UPGRADING MAP PRODUCTION AND DISSEMINATION WORKFLOWS WITH RECENT DEVELOPMENTS IN GIS AND INTERNET TECHNOLOGIES.

Pérez, Rufino
PhD in Geodesy and Cartography (Technical University of Madrid –UPM)
E.T.S.I. en Topografía, Geodesia y Cartografía
Ctra Valencia Km 7. 28031 Madrid (Spain)
Tel: +34 91 336477. Fax: +34 913322560. E-mail: rufino.perez@upm.es

Keywords: *Digital Mapping, GIS, Internet Mapping, Internet GIS, SDIs*

Abstract:
The map production techniques have experienced a tremendous impact with the technological developments during the last thirty years. During the 80´s the CAD, DTP and GIS programs increased a lot the versatility, quality and diversity of the map production workflows. However, some problems such as the accessibility to geographic information (GI), the lack of interoperability among software packages, etc, have only recently been solved. The purpose of this presentation is to briefly describe how recent technological development, if adequately combined, can widen our map production and dissemination workflows. At the same time, some examples of the Spanish Mapping Agencies implementations will be described to illustrate the potential benefits, at many different levels, of this kind of cartographic projects.

In relation with the structuring of the spatial information, the client/server architecture enables to separate the space for analysis and visualization from the space for the storage of the GI in geospatial databases (geodatabase model). The general case is that, in the client side, is stored the database connections, the coordinate system files, the map windows, data windows and layout window information, the symbology and color tables, legends (users´ profiles), queries, filters, etc. These features allow the dynamic updating of maps, queries and functional attributes (calculated attributes) and the scalability of our project. This means the possibility to make our system grow with a lot of project data, for analysis and mapping, without rebuilding the system itself. On the other hand, the interoperability concepts, based on commercial data servers or OGC services, increase the ease of access to GI stored in multiple formats and coming from many different sources. These features are still more interesting when combined with the highly growing activity of the different Mapping Agencies and companies in Spain.

A map within a GIS environment may be considered as one of the multiple views of our model. To produce a collection of varied thematic maps, supporting all sort of planning and decision making scenarios, is a rather flexible and straight forward process. Obviously, the information power of these maps can be further supplemented with analytical raster layers, 3D views and models and animation products. All of them can be used to communicate the results and findings obtained going through multiple analytical processes which are conducted on the project's conceptual model.

Finally, all the maps and results of our project can be easily disseminated to a big audience taking advantage of the multimedia and hyperlinking capabilities of Internet Technologies. The maps can be distributed through different web services in all kind of vector and raster formats (GIF, JPEG; CGM, SVG) or via OGC services (WMS, WFS, WCS,..). The GeoPDF format is also an interesting manner for the distribution of geo-referenced GIS layers in a map-like format. By using this format, users are able to view finished digital maps, turn layers on and off, query attributes, display coordinates, measure distances and track locations via GPS without the need for complex GIS applications or the knowledge of how to use them. Another recent trend is to publish our maps and GIS data combined with other GI Internet application such as Google Earth and Microsoft Virtual Earth. It is also worth a mention to increasing tendency of Spanish Administrations (National, Regional and Local) to enable the geospatial data downloading via GML format or diverse native proprietary format (DGN, DWG, DXF, Shapefiles, etc). There are many cartographic activities carry out by the different Mapping Spanish Administrations, in a coordinate manner, under the umbrella of the National Cartographic System as published in a royal decree in November 2007.

So, in short, we have more GI data available and more powerful concepts and tools to conduct any kind of cartographic tasks and products in the context of all type of engineering and research projects.

1. INTRODUCTION

Though diverse digital mapping projects had been conducted in the previous decades, it was in the early 80´s when the computer science technologies started to be used extensively in Cartography. The concepts and tool of Computer Aided Design (CAD), Desk Top Publishing (DTP) and Geographical information Systems (GIS) allowed multiple new interesting scenarios for both, the spatial analysis and the map design and production. Since that time, these tools and technologies have progressively been developed, not only increasing their analysis and mapping capabilities, but also by applying new concepts such as interoperability, scalability and dynamic updating of maps and queries. The implementation of standards coming from different international organizations is also playing a very important role.

