Towards a new Geomatics university curriculum in Tunisia

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Abstract

Nowadays, Geoinformation has become worldwide an essential component of several applications in many domains. New technologies have transformed the availability and accessibility of geoinformation from all sources and boosted its effective use. Geospatial technologies are becoming more and more accessible, user-friendly, and cost-effective, and if successfully implemented, they have great potential likely to sustain social-economic development and to improve decision-making in increasingly complex and growing developing countries.

However, numerous pivotal challenges should be met, in order to remain on the track and fully realize the growing possibilities geospatial technologies offer. This is particularly performed through geospatial capacity building policies aiming at ways to increase capacity and reduce the "geospatial" divide.

In this context, the paper aims at providing an overview of Geomatics education and how this is being developed in Tunisia. It discusses deeply how developing countries can match correct skill sets to create effective progress in geoinformation science and technology. The evolution and development of Geomatics training and the current status of the programs that have been developed so far will be discussed. I conclude by presenting the origin, objectives and content of a new Master's degree program offered in the field of geospatial sciences at the University.

1. Introduction

In response to a growing need and capacity worldwide, geoinformation has become essential for the implementation of management processes and effective decision-making at different levels of management and almost all sectors of activity. Over the last two decades, new technologies have transformed the availability and accessibility of geoinformation from all sources and boosted its effective use. In the same time, geospatial technologies are becoming more and more accessible, user-friendly, and cost-effective, and if successfully implemented, they have great potential likely to sustain social-economic development and to improve decision-making in increasingly complex and growing developing countries (Boussema, 2013). "Indeed, it is hard to imagine any aspect of human activity that does not depend in some way on the availability of geoinformation" (Goodchild, 2011). In general, geoinformation promotes knowledge, analysis and monitoring of territories. This has resulted in a greatly increased productivity and the generation of substantial gains in terms of improved quality of life, wealth creation and sustainable development.

As I mentioned in a previous communication (Boussema, 2013), the advent of geoinformation requires that numerous pivotal challenges be met, in order to remain on the track and fully realize the growing possibilities geospatial technologies offer. This is particularly performed through geospatial capacity building policies aiming at ways to increase capacity and reduce the "geospatial" divide. These challenges involve obstacles of improving skills and existing infrastructure, as well as providing a basis for research-oriented activities. They also require review of educational strategies to improve the awareness and "literacy" levels of stakeholders and to identify the critical curricula needed to enhance the high level appropriate spectrum of geospatial skills through effective advancements in the implementation of geospatial technology and expertise. It is expected that these high-level skills could successfully influence the use of current and future geospatial technologies in their countries.

2. Geographic science vs Geomatics

Historically, before the 1970s, we were surveyors or cartographers specialized in individual traditional surveying disciplines such as geodesy, topography, photogrammetry and cartography, generally and depending of the countries, grouped under the name of Geographic sciences, Surveying, Mapping or Geodesy. Today, the profession is leading up to the integration of those individual disciplines themselves revolutionized by computers and space technologies that brought significant scientific and technical changes and impacts, and hatched new disciplines such as remote sensing, geographic information systems and geopositioning. Thus, it is becoming an integrated profession called in many countries geomatics, geoinformatics, geoinformation engineering or geoinformation science (Fig. 1). Konecny (2002) considered that "it does not make sense anymore to consider topographic and thematic mapping by photogrammetry and remote sensing separate from geographic information systems. Althemore the tedious and costly local terrestrial survey methods have been augmented and surpassed by GPS positioning using navigational satellites". He then concluded that "for this reason, it is not surprising that "geomatics", "geo-informatics" or "geoinformation" emerged as a new integrated academic discipline" (Konecny, 2002). These terms are now used worldwide by scientists and professional associations, government agencies, private companies and several universities. Presently, activities have diversified and democratized. They are carried by a multitude of private companies whereas they were historically a state mission related to defence and national planning concentrated in most often monopolistic and wide gauge national organizations (Fig. 2).

Geomatics could be therefore defined as a comprehensive and integrated information science and technology, related to the acquisition, measurement, storage, management, displaying, processing, analysis and dissemination of spatial data. It is appealing all the disciplines managing spatial data. This definition is important for the recognition of this new profession and field.

