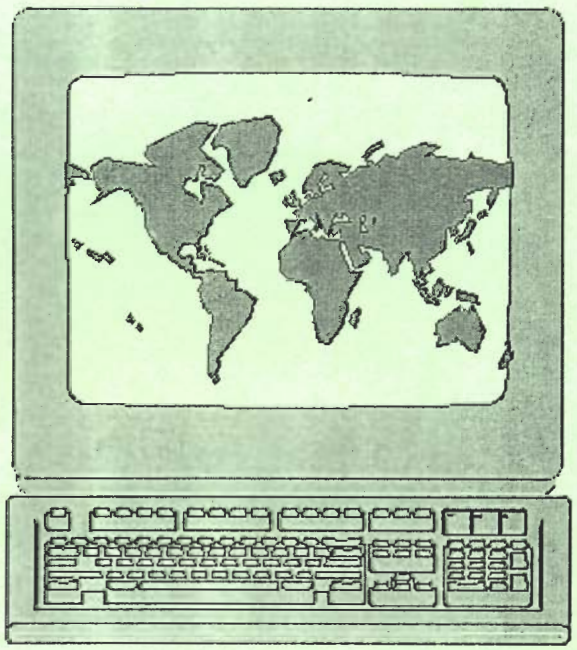
UNIVERSITY OF ARCHITECTURE, CIVIL ENGINEERING AND GEODESY - SOFIA
Department of Photogrammetry and Cartography

E-MAIL SEMINAR OF CARTOGRTAPHY

2000 - 2001

VOLUME 3



CARTOGRAPHIC EDUCATION

SOFIA, 2001

CARTOGRAPHIC EDUCATION IN NTUA
CURRENT STATUS AND FUTURE PERSPECTIVES

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Resume

The current status of cartographic education in the Department of Rural and Surveying Engineering of the NTUA is presented. More specifically, the aims and a short description of four graduate courses are analysed and discussed as well as characteristic topics studied by graduate students to fulfil the degree of Rural and Surveying Engineer. Furthermore, four courses of postgraduate level on cartography are presented and a representative list of research topics is given. The laboratory work of graduate and postgraduate students of the Department is supported by the Geo-Informatics Center, which was recently established. The Geo-Informatics Center expresses the focal point of information technology in the Department and its hardware and software configuration are described. Finally, the authors' thoughts about were cartography education in NTUA has to go in the near future are presented and discussed.

ОБРАЗОВАНИЕ ПО КАРТОГАФИИ В НТУА
СОВРЕМЕННОЕ СОСТОЯНИЕ И БУДУЩИЕ ПЕРСПЕКТИВЫ

Резюме

В статье представлено настоящее состояние образования по картографии на кафедре Землеустройства и геодезии в НТУА. Сделан анализ и обсуждаются цели и короткие

описания четырех учебных курсов бакалаврской степени как и характерные темы изучаемые студентами, которые обучаются на кафедре Землеустройства и геодезии. Представлены также и описания четырех мастерских программ по картографии и приводится представительный список научно-исследовательских тем. Лабораторная работа студентов всех курсов подкрепляется недавно созданным Центром геоинформатики.

Центр геоинформатики представляет основные элементы информационной технологии на кафедре и в статье описаны конфигурация его технического и програмного обеспечения. В конце представлены и идеи автора о направлениях, в которых должно развиваться обучение по картографии в НТУА.

Introduction

The National Technical University of Athens (NTUA) was founded in the year 1887 by the Greek state, and is the major technological academic institution of Greece with a long tradition in engineering education and research. Department of Rural and Surveying Engineering (RSE) is one of the nine Departments of NTUA and was founded in the year 1917. The main objectives of RSE Department is to educate students in the field of Geodetic, Photogrammetric, Remote Sensing, and Cartographic sciences as they are applied to rural and surveying engineering subjects. There are three Divisions within RSE Department: Surveying, Geography and Regional Planning, and Rural Infrastructure.