In 1969, Internet was designed and created as a decentralized and distributed system. Later on, at the beginning of the 90´s, Tim Berners Lee and his team, while working at the European Organization for Nuclear Research (CERN), developed the new protocol of the World Wide Web (WWW). The HTML language and the HTTP protocol allowed Internet users to integrate multimedia contents in HTML documents that, in turn, were interconnected via hyperlinks. The HTTP protocol runs on top of the existing protocol TCP/IP and the Web behaves as a vast global information system with a large collection on interconnected HTML documents (hyperspace, cyberspace).

In 1995, several Internet browsers such as Mosaic, Netscape y Microsoft Internet Explorer were available in the market. By that time, la web became an attractive and fashionable manner to disseminate all kind of information: political, cultural, social, economical and spatial. The spatial information were disseminated through all kind of maps and the new terms “Internet mapping” and “Webcartography” started to be used. The first kind of maps, and more often distributed via Internet, were the street maps, route maps and weather maps, being extended progressively to all types of maps. The techniques to distribute spatial information evolved from the initial static methods of map publishing using raster formats (GIF, PNG and JPG) to the more attractive and effective implementations using dynamic and interactive methods to vector data. Many public administrations started to use these technologies developing new products and applications as a better interaction and service to the citizens. The “Cadastre Virtual Office” of the Spanish Cadastre Institute is a good example of this nature. Figure 1 illustrates the aspect of a client’s browser visiting this site.

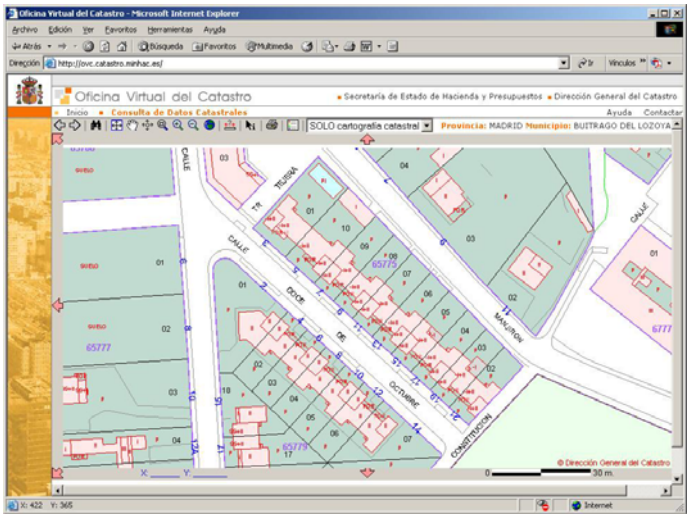


Figure 1. The Spanish Cadastre Virtual Office implementation.

In the second part of the 90´s took place the integration of the concepts and tools of GIS desktop with Internet by means of specific programs or extensions that implemented the required protocols. The basic idea is that any Internet user, through a simple browser, could access the geospatial databases of a GIS project in order to make queries, spatial analysis or to produce maps and reports without the need to purchase any GIS software or to have special knowledge or training in GIS. These types of operations were previously available only for the people working in the GIS department of the project. Due to these accessibility constraints the dissemination of the results and benefits of the project were more difficult. The HTML basic configuration allows only for static dissemination of maps. So, the configuration has to be enhanced somehow to improve the performance of the system. This is normally achieved by installing “*plugins*” or java applets in the client’s side or with Common Gateway Interface (CGI) technology in the server side. The major GIS vendors provide specific programs or extensions to ease the practical implementations of this kind of projects. ArcGIS Server (ESRI) and Geomedia WebMap (Intergraph) are some examples of software aimed to construct Web GIS projects. At the late 90´s, many Spanish administrations (local and regional governments, etc) were engaged in the dissemination of spatial information by means of Internet GIS projects, being the Territorial Information System of Navarra (SITNA), shown in figure 2a, a good example of this type. The figure 2b, shows an application aimed to handle

the traffic in Houston more efficiently by providing any driver with spatial information plus real time traffic and incident information in the street and road networks.