In fact, the heart of geomatics is bipolar: information technology and space. This recent bipolar advancement in geoinformation disciplines made that the currently access to geomatics takes place in several ways. Nevertheless, we always distinguished the user's world from the production world. The user and the producer must henceforth both be trained in geomatics but not in the same way. We can find here a situation somewhat similar to that of the producers of Microsoft Windows or Word and the users of these software tools. The first ones are computer scientists and the second ones are computer users. So is even in geomatics. In addition, we are witnessing an expansion of geoinformatics following the example of IT management. Of course the latter cannot be confused with the management discipline; therefore geoinformatics cannot fully replace geomatics.

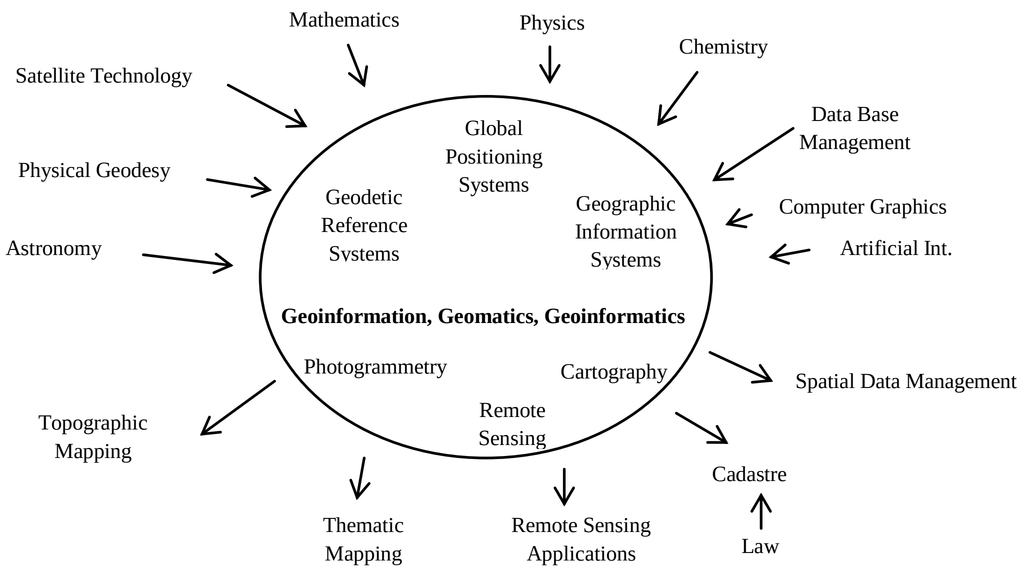

Figure 1. Geoinformation, Geomatics, Geoinformatics (Konecny, 2002)

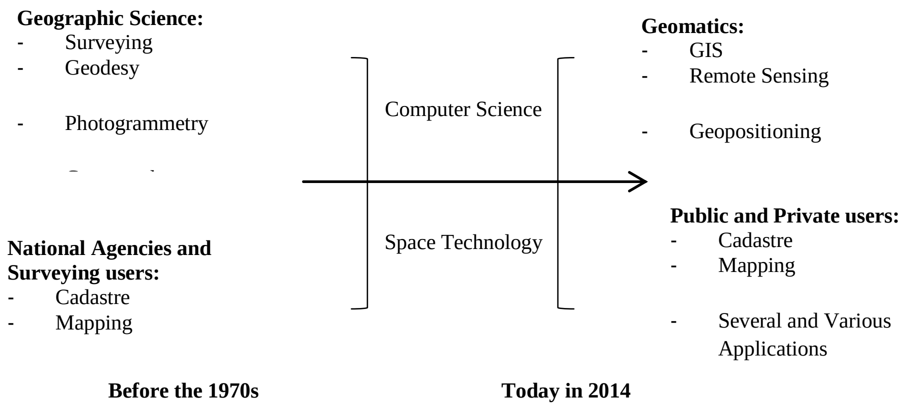

Figure 2. Geographic science vs Geomatics: Disciplines and Users.