Surveying Division is mainly directed to give introductory and advanced knowledge in geodetic sciences, to provide skills in handling spatially referenced data and understanding of the concepts involved, to evaluate spatial data quality, and finally to expose students to the entire scope of carrier opportunities in the surveying field. The Division of Geography and Regional Planning provides an understanding of the spatial information sciences, gives an appreciation of data and information quality within a GIS framework, and expose students to the methods and techniques applied to analysis and processing of the qualitative and quantitative characteristics of spatial phenomena. The Division of Rural Infrastructure provides the knowledge for the design and evaluation of transportation networks, exposes students to the methods and techniques of hydraulic works and management of water resources.

Since the academic year 1998-99 the RSE Department in cooperation with the Department of Electrical and Computer Engineering and the Department of Mining Engineering and Metallurgy organises and operates a postgraduate Program in Geo-Informatics. The high relation of the Program with the new technologies and their relations with earth sciences have led to the inter-scientific and inter-Departmental character of the Program. After one successful year of studies a specialisation postgraduate degree in Geo-Informatics is awarded. Students with high qualifications can apply for admission in one of the cooperative Departments, and continue their studies as doctoral of engineering candidates.

The cartography in the graduate level of RSE Department studies

The Department offers a first degree Diploma after five years of studies attending successfully 57 courses and executing a thesis at the last semester. During the first four semesters 17 courses of general education (mathematics, physics, statistics, computer science and humanities) are offered to the students served by other Departments. The Department offers a set of twenty mandatory courses. By these mandatory courses students are introduced to the basic principles and

concepts covered by the three Divisions. Additionally, students have to take 20 elective courses after choosing a major and a minor field of study. The offered fields of studies are:

- surveying engineering,
- spatial analysis and planning,
- transportation engineering and
- hydraulic engineering and management of water resources.

The educational and research activities of cartography within the framework of RSE Department are focused firstly to serve the objectives of Surveying Division and secondly to support as a technological tool the objectives of the other Divisions.

Four courses of cartography are offered at the graduate level of RSE Department studies: "General Cartography", "Analytical Cartography", "Thematic Cartography" and "Digital Cartography". In total, these courses cover 100 hours of lectures, 50 hours of training assignments, and 50 hours of laboratory work.

General Cartography

This course is introductory to the science of cartography. During the two hours per week lectures the historical evolution, the fundamental principles and the basic cartographic concepts are presented and discussed. In addition, students have to attend another two hours per week laboratory work to develop cartographic skills in using and creating a topographic map. The course is offered at the second semester and is supported by lecture notes in Greek (Nakos and Filippakopoulou 1993) and by the widely approved textbook of Elements of Cartography (Robinson et al. 1995), which recently was translated in Greek.

Analytical Cartography

The aim of the course is to introduce students to the analytical methods of cartography as they have developed the last decades. The course is elective and is composed of two parts. The first part is dedicated to the theory of map projections from the earth's ellipsoid to the plane. The second part of the course encompasses the mathematical concepts and cartographic transformations involved in map analysis and digital mapping. Analytical Cartography is a four hours per week course out of which two hours are lectures and the other two are dedicated to students' tutoring and assignments. The course is offered at the fifth semester and is supported by lecture notes in Greek (Nakos 2000).

Thematic Cartography

This course provides students with a comprehensive knowledge on the principles of cartographic design, the character and the nature of thematic data spatial variation and the techniques of thematic mapping. These topics are analysed during the two hours per week lectures. In addition, during laboratory work (two hours per week) in the Geo-Informatics Center of RSE Department students compose thematic maps covering all the methods of processing and representing geographical data in digital form. The course is elective, offered at the sixth semester and is supported by lecture notes in Greek (Nakos and Filippakopoulou 1992).