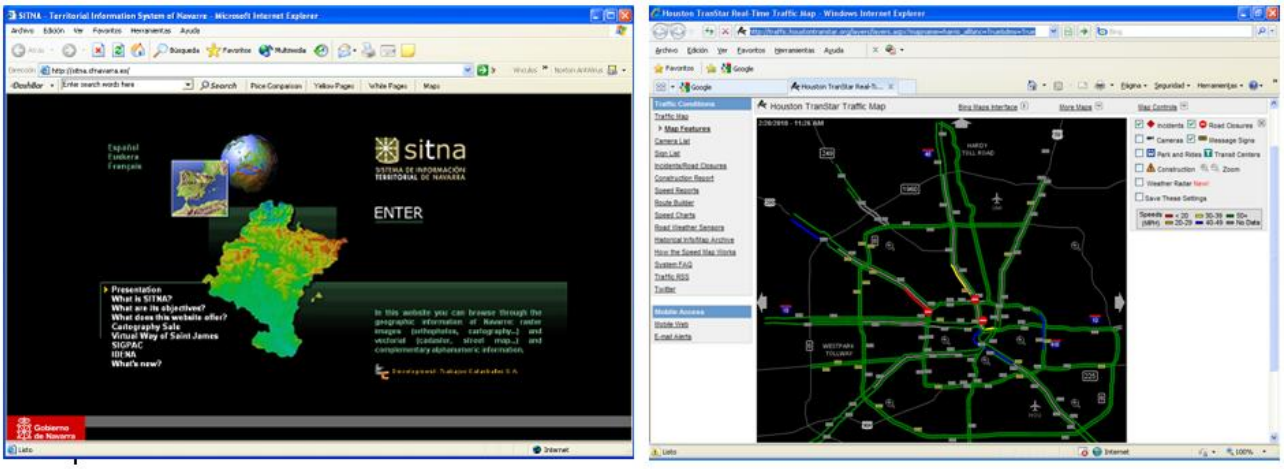


Figure 2. Internet GIS implementations: a)SITNA and b)Traffic in Houston.

2. RELEVANT ASPECTS DEALING WITH GEO-INFORMATION

The rapid developments in data capture technologies have increased significantly the availability of multipurpose geographical data that, in turn, have improved the accessibility to more accurate and up to date spatial data. The GPS, and the integration of total stations with GPS have added versatility and productivity in the fieldwork. The new satellite images with higher resolutions (spatial, spectral and temporal), the LIDAR and 3D terrestrial scanners have also contributed to larger availability of geodata. On the other hand, the advances in digital mapping, GIS and Internet technologies are playing an important role in the modeling, analysis, mapping and visualization activities within engineering and research projects.

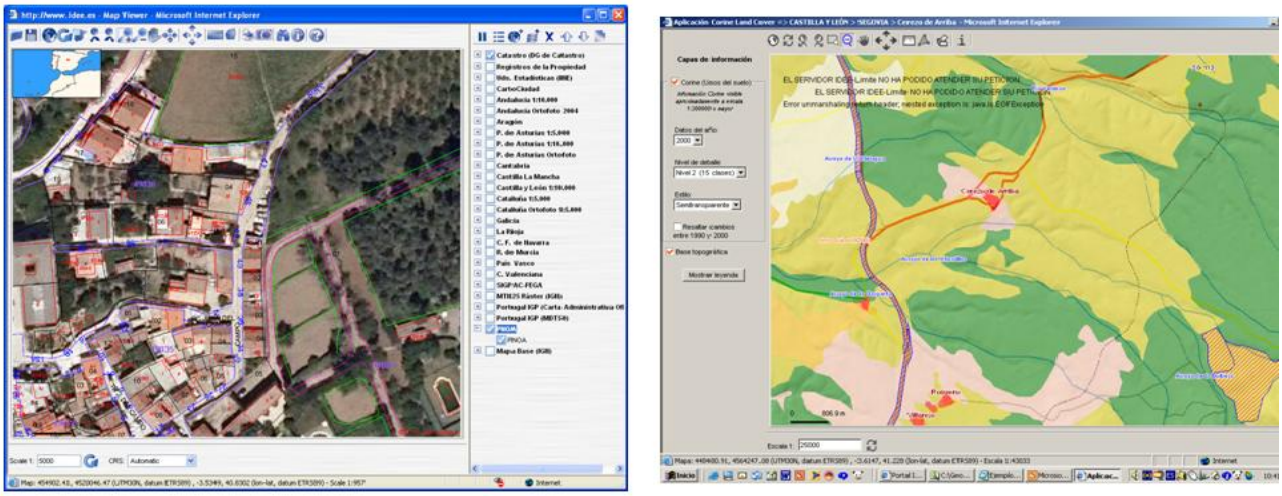


Figure 3. Spanish SDI Implementations: a)Map Viewer and b)CORINE Project.

