FROM CARTOGRAPHY TO GEOPATIAL SOLUTIONS: A CHALLENGE FOR UNIVERSITY TEACHERS IN ENGINEERING ENVIRONMENT

Pérez Gómez, Rufino
E.U.I.T. Topográfica (Polytechnic University of Madrid), rufino@euitto.upm.es

Abstract: *Surveying and Mapping have always been relevant subjects within engineering training programs in most Universities. This is caused by the need to handle properly the espacial and temporal component in complex and dynamic engineering and environmental projects. In the last decades, an increasing number of emerging technologies have drastically changed our behaviour, both as professionals and as university's teachers.*
Surveying engineers, who receive a deep training in the data capture techniques (Geodesy, Photogrammetry, Field Surveying, etc), need to involve themselves in most of the steps of a complex project: problem identification, conceptual modeling, implementation and analysis of the model through GIS tools, and presentation of the results through Cartography, multimedia or Internet capabilities. Presently, the term "Geospatial Solutions" is often used to express the combined used of Geoinformation (GI) and Information Technologies (IT).
This paper present a detailed analysis of the problems encountered in our Faculty when trying to incorporate these new technological developments and their "promising" benefits. This is specially important when trying to guarantee a place for our students, as new professionals, in a very competitive market. Finally, some conclusions and recommendations are presented as strategic features to be considered in the education process.

INTRODUCTION

Emerging technologies have increased quite a lot the availability of multipurpose geographic data. GPS has revolutionized Geodesy and Surveying and are widely used today in a great variety of projects. A step still further is the full integration of Total Station and GPS in one equipment, like Leica SmartSation [1]. This enables to work faster, more accurately and more efficiently, because there is no need for control points, long traverses or resections. Initially, the GPS antenna allows to get the coordinates of the first point. RTK determines the position to centimeter accuracy within a few seconds at ranges up to 50 km from a reference station. Afterwards, we can use the total station for normal measurements. This provides to the field surveyor with a greater flexibility, besides significant time and cost reductions, when making topographic surveys in rural and urban areas, or while working in construction sites.

Another recent development is the 3D Laser Scanner, like HDS series of Leica Geosytems [1], which enable high-definition field data capture more efficient and easier for a wider range of surveying and engineering projects. The point cloud data is a high-definition and high-detail spatial datasets that are further processed for analyzing and visualization purposes in 3D models within CAD packages like MicroStation or AutoCad. This technology let users create highly accurate deliverables while minimizing both field time and office processing time for a wide range of applications and project sites.

A very significant impact in geodata gathering is also caused by the latest high resolution satellites (Ikonos II, EROS A, QuickBird, SPOT 5, etc) that deliver better images with higher spatial, spectral and temporal resolutions.

All the above mentioned developments enable a greater availability of geographical data to be used in a wide range of projects, where Cartography, GIS and Internet technologies will play a key role for modeling, analysis and final presentation of results.

DIGITAL MAPPING: A SHORT HISTORICAL OVERVIEW

During the 80´s, it took place a great impact of computer developments that influenced Cartography with the appearance of CAD, DTP and GIS software packages This allowed the computer cartographer to design a great variety of production lines. Suddenly, it was possible to produces a great number of maps and atlases, in a very short time, compared with the traditional cartographic techniques.