Digital Cartography

The aim of the course is to provide a comprehensive presentation of digital mapmaking procedures. In two hours per week lectures the topics of acquiring, processing, storing, evaluating and portraying cartographic data are studied. In addition, during laboratory work (two hours per week) in the Geo-Informatics Center of RSE Department students compose a sample of topographic map from scratch. The course is elective, offered at the seventh semester and is supported by lecture notes in Greek (Tsoulos 2000).

Diploma Thesis in Cartography

An average of twelve approximately diploma thesis in cartography are implemented by students per each academic year, covering a wide variety of topics. A short list of topics carried out lately indicates the areas of interest:

- Map and atlas design
- Maps for children
- Design and production of tourist maps
- Software development for creating electronic atlases
- Digital techniques for hill-shading
- Development of user interface for map compilation
- Automation and map production
- Cartographic generalisation

The cartography in the postgraduate level of RSE Department studies

A Program of postgraduate studies on Geo-Informatics with postgraduate level courses lasting up to two years is offered by the RSE Department. Postgraduate students are attending eight courses in two semesters and afterwards are implementing a thesis by research. During the first semester, twelve full teaching weeks, students are selecting four out eight offered primary courses. At the second semester eighteen specialisation courses are offered out of which students are attending by selection four of them. After successful attendance students are awarded a specialisation postgraduate degree in Geo-Informatics. The highly qualified postgraduate students can continue their studies through research towards a Doctorate of Engineering.

One of the primary courses, titled “Processing, Analysis and Representation of Spatial Data”, deals with cartographic aspects. Among eighteen specialisation courses three of them are purely cartographic: “Special Topics on Cartography”, “Analytical and Digital Cartographic Methods” and “Digital Map Production”.

Processing, Analysis and Representation of Spatial Data

This primary postgraduate course is offered in the first semester and provides an integrated overview of the technologies involved for managing spatial data. More specifically students are exposed to advanced topics related with digital photogrammetry, remote sensing and cartography. In addition, during this course students are studying in depth the existing methods of spatial

analysis. The cartographic branch of the course is mainly directed to a comprehensive analysis of spatial data and to advanced topics related to 3-D representations, dynamic mapping and evaluation of spatial data quality. All topics are analysed during the two hours per week lectures. In addition, students have to attend another one hour per week laboratory work for their assignments in the Geo-Informatics Center of RSE Department.

Special Topics on Cartography

It is a specialisation course mainly focused on the theoretical issues of cognition in cartography and cartographic communication. The course is offered in the second semester and students are studying in depth the processes of visual perception, recognition, differentiation, cognition and transformation as they are related to map reading. In addition, students are exposed to advanced topics related to graphical semiology and colour analysis in designing map symbols. All topics are presented during the two hours per week lectures. In addition, students have to attend another one hour per week laboratory work for their assignments.

Analytical and Digital Cartographic Methods

Analytical and digital cartography in this specialisation course is faced as a major area of cartographic research and as the core area of Geographic Information Science. The course is offered in the second semester and students are exposed to advanced topics related to the structure of the digital map, use of hyper-media in dynamic mapping, analytical hill-shading techniques and evaluation and resolution of line simplification conflicts in the context of automated generalisation. All topics are presented during the two hours per week lectures. In addition, students have to attend another one hour per week laboratory work for their assignments in the Geo-Informatics Center of RSE Department.

Digital Technology and Map Production

It is a specialisation course of cartography offered in the second semester dealing with advanced topics related to the incorporation of new technologies in map production. Students are exposed to the techniques of image reproduction with continuous or discrete tones using digital screen tints or halftone screens. In addition, students are introduced to the offset technology for colour printing and to high quality plotting devices. All topics are presented during the two hours per week lectures. In addition, students have to attend another one hour per week laboratory work for the production of a sample map using Arc/Info software package in the Geo-Informatics Center of RSE Department.