However, in spite of the previously described developments, going through a literature search to analyze the results of multiple GIS projects, some obstacles have been identified by the GIS community during the last decades: gaps in the availability of data, fragmentation of datasets and sources, duplication of information collection, lack of harmonization of datasets at different scales, lack of interoperability (proprietary formats and proprietary programming language). Besides that, they are complex and dynamic tools with usually high prices. For all these reasons, it used to be frequent to spend a lot of time and money in the acquisition and structuring of the data before the system started to work causing, at the same time, a decrease in the efficiency and economical viability of the technology. Fortunately, the development, during the last years, of different standards such as those of the Open GeoSpatial Consortium (OGC), have solved some

of the problems enabling the location of available data through metadata catalogues, increasing the accessibility of geodata via network services and integrating data from different sources by applying the OGC interoperability concepts.

Te Spanish Spatial Data Infrastructure (SDI) main Geoportal offers to the internet users different services by applying the mentioned concepts. The Map Viewer service allows the visualization, in a combined manner, of the existing information of a given area, such as digital maps, orthophotos and satellite imagery, as coming from different mapping agencies and public administrations in Spain. The figure 3a shows the visualization of cadastre maps and orthophotos (PNOA project) while 3b illustrate land use information as part of the CORINE Land Cover project. Both services were built up by implementing the OGC WMS specification (ISO 19128).

3. INTERNATIONAL STANDARDIZATION ORGANIZATIONS

Tim Berners-Lee and his team, that had led to the creation of the WWW protocol, also contributed to the creation of the World Wide Web Consortium (W3C). This International Consortium, as stated in its website, "*is an international community that develops standards to ensure the long-term growth of the Web*". Since 1994, the W3C has published more 110 standards dealing with the different aspects of the web: web design and applications, web architecture, XML technology, web services, browsers, etc. The Internet GIS programs should comply with W3C standards in order to succeed in their implementations.

Table 1. Renaming Territorial Information Systems with SDI names when applying OGC services

Before 2004	After 2004
Sistemas de Información Territorial de Galicia (SITGA) *Territorial Information System of Galicia*	Infraestructura de Datos Espaciales de Galicia (IDEG) *Spatial Data Infrastructure of Galicia*
Sistemas de Información Territorial del Principado de Asturias (SITPA) *Territorial Information System of Asturias*	Infraestructura de Datos Espaciales de Asturias (IDEAS) *Spatial Data Infrastructure of Asturias*
Sistemas de Información Territorial de Navarra (SITNA) *Territorial Information System of Navarra*	Infraestructura de Datos Espaciales de Navarra (IDENA) *Spatial Data Infrastructure of Navarra*

On the other hand, the Open Geospatial Consortium (OGC), that was also created in 1994, is an International Consortium with more than 400 members including National Mapping Agencies, universities and privates companies. OGC develops interoperability standards of software components which process geographical information. Some of the more often used standards as implemented in SDI geoportals are the Web Map Service (WMS), the Web Feature Service (WFS), the Web Coverage Service (WCS), the Geographic Markup Language (GML), and KML.