However, it is easy to agree that the Geomatics situation keeps to some extent pace in the same direction as that of the development of the information technology and communication sector. It is also a growing sector characterized by large processing capacity, volume, speed and efficiency, and huge opportunities offered by the internet network for the dissemination of data to an increasingly broader and avid public.

Geomatics professionals provide software, hardware and value-added services that help address problems and opportunities in a wide range of application fields. The global market in geomatics related products and services is substantial and rapidly growing. “Today´s primary products of surveying and mapping are digital databases of geospatial information which can be analysed, modelled and integrated with other kind of information and presented to the user in digital or graphical form tailored to his specific demands” (Sima, 2007).

3. Capacity building in Geomatics

On another level, training in traditional geographic science was stereotyped and clearly delimited. User training did not exist per se. As I found out previously (Boussema, 2013), even traditional GIS or Remote sensing training contributes little to prepare young researchers and practitioners for the challenges to overcome. Moreover, geospatial science and technology is not yet an established field in most universities in developing countries. It has not yet built up a core discipline, and this is apparent in the lack of dedicated curricula. But the recognition of the discipline is evidenced by curriculum changes put in place in the last few years by many of the universities.

In addition, areas of priority research should be identified and undertaken on both long term fundamental issues and shorter term applications-orientated issues. Both curricula and research should focus on new themes leading to a real mastering of the discipline such as Geoinformatics, Spatial Data Modelling, Interoperability, Standards, and Spatial Data Infrastructures.

Thus, implementing geoinformation capacity building systems will allow the developing countries to make available good researchers, experts and professionals. This explains why there is a need to encourage universities and other research organizations to emphasize on capacity building in geospatial science and technology.

This above discussion has been carried out because a few months ago, I was asked to propose a master's program in geomatics. Putting myself at work, I was brought primarily to be mindful of current and future trends in the geomatics field and also to take into account the state of geomatics in Tunisia and available geomatics curricula in Tunisian universities.

4. Trends in geomatics worldwide

The current and anticipated future trends in geomatics illustrate how deep the actual surveying profession will be changed in the future. The main focus of its activities will transfer from labour-intensive collection of geospatial data to their processing, maintenance and presentation for the needs of scientific, administrative, legal and technical operations (Sima, 2007).

Moreover, there are two key factors in promoting the Geomatics forward. One is the technical support of quick development of spacecraft, aircraft, computer and Internet. The other is the major technical support for solving these global problems that are global change and social sustainable development that have become the focus of human beings gradually (Li and Li, 1999).

We must therefore be attentive to what is emerging and will have some profound implications:

- Geoinformation will represent in the coming years a significant potential for economic growth and job creation,
- Developing countries seek to dispose with legal environment that enables to create national geoinformation infrastructure which will be characterized by the need to harmonize standards and to improve the interoperability of software and data (Goodchild, 2011),
- Geoinformation is and will be of a growing interest for individuals, businesses and public authorities,
- Geoinformation will generally be accessible through Geoportals that will provide all users with geospatial data at various scales. Many tools previously reserved for professionals will become available, inexpensive and user-friendly public tools,
- Future geoinformation trades are expected to be more and more based on the mobility and location-based services. We are even talking about web-based tools or Geoweb,
- Geoinformation tools are increasingly integrated in the decision making sphere that can contribute to geomatics changing careers and skills,
- Geospatial industry is becoming a key industry and employment multiplier. Broadly defined to include software, data and online services, the field of Geomatics has grown to a multi-billion-dollar industry (Goodchild, 2011),
- Territorial intelligence that develops such as the Smart City concept. The system of terrestrial laser scanning for surveying of buildings, streets, industrial objects, engineering constructions and underground objects may be introduced (Sima, 2007),
- Digital Earth as described by vice president of United States of America Al Gore (1998), is implying numerous Digital Earth programs in many developed countries, having applications in many areas about the Earth by exploring a digital representation (Goodchild, 2011),
- The current vogue for big, connected and open data accelerates the process of freely dissemination of geomatics tools and geospatial data to the general public,
- Crowdsourcing is a novel way of generating geospatial data and maps using informal social networks and web 2.0 technologies. Boulos et al. (2011) are talking about ’Wikification of GIS by the masses’. They are considering Google Earth as a “full-fledged, crowdsourced ‘Wikipedia

of the Earth' par excellence, with millions of users contributing their own content to it, attaching photos, videos, notes and even 3-D models",

- Open Source software environment and products are becoming very dynamic, mature and cheaper solutions. They are competing with proprietary solutions on features / price ratio along with numerous other benefits thanks to the accessibility of source code (Di Leo et al., 2012).

