore it imposed radical changes in the structure of academic studies, in the structure of fields and specialties, and in the assessment mechanisms. Introducing these new regulations, the Romanian higher education is sought to be brought in line with the European education. These regulations have been applied since October 2005.

2. THE ROMANIAN AGENCY FOR QUALITY ASSURANCE IN HIGHER EDUCATION

Once with Romania's participation in Bologna Process, as of 1999, the evolutions inside the European Higher Education Area required a new approach on the concepts and procedures of quality evaluation and assurance. Thus, ARACIS was established in 2005, in compliance with Government Emergency Ordinance no. 75/2005 approved with modifications by Law no. 87/2006. Although, according to the law, ARACIS took the patrimony and all rights and obligations, logistic infrastructure, technical staff and database of the National Council for Academic Evaluation and Accreditation, the new institution's mission and way of operation

are defined in compliance with the European trends established by higher education ministers in the conferences carried out every two years, as of 2001.
ARACIS is an autonomous public institution, of national interest, having a legal personality and its own income and expenditure budget. The agency is not submitted to political or any other types of interference. According to the legal provisions, ARACIS is funded as follows:

- income from service contracts for quality evaluation, concluded with the Ministry of Education, Research and Innovation inclusive;
- authorisation and accreditation fees of higher education institutions on study programmes, proposed by ARACIS and approved by Government decision;
- quality external evaluation fees, established by ARACIS and approved by Government decision;
- external non-reimbursable funds obtained by participation in international programmes, donations, sponsorships, other legally established sources.

The Romanian Agency for Quality Assurance in Higher Education (ARACIS) was registered in the European Quality Assurance Register for Higher Education (EQAR). As of 30 September 2009, in compliance with the decision of the Analysis Committee of applications, ARACIS was registered in the European Quality Assurance Register for Higher Education – EQAR. This decision is meant to recognise the results of the continuous efforts made by ARACIS, together with the academic community members, in order to effectively develop and assure quality culture in the Romanian higher education, in European context.

According to G.D. 1175/2006 academic degree fields and study programmes, for our specialties is: **Fundamental fields of science,** Engineering**, Master of science university study fields** GEODESIC ENGINEERING**, Specialties** Terrestrial Measurements and Cadastre.

For this specialties by the regulations of the Romanian Agency for Quality Assurance in Higher Education, the percent of the physical classes in the subjects belonging to the groups of courses that assured the training of the future specialists, through short-term or long-term studies, was:

1. FUNDAMENTAL COURSES AT LEAST 17%, the main courses being: Mathematical Analysis, Algebra, Analitic and Differential Geometry, Superior Mathematics, Theory of errors and Statistics, Descriptive Geometry and Technical Drawing, Informatics and Computer Programming and Use, Physics,
2. TECHNICAL FIELD COURSES AT LEAST 38%, the main courses being: **Instruments and methods for surveying measurements**, **General Topography**, Geodesy, **Engineering Surveying**, Cadastre, Photogrammetry, Remote Sensing, Astronomy, General Constructions, Mathematical Cartography, Geodesic Informational System, Electronic measurements, Land management and ecology, Organizing surveying, geodesyc and cadastre works, Management, **Mining measurements.**
3. SPECIALITY COURSES AT LEAST 25%, the main courses being: Constructions – Traffic routes, Cartography, G.I.S, Management, Organizing cadastre works, Specialty Cadastre, **Sensors and measurements in the cinematic regim, Monitoring the time behavior of buildings and terrains,** Civil law and Cadastral Legislation, Physical Geography.

4. OPTIONAL COURSES AT LEAST 10%, Systematizing, Urbanism, Urban Management, Accounting, CIS, Tunnels and metro-tunnels, Working security, Mechanics of structures and soils, General Mining, Eco-management, Land evaluation, **Special Survey measurements.**
5. COMPLEMENTARY COURSES AT MOST 8**%,** Foreign Languages, Physical Education, Social Sciences.
- The percentage of the course hours with respect to other hours (seminaries, tutorials, projects, practice, diploma thesis) at least 70%.
- The academic year contains two semesters of 14 weeks each, two exam sessions of 4 weeks each, two weeks of practice,
- The number of hours on a week is 24-28,
- The number of exams in a semester 3-5, the number of colloquia 2-4, the number of projects 1-3, in general 5-6 projects, minim 4,
- The graduation exams is sustained after finishing the 8th semester and a period of drafting.