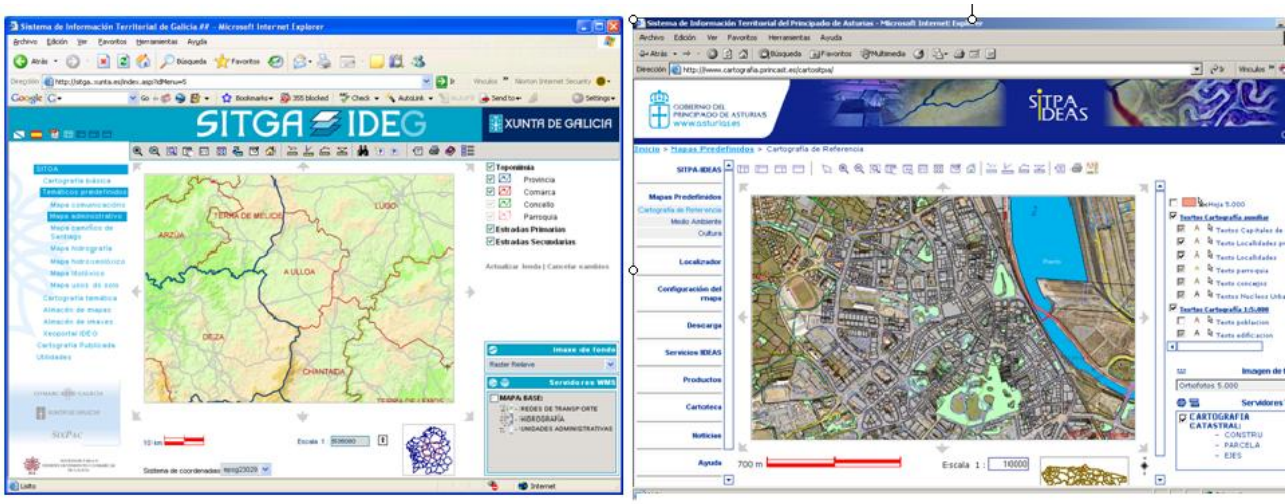


Figure 4. Spanish Regional Government SDIs: a)SITGA-IDEG b(SITPA-IDEAS

A basic idea of the OGC services is that any Internet user could discover and access, in a simple and interoperable manner, to the geographical data produced by any mapping agency, public administration or private company. This enables to reuse the spatial data for many people in distinct projects with different purposes. Actually, this is the idea of the first principle of the European Directive INSPIRE that was initially published in July 2004. The first implementation of the Spanish SDI main website took place in June 2004. We should also consider that the OGC services can behave as a technological bridge between the Internet GIS and SDI concepts and implementations. By doing so, the so called "*Territorial Information Systems*" projects conducted in Spain till 2004, were upgraded with OGC services and renamed as SDIs. The table 1 gives some examples of different regional government implementations that were enhanced with the described concepts and services and renamed accordingly. The figure 4 illustrate 2 of these implementations: the *Spatial Data Infrastructure of Galicia* (SITGA-IDEG) and the *Spatial Data Infrastructure of Asturias* (SITPA-IDEAS). The Internet GIS component of these websites allows the internet users the access to interactive maps in vector format (CGM, SVG) while are also supplemented with OGC services like metadata catalogues and WMSs.

4. NEW CARTOGRAPHIC WORKFLOWS

The new GIS tools, based on the client/server architecture, offers a larger flexibility in the different analysis and mapping workflows. In relation with the structuring of the spatial information, the client/server architecture enables to separate the space for analysis and visualization from the space for the storage of the GI in geospatial databases (geodatabase model). The general case is that, in the client side, is stored the database connections, the coordinate system files, the map windows, data windows and layout window information, the symbology and color tables, legends (users´ profiles), queries, filters, etc. These features allow the dynamic updating of maps, queries and functional attributes (calculated attributes) and the scalability of our project. This means the possibility to make our system grow with a lot of project data, for analysis and mapping, without rebuilding the system itself. On the other hand, the interoperability concepts, based on commercial data servers or OGC services, increase the ease of access to GI stored in multiple formats and coming from many different sources. These features are still more interesting when combined with the highly growing activity of the different Mapping Agencies and companies in Spain.