Doctor of Engineering Thesis

At the present seven postgraduate students are working on their Doctor of Engineering Thesis supervised by the Faculty members of Cartography. Research topics are within the areas of:

- Expert Systems in Cartography
- Spatial Data Quality and Accuracy
- Spatio-Temporal Modelling
- Children Cartography

- Cartographic Visualisation
- Cartographic and Model Generalisation
- 3-D Visualisation

Geo-Informatics Center of RSE Department

The Geo-Informatics (GI) Center was established in 1996 and is the focal point on information technology at the RSE Department. GI Center's main activity is the support and provision of the necessary environment (hardware and software) for the graduate as well as the postgraduate studies. The Center also supports research activities on GI conducted by the postgraduate students and the teaching stuff. The hardware configuration is illustrated in Figure 1 and the software configuration is described in detail in Table 1. The GI Center is a domain of the NTUA network and supplies web, mail and naming services to the users (graduate/postgraduate students, teaching and other technical stuff) of the RSE Department. Most of the taught courses utilise the facilities of GI Center.

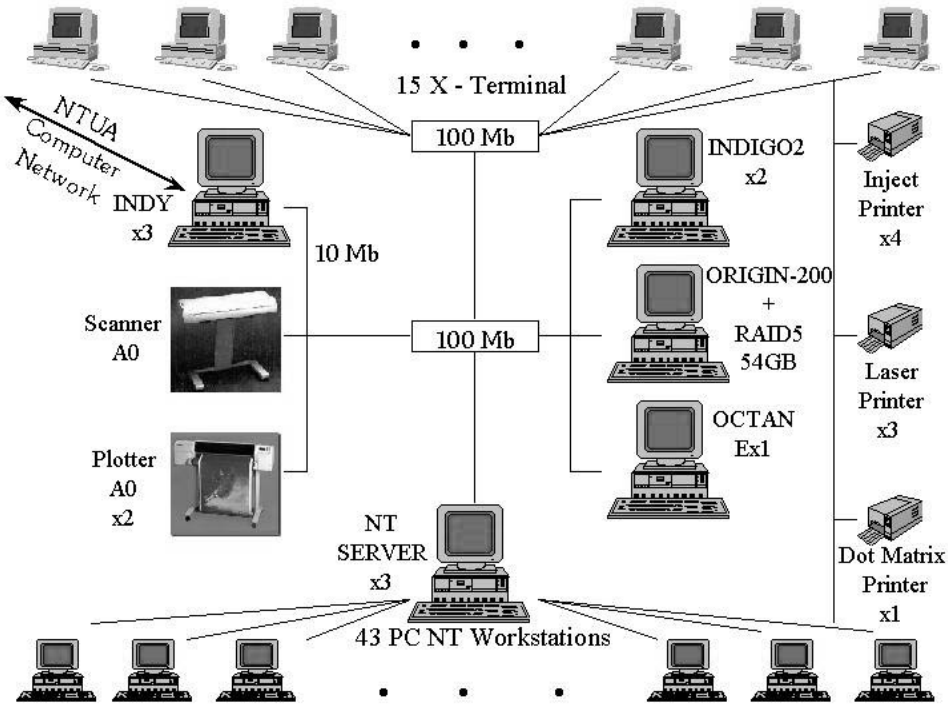

Figure 1. The hardware configuration of GI Center.

Table 1. The software configuration of GI Center.

Silicon Graphics IRIX 6.5.1		**Windows NT**	
Operating System		*Operating System*	
SOFTWARE	**LICENSES**	**SOFTWARE**	**LICENSES**
ESRI Arc/Info 7.2.1	24	MS-Office Professional 95	15
ESRI ArcView 3.0	24	COREL DRAW 6	10