3. THE ACTIVITY SPHERE OF TERRESTRIAL MEASUREMENTS

The assembly of sciences that contribute to the measurement and representation of terrestrial surfaces establishes the Science of Terrestrial Measurements. There can be distinguished three main goals of this science, from the following perspectives:

- *Scientific*: knowing the shape and dimensions of the Earth, as a planet;
- *Direct practical*: obtaining topographic plans and maps;
- *Indirect-applicative practical*: placing, directing and tracing the designed investments in the field, based on and comply with the execution project.

Topography(surveying) is one of the Science of Terrestrial Measurements, practically is the base of this important groups of the sciences. Depending on the solved problem, there exist two components of TOPOGRAPHY:

- **General Topography** (direct topographic problem), which comprises:
  - The study of general methods and instruments, used for different works;
  - Measuring and representing terrestrial surfaces of limited extent on topographic plans and maps (the direct problem of topography).
- **Engineering Topography** (inverse topographic problem), which consists of:
  - Ensuring maps, plans, profiles, bearing points, measurements and computations (that belong to the direct problem) for the design of different investments;
  - Office and field works for applying the engineering projects and monitoring the time behavior of the terrains and constructions (the inverse problem of topography).

General topography, as office science, precedes engineering topography. If the former has a universally valid character, the latter is profiled and adapted to the conditions and the domain that it is applied to. There are many applications of topography in different branches of economy. Thus, in <u>constructions</u>, topography precedes, accompanies and follows the execution works, in <u>mining</u> topography also takes part in all phases of the activity: investigation, design, exploitation, monitoring.

Table 1 The direct and inverse topographic problem

DIRECT TOPOGRAPHIC PROBLEM	INVERSE TOPOGRAPHIC PROBLEM	THE NATURE OF THE PROBLEM
GENERAL TOPOGRAPHY	ENGINEERING TOPOGRAPHY	SUBJECT OF STUDY
MEĂSURING	TRACING	TOPOGRAPHIC OPERATION
2 known points *	**2 known points**	**Known support base**
National **– prevalently**	Local **– prevalently, Connected to the national system**	**Support system (X, Y)**
National	**National**	**Height system**
Characteristic points	**-**	**Points existing in the field**
-	**Base points of the designed building**	**Designed points**
α_i, L_{ij}, φ_{ij}, ΔZ_{ij}, D_{ij}	**-**	**Topographic elements measured in the field**
-	ω_{ij}, D_{ij}	**Topographic elements traced in the field**
Measured characteristic points	**-**	**Points represented in the plan, the map**
-	**Points of the designed building**	**Points resulted in the field**
Given: (X_A, Y_A); (X_B, Z_B), Z_A **To be measured:** $\alpha_{1,} L_{A1}, \varphi_1$ **Computations:** $D_{A1} = L_{A1} \cos\varphi_1$ $DZ_{A1} = L_{A1} \cos\varphi_1$ $DX_{A1} = D_{A1} \cos\theta_{A1}$ $DY_{A1} = D_{A1} \sin\theta_{A1}$ **Where** $\theta_{A1} = \theta_{AB} + \alpha_1 - 400^g$ $\theta_{AB} = arctg \frac{\Delta Y_{AB}}{\Delta X_{AB}}$ **depending on the orientation dial** $X_1 = X_A + \Delta X_{A1}$ $Y_1 = Y_A + \Delta Y_{A1}$ $Z_1 = Z_A + \Delta Z_{A1}$	**Given:** (X_M, Y_M); (X_N, Z_N), Z_M (X_{A1}, Y_{A1}), Z_{A1} **Computations:** $\theta_{MA1} = arctg \frac{\Delta Y_{A1}}{\Delta X_{MN}}$ $\theta_{MN} = arctg \frac{\Delta Y_{MN}}{\Delta X_{MN}}$ $\omega_{A1} = \theta_{MA1} - \theta_{MN}$ $D_{M.A1} = \sqrt{\Delta X^2{}_{MA1} + \Delta Y^2{}_{MA1}}$ $DZ_{MA1} = Z_{A1} - Z_M$	**Basic computations**
The topographic plan, map	**Points, axes, surfaces, distances, volumes of the designed building, materialized in the field**	**The result of the topographic operation**