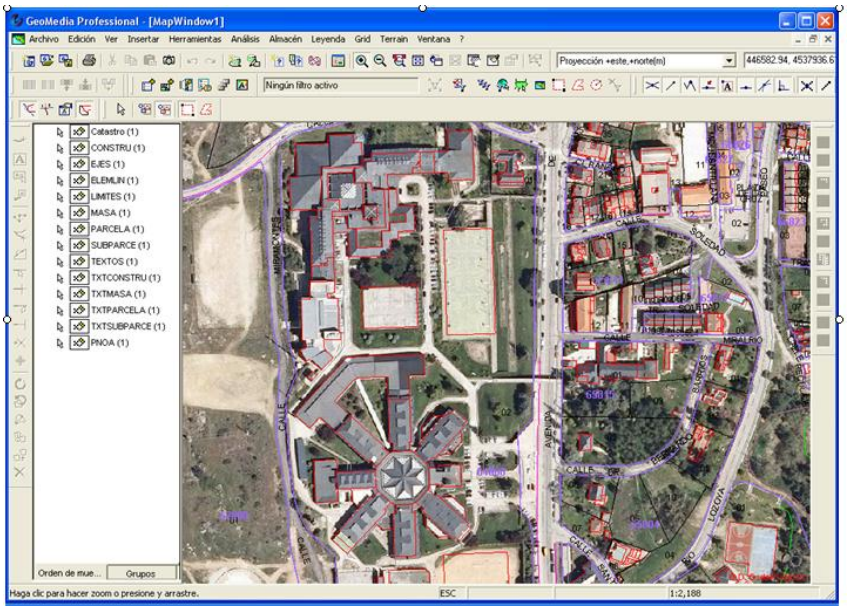


Figure 5. Connecting GIS desktop (Geomedia) with Spanish Administration WMSs (Cadastre,PNOA)

The figure 5 illustrates the integration of GIS desktop technology (*Geomedia Professional v 6.1*) with spatial data coming from different Spanish Administrations through WMSs. The integration of GIS local data with external data increases the feasibility of many projects. The major GIS vendors, such as ESRI, Intergraph, Bentley, Mapinfo, etc are OGC members and tend towards the continuous implementation of W3C and OGC standards.

Nowadays, most Spanish Mapping Agencies, besides the visualization of spatial data through distinct map viewers in the client's browser, allow data downloading. The current situation encompass two different strategies, on the one hand enable data downloading in image, CAD or GIS proprietary formats (DGN, DXF, DWG, JPG, PDF, Shapefiles, etc) and, on the other hand, via OGC standards (GML, KML).

The last generation of GIS programs have also improved the printing capabilities of maps via the so called "*layout environment*". A few years ago, it was quite frequent to export the GIS results and maps to CAD formats for the final printing of the graphic documents. With the previously mentioned client/server architecture is rather easy to produce a collection of thematic maps as a response to the needs of different users. These maps can be obtained by combining features classes with different symbologies adequate to the maps users, by processing the database contents with thematic mapping operators or as a result of analysis workflow.

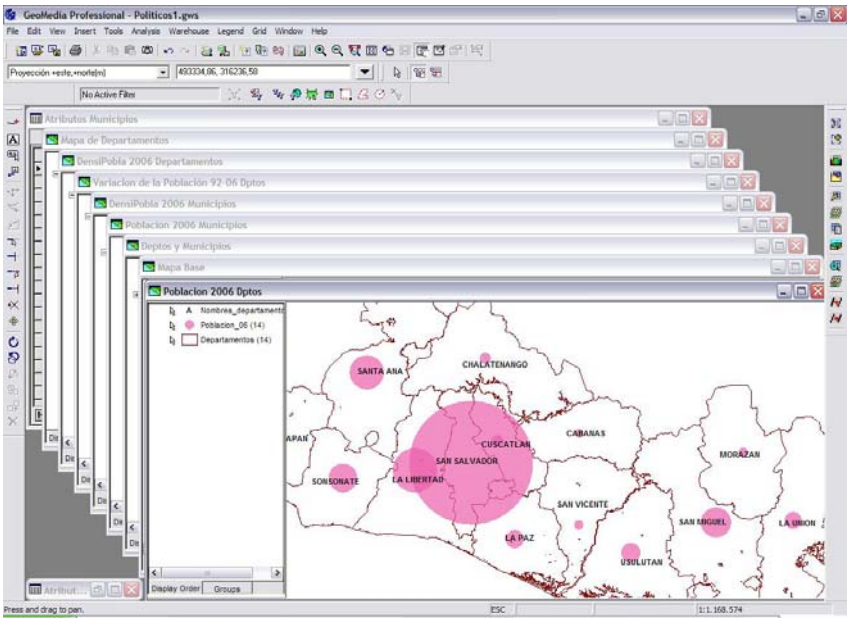
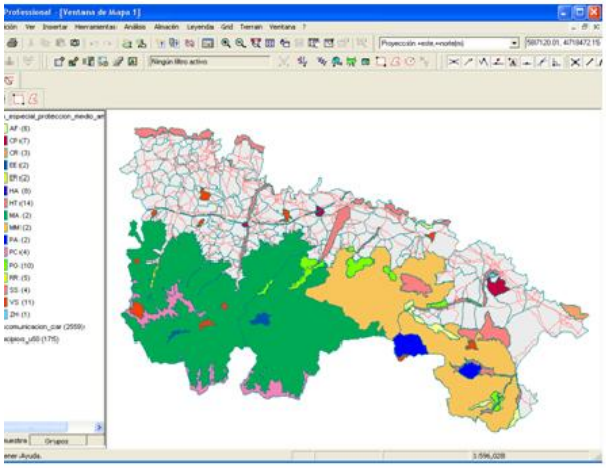