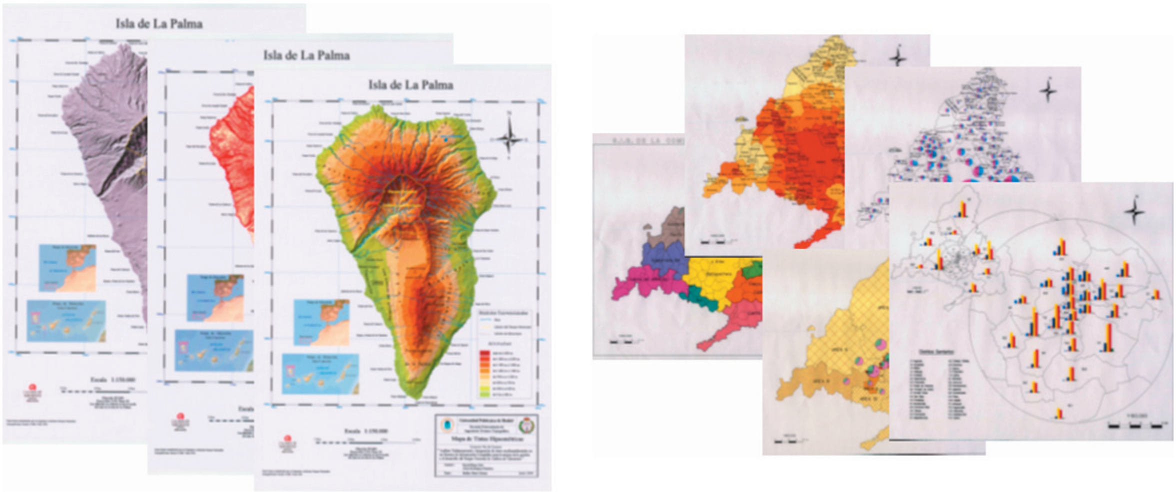

Figure 1: Maps produced by our students with DTM and GIS packages.

CAD programs have been extensively used by surveyors in large scale mapping in engineering, urban and cadastral projects, to mention some examples. They also behaves as key components at the digitizing, editing and plotting stages within GIS projects when these environments were not so efficient in those tasks. DTP packages have often been connected to small scale thematic mapping and atlases. DTM packages within GIS environment, or in stand alone configuration, have also proved as efficient tools for the cartographers in order to obtain a great variety of map like products: hill shading, layer tints, slope maps, aspects maps and viewshed analysis are good examples of this type (see figure 1).

The GIS concepts and technologies produced a tremendous impact in cartographic world at its beginning. Many public and private institutions in each country produce a huge amount of statistics characterizing multiple phenomena. GIS packages appear to be the appropriate tools for modeling and analysis. However, the powerful communication capabilities of maps, as graphical images, make them unrivalled to convey spatial information in the form of patterns, distributions, interrelations, etc. Maps remain as the ideal form to present or outline a problematic situation in its spatial contexts, it also works very well as a control mechanism for evaluation of dynamic process and phenomena, or to set up target images of the future. This is still true no matter how is the evolution of GIS technologies.

For their combined capabilities, the GIS packages have evolved into being the modern production tool for nowadays cartographers and surveyors. However, the traditional systems used to be based in proprietary formats and lacked of interoperability. Besides that, the low availability of data, and the character of these complex and dynamic tools, have been obstacles for a much faster development.

Most surveyors deal with large scale mapping and processes of geographical data within engineering projects. In this context, 3D reconstruction or models constitutes a very efficient way to analyze and visualize the 3D space of the study area. Building up a detailed 3D reconstruction is a time consuming operation. However, once it is realized, a lot of applications and benefits can be obtained (plans, details, profiles, cross sections, perspective views, realistic photos, animations, volumes, etc.). The figure 2 shows some examples as produced by our students.

Webmapping can be mention here as one of the most innovative developments lately. Street maps, road maps, weather and tourist maps, are among the most frequent published maps through the Web, as long as we refer to private companies. Other National Mapping Agencies, Cadastral Institutes and Statistical Organizations, are also actively involved in the dissemination of maps and geographical data through Internet, as a better service to the citizens.

Figure 2: Three-dimensional reconstructions carry out by surveyors.

FROM CARTOGRAPHY TO GEOSPATIAL SOLUTIONS

The traditional role of maps to store and communicate spatial information has changed a lot in the last decades. Recently, maps have been applied to the exploration and analysis of complex and dynamic spatial problems of the environment and the society. Presently, the term "Geospatial Solutions" is often used to express the combined used of Geoinformation (GI) and Information Technologies (IT).

For the management of engineering projects have largely been appreciated the alternative process with GIS, because this method integrates all the data and considerations (environmental, human, social, economical, etc) at the beginning of the process rather than time-consuming post-processes. Besides that, all the data is presented in a single context, and all the departments or agencies involved in the decision process can ensure their data is considered as part o the design process. Furthermore, the decision making rules are more transparent and "what if" scenarios can be generated efficiently. Finally, the powerful communication tools enable to present the results successfully.