4. THE PRINCIPLES OF THE TECHNICAL SCIENCE IN TOPOGRAPHY

The importance of topography as applied science is undeniable. All this, in the case in which the execution precision of topographic works is respected and is correlated to that of the works they are applied on. In the same way, the leading role of topography in different application domains should not be neglected, since it implies great responsibility. In order to correspond to these requirements, the topographic works should be executed respecting the technological discipline, wee concisely reflected by the following principles:

1. VERIFYING THE OPERATION:

At least one verification is needed for every topographic work.

2. VERIFYING THE MEASURED DATA:

When the operations in field are finished, the data taken during that measurement cycle will be verified.

3. THE NECESSARY PRECISION:

The precision of the topographic tracing or measurement works will be given by the execution precision of the designed objective.

4. APPLYING AUTOMATED CALCULUS:

Data processing is performed, if it is possible, by using means of automated calculus.

5. THE PERIODIC VERIFICATION OF INSTRUMENTS:

In order to maintain over time the functional qualities of the topographic instruments (especially the optical ones), their periodic verification and rectification is required.

6. FAVORABLE METEOROLOGICAL AND NATURAL CONDITIONS:

There will be performed no work in the field, except if the meteorological and natural conditions are favorable to the chosen methods and devices. In case of emergencies, there will be taken such operation measures that the influence of the environment to be minimal.

7. THE PROFITABLENESS OF TOPOGRAPHIC WORKS:

The choice of methods and instruments used in a topographic operation should depend on the necessary working precision.

8. GEOMETRIZING THE MEASURED AREA:

The terrain cannot be measured as it is, so it is geometrized. In the choice of the points by which topographic surface is geometrized, it is essential that the scaled down image (the plan, the map) obtained as final product to be complete, corresponding to the requirements of the beneficiary, but not to contain more elements than necessary.

9. AVOINDING LAUNCING INTO THE WORK:

Before beginning a topographic work, there should be drafted a rational activity schedule, which should be respected along the entire period of execution of the work.

10. RESPECTING THE SAFETY MEASURES OF THE WORK:

In order to avoid any possibility of accident or sickness, the safety measures of the topographic work and those specific to the domain that is operated within (mine, construction site, etc.) should be respected. One should work only being completely healthy.

5. THE OBJECT OF STUDY AND THE IMPORTANCE OF GENERAL TOPOGRAPHY

This course represents the general part of TOPOGRAPHY, the direct side by which planimetric and leveling terrain surfaces are measured in order to be represented on topographic plans. Content of the course is:

1. TOPOGRAPHY – THE SCIENCE OF TERRESTRIAL MEASUREMENTS
   - the activity sphere of terrestrial measurements, the object and the topographic applications in constructions and mining and others area, the principles of the technical science in topography
2. THE SHAPE AND DIMENSIONS OF EARTH, PROJECTIONS, REPRESENTATIONS
   - the general shape of the earth, the dimensions of the earth, cartographic projections. overview. Classifications, general principles, projection systems used along time in our country
3. ELEMENTS OF THE TERRAIN
   - topographic surface, details, geometrizing the terrain, characteristic points, projections, maps, plans, topographic elements of the terrain, planimetric and leveling topographic surveys, introductory elements
4. PLANIMETRIC SURVEYS
   - planimetric control networks, the geodetic control network – the geodetic control basis the state geodetic trangulation network, local control networks, designating and, signaling the points of the planimetric control network, the topographic description of points (the marking file of the topographic point), computing the coordinates of control networks, classification of traverses, designing planimetric traverses, field operations, computational operations, survey of planimetric details
5. LEVELING SURVEYS
   - the leveling heights, level surfaces, the effect of the influence of the earth curvature and the atmospheric refraction, leveling types, leveling networks, designating and signaling leveling points, geometric leveling, middle geometric leveling, end geometric leveling, middle geometric leveling traverses, classification of geometric leveling traverses, middle geometric leveling traverse supported at both ends, computing the traverse, leveling traverse in circuit, floating leveling traverse, leveling networks, leveling survey of surfaces through geometric leveling, radiation, the method of squares, surface leveling through small squares, surface leveling through large squares, the precision of geometric leveling, surface leveling through profiles, trigonometric leveling, leveling traverses, radiation, tacheometric leveling,
6. PLANS AND MAPS
   - the elements of plans and maps, definitions, scales, the graphical precision of topographic plans, classification of maps and plans, topographic symbols, leveling symbols, using maps and plans, planimetric and leveling problems, determining surfaces on maps/plans.