As regards the technological evolution, Sima (2007) has noted that:

- Global positioning system will reach millimetre accuracy in geodetic kinematic applications,
- Airborne multispectral digital images will be frequently used to various thematic applications. An airborne laser scanner (LIDAR) will be routinely applied to modelling of terrain or surface relief and their temporal changes,
- Remote sensing technologies will utilize many small satellites providing multispectral digital images with large amount of narrow visible, infrared and thermal wavebands. High resolution satellite digital images will replace to some extent aerial photogrammetry in the case of updating the topographic databases,
- Cartography will be significantly influenced by the development of information technologies. It seems that it will be above all a service for cartographic visualization of geospatial data processed by GIS technologies,
- Internet will facilitate quick access to cartographic products and it becomes a global geoinformation system.

This has led to a multitude of innovation aspects and accessories: ready-made tools and widgets instead of traditional software, new data formats, hardware input devices in the field (GPS, digital camera, tablet, smartphone), geolocation by the most various means (IP address, wireless terminals, GSM, ...), new open source communities of developers, and so on.

So, current and future trends in the field of geomatics worldwide are characterized by both technological evolution and users' needs. All indications are that this trend will continue, as newer, faster, more powerful and often cheaper technologies become available (Goodchild, 2011).

5. Geomatics education in Tunisia

Before the independence of Tunisia in 1956, there was no training in surveying in the country. Afterwards and gradually, training has been introduced for both civilian and military purposes. A topography section has emerged at the High school "Lycée Emile Loubet (actually "Lycée technique de Tunis") to form surveying operators. In the same time, more than 200 technicians, engineers, and even cartographers have been graduated from "Ecole nationale des sciences géographiques/Institut national géographique (ENSG/IGN)" in France in more than half a century (Table 1).

Table 1. Graduates in surveying from ENSG/IGN France (1952-2014)

Doctor-Engineering	Engineering	Master	Bachelor	Total
2	103	23	72	200

Nowadays and because of a great demand for graduates, new “Licence” (Bachelor) and Master curricula in geomatics were accredited at the Tunisian universities.

The Technical Committee of the GEONAT project in Tunisia (started in 2000 with the support of the Government of Canada) has even supported the creation of a specialized higher education institution that meets international standards and could meet domestic needs in a first step and open up internationally in a second step (GEONAT, 2012). Unfortunately, this recommendation has not yet been implemented.

5.1. The undergraduate geomatics programs

The “Ecole nationale d’ingénieurs de Tunis (ENIT)” depending of Tunis El Manar University was the first university establishment that implemented the first undergraduate surveying course in 1979 within civil engineering department and with the support of technical cooperation of Switzerland. Then this course was transferred to “Institut supérieur d’études technologiques (ISET)” of Nabeul in 2003. Another course was created in 2004 at the “Faculté des lettres” of Manouba at the Geography department. Both were named as Geomatics undergraduate courses.

Table 2. Bachelor’s degrees distribution

University	Title	Type	Discipline	Creation
Tunis El Manar	Geosciences / Mapping	Fundamental	Geology	2007/ 2008
Tunis El Manar	Geomatics, Earth and Environment	Applied	Geology	2011/ 2012
Tunis El Manar	Geomatics, Earth and Environment	Applied	Applied sciences and technology	2006/ 2007
Carthage	Geosciences / Mapping	Fundamental	Geology	2007/ 2008
Sfax	Geography / Mapping	Applied	Geography	2007/ 2008
Gafsa	Geomatics, Earth and Environment	Applied	Geology	2009/ 2010
ISET-Nabeul	Civil Engineering/ Geomatics and Surveying	Applied	Technology	2008/ 2009
ISET- Tozeur	Civil Engineering / Geomatics and Surveying	Applied	Technology	2013/ 2014

Today, within the framework of the new LMD (or BMD) system (‘Licence’ or Bachelor (3 years), Master (2 years), and Ph.D. (3 years)), teaching geomatics seems to be growing and gaining ground in Tunisia. Eight ‘Licence’ courses are accredited so far (Table 2). They group 6 ‘Licences appliquées' (professional) and 2 'Licences fondamentales' (basic). Compared to 2006, the starting date of the LMD reform, the number of geomatics curricula appears to have obviously risen.