Lately, it has taken place the integration of GIS with Internet. This development has enhanced the value of GIS many times over. The idea behind Web-based GIS is to provide real-time access to geospatial databases online and equip users with GIS query, analysis, and visualization tools so they can build maps and extract meaningful information. Any user equipped with a standard Web browser can accomplish these tasks and more with no GIS training. The figure 3 represent un implementation of this type as developed by one student in her final study project, and by using the Geomedia Web Map environment.

The last generations of GIS programs provide some enhance features such as interoperability, increased viewing flexibility, more powerful analytical tools and scalability. The interoperability is related to the access of data, for analysis and mapping, in multiple native formats without conversion or translation. The standard raster viewing capabilities of Internet are further upgraded to enable raster and vector (ActiveCGM, SVG) display. This is normally accomplished through installing some ActiveX control, plug-in, or a Java applet in the client's browser. The scalability refers to the possibility for the users to grow their systems without rebuilding them by linking as many GIS, CAD, digital mapping, and database systems they wish. Some vendors ensure that their products are designed to accommodate viewing commands and analysis queries from thousands of simultaneous users.

The interoperability in the commercial sector is achieved through their own developments. For instance, Intergraph accomplished this feature by inventing Geographic Data Objects (GDO) technology and building a separate GDO server for each of the popular GIS and CAD packages. Apart from the different commercial solutions available in the market, as provided by GIS vendors (ESRI, Intergraph, Smallworld, Bentley, AutoDesk, etc), there are a growing number of projects related to the Spatial Data Infrastructures (SDIs). This is still truer since the publishing of INSPIRE directive in July 2004 [3]. In this case, the interoperability is based on the concepts of the Open GeoSpatial Consortium [4]. The SDIs try to overcome some of the problems in the traditional GIS projects: gaps in availability of data, fragmentation of datasets and sources, duplication of information collection and lack of harmonisation between datasets at different geographical scales. These problems make it difficult to identify, access and use data that is available. Among the most outstanding implementations in Spain we should mention the Spatial Data Infrastructure of Spain [5] and Spatial Data Infrastructures of Catalonia [6]. US and European Union government data sources are increasingly offering their data through implementations of OGC standards [4].