6. THE OBJECT OF STUDY AND THE IMPORTANCE OF ENGINEERING TOPOGRAPHY, CONTENT OF THE COURSE

Engineering topography (applied, special) deals with the study of the methods involved in the field application of investment objectives belonging to different activity branches.
By investment objective we call any work that modifies the moment appearance of the terrain, either by implementing a new building or by modifying the existing one.
The field application of execution projects of constructions – investments by means of topographic tracing represents the subject of the INVERSE TOPOGRAPHIC PROBLEM
Engineering topography studies and solves problems concerning: the technical-economical analyses that fundament the design, planning the design for the execution of the objective, its execution and exploitation, and the surveillance of the time behavior of the performed building.

General content of the course:
1. Preliminary concepts. the direct and inverse topographic problem. the role of terrestrial measurements in the field application of investment projects
2. Tracing elementary topographic elements in the field
2. Tracing designed topographic elements in the field
3. Topographic works for the design, execution and exploitation of civilian and industrial constructions
4. Topographic works for designing and executing traffic routes and art works
5. Topographic works for the design execution and surveillance of hydro-technical and hydro-improving constructions.
In engineering topography, starting from the methods and instruments used in topography there have been developed new methods and instruments specific to the execution process (building-assembly) of some investment objectives in all activity branches that operate at the level of the terrestrial surface: Geology, hydrology, mining industry, improvements, civilian, industrial and agricultural constructions, traffic routes and art works, archaeology, external network constructions (water, sewer, methane gas, oil, etc.).
Engineering topography includes the following main categories of works:Technical-topographical analyses; Topographical-engineering design; Topographical-engineering assurance of the execution process of the designed objective; Monitoring the time behavior of the performed buildings and of the fields in their location area.

7. THE OBJECT OF STUDY AND THE CONTENT OF THE OTHERS SURVEYING COURSE

Instruments and methods for surveying measurements, Apply basic mathematical (geometry and trigonometry)and measurement principles that form the theoretical framework of professional surveying practice. Surveying topics will include distance measurements, leveling, angles, directions, traversing. Topographic instruments, studying theodolites, verifying and rectifying theodolites, instruments for direct measurement of distances, electronic devices for measuring distances, geometric leveling devices leveling devices with telescope, verifying and rectifying leveling tacheometric devices, selfreducing tacheometers with refraction or divorced image, optical telemeters, parallactic and trigonometric methods for measurement of distances.

Mining measurements. Mine surveying is a specialist area of surveying involving the measurement, representation and management of data associated with a mining operation. Mine surveying are responsible for marking out, measuring and maintaining direction of all surface and underground workings on a mine site. In addition they are also legally responsible for the preparation and updating of all mine surveying plans for open pit and underground workings on the mine site.

Sensors and measurements in the cinematic regim, relates to a sensor network and to a method for monitoring a terrain. Sensors and measurements in the cinematic regim describes the use of instruments and techniques for practical measurements required in engineering sciences. The discipline examines: -Sensors -Hardware -Software -Techniques -Information processing systems -Automatic data acquisition -Reduction and analysis as well as their incorporation for control purposes. Chapters present information on three levels: -Basic information without equations and a description of the subject that can be understood by the newcomer -Detailed text and mathematical treatment essential for discovering applications and solving problems outside one's field of specialty -Advanced applications of the subject, evaluative opinions, and areas for future study. It covers an extensive range of topics that encompass the subject of measurement, instrumentation, and sensors. Contents: Measurement Characteristics , Spatial Variables Measurement, Time and Frequency Measurement , Mechanical Variables Measurement , Electromagnetic Variables Measurement, Optical Variables Measurement Signal Processing, Displays, Control.