It should be noted in this context that professionalization of curricula has been boosted by the LMD reform. Moreover Table 2 shows that currently only two 'licences appliquées' (professional) are relevant to Geomatics and Surveying. They are both assigned to civil engineering. The other 'licences appliquées' have linked Geomatics to Earth and environment sciences and belong essentially to Geology. The 'licences fondamentales' (basic) are in Mapping and related to Geology too. There is also a 'licence appliquée' in Mapping which is related to Geography. The Courses include content that focuses on the use of geomatics. They contain some modules dealing with spatial data structures, software engineering and spatial data analysis. This was seen as an initial step for students to be able to complete a Bachelor's degree in Geomatics and a Bachelor's degree in Mapping in three years.

Averages of 150 students per year are enrolled in these programs during the period between 2006 and 2013. More than a hundred beginners are graduated each year from the eight dedicated 'licenses'. Geography and Geology students are more specifically targeted.

5.2. The postgraduate geomatics programs

In Tunisia, the real needs of the geomatics sector are far from being met in terms of numbers, specialty and qualification. If we apply a ratio of 1 geomatics professional per 10 000 inhabitants which seems to be a desirable figure expressing the demand as advocated by Konecny (2002), Tunisia needs about 1100 geomaticians. The problem is that Tunisia has today a workforce of more than 1000 professionals in surveying and mapping. However, a bit more than 10 % have received postgraduate education in Geomatics. That is why the emphasis is on continuous education of professionals in short courses to widen their scope of activities. This explains the flourishing of the continuous training sector in Geomatics. Even the universities are involved in this sector.

Most of the participants are rather beginners or coming from other disciplines such as civil engineers, geographers, geologists, foresters, etc., looking for basic training. Almost all of them are involved in geoinformation activities without having any formal education in the discipline and had found employment in the surveying and mapping profession thereby meeting the development needs of the country.

Despite the efforts, the training offer remains poorly suited to the specific needs of businesses, in particular with regard to engineering. The training programs are not enough specialised for a person who wishes either to improve his skills in a specific topic or to specialize in areas such as GIS designers. There is still a lack of specialists in the field as a result of the small number of Geomatics education programs at the universities. There are not yet e-leaning courses in Geomatics. There is no Geomatics Department in the Tunisian universities. In fact, there is no strategy elaborated to create such a department. And accordingly the number of academic staff especially teachers specialized in Geomatics is very low.

Several attempts during the three past decades have failed to create an engineering degree in Geomatics. However, it is worth noting the existence of a small number of graduate programs leading to Master’s degree specialized in geomatics. Also, there is no Master’s degree research that could pave the way to doctoral training in the field.

Postgraduate programs are recruiting students with Bachelor’s degrees from geomatics or mapping and also from geography, geology, agriculture, and even engineering in targeting students from the 5th grade in a faculty of engineering.

Before the LMD reform, there was only one Professional Master provided at ENIT from 2001 until 2012. Afterwards, three kinds of professional masters’ curricula in Geomatics were created in three universities of Tunis region and belonging to Geography and Geology (Table 3).

Table 3. Master’ degrees distribution

University	**Master**	**Type**	**Discipline**	**Creation**
Tunis El Manar	Geomatics (Land and Planning)	Professional	Geology	2010/2011
Tunis	Planning, Environment and Geomatics	Professional	Geography	2011/2012
Manouba	Geomatics for sustainable development	Professional	Geography	2009/2010

Founded in 1990, the “Laboratoire de Télédétction et SIRS (LTSIRS)” which is a research laboratory in Remote Sensing and GIS belonging to the University of Tunis El Manar has "trained" dozens of students, researchers and Geomatics specialists over the past two decades. By offering internships and the opportunity to take part in research projects, LTSIRS is a leading player in the development of the Geomatics sector in Tunisia. It now offers a wide variety of research programs covering a great number of Geomatics issues, especially in Remote Sensing and Imagery including Digital Photogrammetry, GIS, Geoinformatics, Satellite Positioning, Cartography and Hydrography. They are now 15 teachers producing an annual average of 10 Geomatics graduates.