Feflow 4.5	1	TOOLBOOK II 5.0	1
Imagine Vista 8.3	1	GPSurvey 2.35	8
Soft Plotter 2.0	Unlimited	AutoCAD MAP 3	15
TerraModel +3 v. 8.41	1	AutoCAD 2000	30
Informix Universal Server	5	3D STUDIO MAX	5
		AutoVision 2	Unlimited
		RAPORT 4.2	15
		TransCAD 3.0	8
		Idrisi for Windows v.2.0	Site
		Surfer 6.04	1
		Adobe Photoshop 5.01	10
		PC-Xware	50
		WaterCAD CyberNet 3.1	30
		AutoTURN 3.0	1
		Exceed 6.1	22
		Mathematica	10
		MathCAD	10
		Microsoft Visual Studio 6.0	22
		MS-Office Professional 2000	22
		Imagine 8.3.1	5
		Neuro Genetic	1
		Geo Slope	1
		ESRI Arc/Info 7.2.1	1
		ER Mapper 6.0	15
		Visual Fortran	10
		B – AXIES	1

A short review of future perspectives on cartographic education

Traditionally, cartography is a basic component of what is formally known as geodetic sciences. In our days geodetic sciences are in a period of transition influenced by the revolution of information technology. A new term, named Geo-Informatics or Geomatics, has been introduced for the scientific fields involved in this area. Cartography being in transition too is facing the problem of redefining new methods and new concepts. This transition has a great impact on the education curricula in academic institutions where cartography is taught.

In the last decade in a lot papers the cartographic curriculum and the future trends of cartographic education are analysed. According to the educational program they can be distinguished as geography or engineering oriented. In all these papers the same agony is expressed: how to combine the recent technological knowledge with the scientific theory of cartography. Thus,

Fryman (1996) gives an integrated profile of the cartographic education in the United States and Canada and stimulates the increase in the use of personal computers in cartography courses. Müller (1986) describes the present state of higher cartographic education in Germany. He expresses the dilemmas of continuous curricula revision, creation of new courses and abandonment of traditional cartographic topics (such as the history of cartography, atlas production, map perception, map interpretation, etc.). Cauvin (1996) is envisaging the future of cartography lying in parallel with the evolution of technology and extending to every discipline related to space. She states, in addition, that cartography, spatial analysis and spatial modelling cannot be separated. The same author is emphasising that teaching only technical cartography is equal to the reduction of a very rich discipline to one of its components. On the other hand, in a discussion paper the educational and training in Geomatics in Canada are faced as demand-driven activities (Groot 1991). The same author proposes a qualitatively separation of Geomatics education and training into two directions, the first one necessary to build infrastructure and the second one to apply Geomatics technology. Such a conception being too technically oriented overestimates the practical (professional) issues against the scientific principles. From another perspective, McMaster (1997) is presenting a new conceptual framework for cartographic education in the United States. This paper presents the growing tendency of the academic institutions to balance curricula with the principles of cartography and GIS. He finally stimulates that "…unfortunately, only a select set of institutions offer a class in the history of cartography" (McMaster 1997, p. 1429). The current state of academic cartographic research and education activities in the United States is summarised by Brewer and McMaster (1999). The authors are over-viewing the research activities within six themes: visualisation, cognition, symbolisation and design, digital spatial data, analytical cartography and social cartography. In the same direction Keller (1996) proposes an introductory curriculum focused on communication and visualisation, contemporary design opportunities, cartographic information management, professionalism, and bridging of the gap between theory and application.

Concluding remarks

In our opinion the six themes for cartographic research and education introduced by Brewer and McMaster (1999) include a well-balanced integration between the theory of cartography and the technological innovations, and so they could form the basis of a contemporary cartographic educational framework. By judging the present educational cartographic curriculum of the RSE Department it can be stated, that the covered topics and the balance between technology and cartographic theory is efficiently tuned. Of course it is rather difficult to visualise the content of the cartographic education in the future in such an information revolutionary age. According to our opinion a basic statement should dominate any curriculum revision: the adoption of any new technological innovation should not replace theoretical basic knowledge. We know that it is rather difficult to keep this statement and at the same time follow the technological advances, but it has to govern the philosophy of any revision. It is the only way for students to learn that "the more they learn fundamental theoretical principles the more they can survive in their profession" otherwise graduates would be users only of CAD packages or GIS software programs.

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