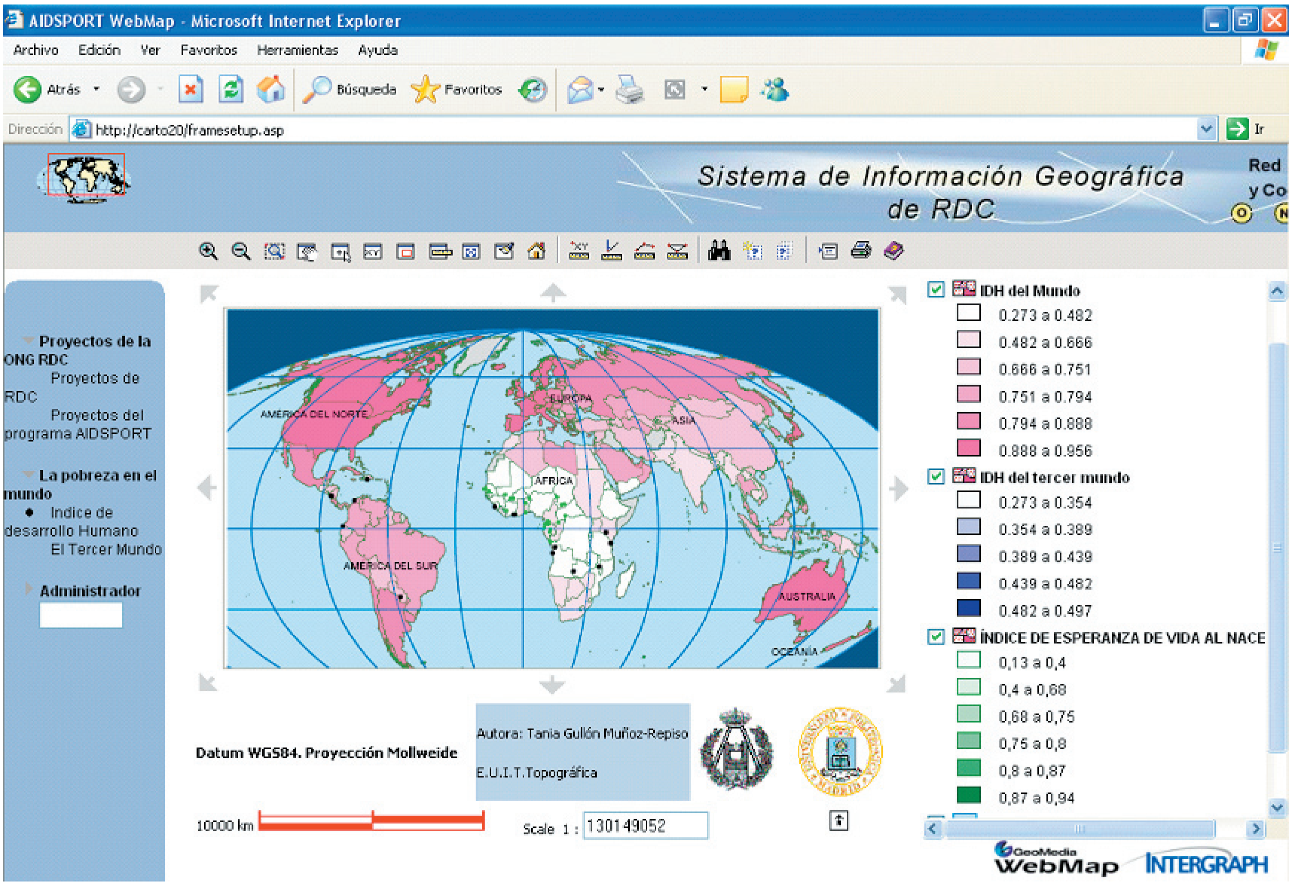

Figure 3: Geospatial solution built up with GIS and the Internet technologies.

Besides the multiple SDIs developed following different directives like INSPIRE, there are other geospatial solutions based in Free and Open Source Software (FOSS). An example of this type is described by Creager (2005), where around 300 weather observing stations report to a common point for display of the data in near real-time. For dissemination over the web, the site provides a real-time view of weather using the Minnesota MapServer software with web mapping and data access services that implement the OpenGIS Web Map Service (WMS) and OpenGIS Web Feature Service (WFS) Specifications. The data are archived and available to the public and the academic community for research and analysis. Making the data available through Web Services also gives GIS users the ability to add a weather dimension to their work.

Though different technological developments have been briefly mentioned in the previous paragraphs, they are not the most important factor. What I would like to underline at this point is how the geographical data is a key factor in the management of multiple projects. The awareness of this strength should be considered as one of the strategic factor when setting up teaching programs for surveyors and cartographers. Surveyors, at least in Spain, has been mostly related to the geometrical aspects of the engineering and urban projects. We do need to change our perspective from geodata providers to geospatial solutions providers. We need to put the data in the context of modeling, analysis, planning and problem solving scenarios.

A good example of the above mentioned strategy is very well illustrated by the "Approved Resolutions of the XXth ISPRS Congress" held in Istambul last year [8]. Our colleagues of sister society ISPRS, work in the development of new sensors and platforms (aerial, terrestrial and space systems) to obtain new imagery with higher spatial, spectral and temporal resolution. This imply some algorithm development for radiometric and geometric sensor calibration parameters, and 3D Object Generation and Database Updates, just to mention some examples. With this data proceed further into Image Classification and Analysis Methodologies, Dynamic and Multi-Dimensional GIS, Raster-Based Spatial Analysis on the Web and Design and Operation of Spatial Decision Support Systems. By doing so, it appears there are and endless list of application fields:

- Topographic and Thematic Mapping
- Visualization and Animation
- Location-Based Services
- National and Regional Spatial Databases
- Global Databases and Environmental Infrastructures
- Landscape and Visualization
- Applications in Cultural Heritage
- Sustainable Development and Sustainability Indicators
- Agricultural Systems Management
- Forest Management and Biodiversity
- Mineral Resources and Study of Geohazards
- Human Settlements and Impact Analysis
- Disaster Monitoring, Mitigation and Damage Assessment
- Coastal Zone Management and Ocean Color Research
- Water Resources Security
- Ocean State Forecasting
- Supporting Implementation of International Policies and Treaties
- Polar Research

So, photogrammetric and remote sensing especialysts, knowing the value of geographical data, expand their activities to all the aspects of the real life projects, ranging from the initial step of data gathering, to the final applications, going through the modeling and analysis stages with the enabling technologies.

CONCLUSIONS

One of the main conclusions I would point out is the need many surveyors have to change in mentality from geodata providers to geospatial solution providers. We need to prove permanently the usefulness of geodata for solving problems, not only to produce nice maps. We should we aware of or weaknesses and strengths. We should try to use our knowledge in the data capture techniques, together with the great capabilities that Cartography and 3D viewing techniques, offer us to communicate the results of the different analysis very effectively. This still more important because, nowadays, thousand of low quality maps are produced with GIS by people lacking of the required cartographic knowledge.

TI Market claim to provide multiple benefits. However, very often the results are behind the expectations. Besides that, frequently, the final technical solution require to integrate the capabilities of multiple programs of different environments. To handle this situation successfully, adequate interdisciplinary teams should be created. In this teams surveyors and cartographers should effectively work with computer experts, mathematicians and other geo-scientis, as required in each project.

The study and evaluation of most recent developments in TI such us GIS and Internet, Spatial Data Infrastructures and Free and Open Source Software (FOSS), should be permanent activity in the universities. This should allows us to put the geodata in the most valuable context and provide strategic benefits for our students and colleagues.

REFERENCES

1. http://www.leica-geosystems.com/
2. Martin, C. And Dunn,Ls. Laser Scanning for Everyday Survey Work. The American Surveyor. Jenuary/Februry 2005.
3. http://inspire.jrc.it/
4. Open Geospatial Consortium, Inc. http://www.opengeospatial.org/
5. Spatial Data Infrastructure of Spain: http://www.idee.es/
6. Spatial Data Infrastructures of Catalonia: http://www.geoportal-idec.net/
7. Creager, Gerry (2005): Texas weather data online via opengis implementation. OGC User Magazine. May 2005.
8. Approved Resolutions of the XXth ISPRS Congress- Istambul 2004. ISPRS Magazine Highlights, Vol. 9, nº3, September 2004 (pp 34-41). See also: http://www.isprs.org/
9. Dent, B. D. Cartography : Thematic Map Design. McGraw-Hill (1999)
10. Kraak, M-J. y MacEachren, A. M. Visualization for exploration of spatial data. International Journal of Geographical Information Science, 13(4): pp.285-287, (1999).
11. Kraak, M. y Brown, A. (Ed.). Web Cartography: Developments and Prospects. Taylor and Francis, London, 213 pp. (2001).
12. Laurini, R. y Thompson, D. Fundamentals of Spatial Information Systems. Academic Press,680 pp. (1992).

13. Tomlin, D. Geographic Information Systems and Cartographic Modeling. Prentice-Hall, Englewood Cliffs, NJ (1990):
14. Peterson, M. P (Ed). Maps and the Internet. Elsevier Science. (2003)
15. Pérez, R, Martínez, R. Publishing geomorphological maps in internet as a contribution to the sustainable development. Proceedings of Intercarto 9 Conference. Sebastopol, June 2003.
16. Pérez, R, Martínez, R. Análisis semiológico de mapas temáticos complejos, su programación en entorno de cartografía digital y su publicación en Internet. Ponencias del congreso Geomática 2004. La Habana, mayo 2004.
17. Geomedia Professional 5.1 Reference Manual
18. Geomedia Grid 5.1 Reference Manual
19. Geomedia Web Map 5.2 Reference Manual