Monitoring the time behavior of buildings and terrains,

Deformation survey: a survey to determine if a structure or object is changing shape or moving. The three-dimensional positions of specific points on an object are determined, a period of time is allowed to pass, these positions are then re-measured and calculated, and a comparison between the two sets of positions is made. Deformation measurements on man-made structures are important because they provide an independent check on whether or not the structure is exhibiting a safe deformation behavior the measurement of very small movements of the terrain over time.For a good functionality of a building, it is necessary to the building behavior, using precise surveying methods and instruments. The observations must be made at different measuring époques. After computing the observations, the data can be used in order to predict the trends of building behavior. The surveying methods used with the purpose of predicting the trends of building behavior are tightly related to the type of shifting and distortion pursued. So, for buildings vertical shiftings and deformations, it is used the geometrical leveling method, the trig leveling method and the hydrostatical leveling method. These methods can be used separately or combined, depending on the nature of the parameters highlighted for the observed building. The geometrical leveling method of high precision is the method that provides the highest precision in measuring the vertical shiftings of the observed buildings. It is used in observing the building behavior that requires a high level of precision (buildings, industrial halls, social-cultural edifices, radio and television towers, nuclear reactors, bridges, viaducts, sluices etc.).

Special Survey measurements.
Archaeological survey: used to accurately assess the relationship of archaeological sites in a landscape or to accurately record finds on an archaeological site.
Bathymetric survey: a survey carried out to map the topography and features of the bed of an ocean, lake, river or other body of water. Hydrographic survey: a survey conducted with the purpose of mapping the coastline and seabed for navigation, engineering, or resource management purposes.
Geological survey: generic term for a survey conducted for the purpose of recording the geologically significant features of the area under investigation. . Soil survey, or soil mapping, is the process of determining the soil types or other properties of the soil cover over a landscape, and mapping them for others to understand and use.
Special survey measurements for a wide range of users: merging and modernizing agrarian areas, agriculture, forestry, irrigation, transportation and industry engineering, irrigation, radiocommunication, environment protection, railway sector, traffic management, emergency services and crisis management.

Nr.	Disciplines	Semester
1.	Instruments and methods for surveying measurements 1-methods	1
2.	Instruments and methods for surveying measurements 2-instruments	2
3.	General topography 1	3
4.	Engineering Topography-basis	3
5.	General topography 2	4
6.	Engineering Topography 1	5
7.	Engineering Topography 2	6
8.	Special Survey measurements	6
9.	Mining measurements.	7
10	Monitoring the time behavior of buildings and terrains,	7
11	Sensors and measurements in the cinematic regim,	8

Number total of credit points for topographical group of disciplines: 47; **19,58%** of total credit, 60/yearX4years=240 credits,
Number total of hours for topographical group of disciplines: 728; **23,21%** of total houres, 28 hours/weekX28 weeksX4years=3136 houres.

8. CONCLUSIONS

In preparation of the Geodesy engineers, about one quarter of work is devoted to study of surveying techniques so that graduates of the Master in Cadastral and Land Measurements have strong expertise of theoretical and practical principles of topographic measurements, performed both classical and modern methods.

The paper aims to highlight the fact that entry into the study of modern methods of measurement and operation does not remove the study of classical methods. For example learning a computer program does not preclude learning calculus in stages nor learning the meaning and importance of each term introduced in the calculation.
The Romanian geodesic education has an age of almost 200 years, being the oldest technical education in our country. It has gone through more phases presented in this paper, it has trained specialists that operate successfully in the entire world. Now, it respects worldwide standards. Thus, in order to accomplish the objectives determined for 2010, measures were taken to analyze the progress obtained in the Bologna Process, thus providing useful information concerning the evolution of the process, offering the possibility to take the necessary steps for accomplishing the objectives.

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BIOGRAPHICAL NOTES

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Professional activity: Geodesy engineer, 1974-1978,Energoconstructia Trust, Bucharest, Teacher, 1978-1980, Agricultural high school with specialization in topography, Branesti, Ilfov County, Assistant, 1980-1990, Institute of Polytechnics, Cluj-Napoca, 1980-1985, Engineering Institute, Baia Mare, 1985-1990, Senior lecturer, 1990-2004, the teaching lines of Topography, Cadastre, Engineering Topography, The Northern University, Baia Mare, Professor, 2004- the teaching lines of Topography, Cadastre, Engineering Topography, The Northern University, Baia Mare, **Articles** published abroad, in international field journals, in

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