6. The new geomatics postgraduate curriculum

In 2014, a private university set up a professional master's degree in geomatics. The first students from this course will graduate in 2016.

The composition of this new curriculum is based on:

- a reviewing of the different aspects of geomatics, the variety of its businesses and therefore training needs in order to embrace new technologies and prepare graduates for new market segments,

- an understanding of the geomatics market, the disciplines involved, and the various niches that could be targeted by the postgraduate programme,
- a profound analysis of future trends and applications of geomatics as mentioned above in 4, taking into account the ongoing national projects and new needs expressed by the various users of public and private sectors, organizations and companies involved in the production or use of geoinformation.

The new curriculum has to answer to those needs and challenges to provide the skills required for a graduate to be competent in one or more of a variety of different market segments, particularly in the geomatics industry. At the same time, it should be attractive to potential students who are interested in a career in Geomatics.

This particular modern geomatics postgraduate programme is at the intersection of three cultures: a very pronounced engineering culture aiming at developing industrial solutions and project management, a top-level company and service culture, and an academic culture guaranteed by teachers and researchers who provide both the knowledge and professional skills. For this, it is supported by the experience of LTSIRS involved in Geomatics since 1990.

The new geomatics programme had already reached the final stages of design. It offers a two year professional Master's degree programme, after which students are awarded a Professional Master's degree of Geomatics (Table 4).

Table 4. Curriculum outline of the new programme

Terms → / **Pilars** ↓	**1**	**2**	**3**	**4**
GIS	GIS 1 -Fundamentals -Design	GIS 2 -Geospatial data integration and inter-operability -Spatial analysis	GIS 3 -Advanced geospatial databases -Geospatial data quality	
Remote sensing	RS 1 -Multispectral images -Aerial images -Data processing -Data analysis	RS 2 -Radar images -Hyperspectral images		
Geo-Informatics	GI 1 -Geospatial data structure -GIS algorithms	GI 2 -Spatial SGBD -Geomatics algorithms	GI 3 -Open source programing -Visul basic programing	
Geomatics Tools	GT 1 -Introduction -Integrated projects	GT2 -Digital mapping -Spatial geodesy -Geo-positioning	GT3 -Geomatics project management -Organisations and businesses	
3D Modeling		MOD 1 -3D geometric modeling -MNE – MNT& MNS	MOD 2 -Interferometry -Lidar -Stereoscopy	
Other			WebGIS -Webmapping	Theses

			-Web and mobile programing	

As shown by Table 4, the common core courses of the Professional Master's degree of Geomatics are based on five pillars: 1) Geomatics tools essentially mapping and geodesy; 2) Remote sensing and Photogrammetry (aerial and space images, radar and hyperspectral images); 3) Geographic Information Systems (Concepts and design, Integration and Interoperability, Advanced and quality); 4) Geoinformatics (GIS software and scripts, spatial DBMS, Open source, WebGIS / mobile GIS); 5) 3D modelling focusing on Interferometry radar, Lidar and Stereoscopy.

7. Conclusion

Geomatics include whole contents of modern surveying and mapping science. It will get fast-paced development worldwide.

There are a lot of good results in Geomatics after the long-time great efforts made in Tunisia. Engineers, technicians and researchers make great contribution to the field. However, the gap at instruments, computer sciences and communication techniques between developed countries and developing countries is still large. Greater efforts should therefore be made to shorten this gap.

The Geomatics education programmes in Tunisia are still in their infancy. However, there are encouraging signs as the student enrolment and the number of curricula has risen. But it is necessary to establish a national strategy for training in Geomatics, upgrading programs, courses, and research to meet the real needs of the sector and the real challenges in the coming years, particularly in terms of staff, specialty and qualification.

Despite the GEONAT recommendations issued more than twelve years ago, it seems obvious that since then, things have not changed much. The battle will be won by successfully completing the separate actions implemented here and there like the new postgraduate program in Geomatics.

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