Figure 6. Producing collection of maps with GIS desktop tools (Geomedia).

Another example is given in figure 7, where data that had been downloaded in ArcView format from the *Spatial Data Infrastructure of La Rioja (IDERioja)*, has been integrated in a GIS desktop program (*Geomedia Professional 6,1*) for the map production phase. The resulting maps are afterwards published on Google Earth in KML format for dissemination purposes. This format is an XML language focused on geographic visualization, including annotation of maps and images. From this perspective, KML is complementary to most of the key existing OGC standards including GML (Geography Markup Language), WFS (Web Feature Service) and WMS (Web Map Service). The OGC and Google have agreed that there can be additional harmonization of KML with GML (e.g. to use the same geometry representation) in the future.



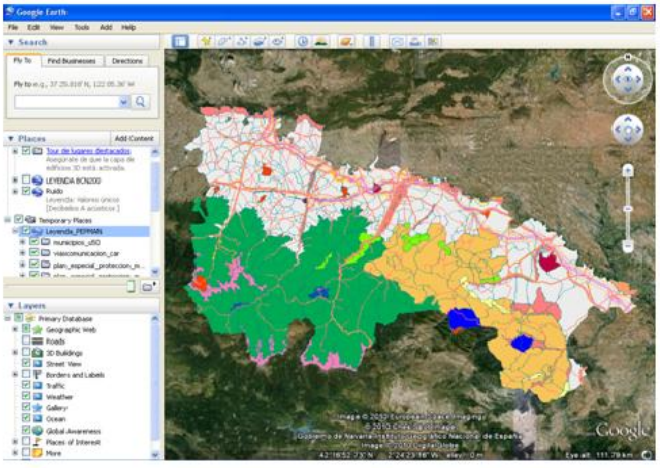


Figure 7. a) Thematic Map Production with GIS desktop b) Publishing maps in KML format from GIS desktop

5. CONCLUSIONS

The main conclusions, based on the different aspects described in this paper can be briefly summarized as follows:

- The European projects such as GMES, Galileo and INSPIRE have raise the dynamics of the Geo-information sector.
- The Spanish Administrations are making great efforts in the data capture and data dissemination of spatial data. The new National Cartographic System, as published in the Royal Decree 1545/2007 (November 2007), help to collaboration among the different Mapping Agencies following common guidelines.
- The major GIS vendors tend to increase the connectivity of GIS Desktop with Internet and SDIs by progressively implementing the W3C and OGC standards.
- Nowadays, GIS tools are more versatile because they allow to apply the interoperability and scalability concepts and, on top of that, they also have more powerful geo-processing tools.
- Putting together the previous conclusions, it may be said that today any GIS user can enjoy a greater availability and accessibility to geo-information. This, in turn, will widen the types and number of engineering and research projects where GIS technology can be used in an economically feasible manner.

6. REFERENCES

TECHNICAL DOCUMENTATION

- Interoperability course documentation: GeoMedia-OGC (Madrid, September 2006).
- Geomedia Professional v 6.1 Reference Manual.
- Geomedia GRID v 6.1 Reference Manual.
- Geomedia WebMap Reference Manual.
- Intergraph´users Annual Meeting. Technical documentation of the event (Madrid, November 2007)
- Intergraph´users Annual Meeting. Technical documentation of the event (Madrid, November 2008)
- Real Decreto 1545/2007 del Sistema Cartográfico Nacional (BOE 30-11-2007)

URLs

ESRI	http://www.esri.com/
GMES	http://www.gmes.info/
HoustonTraffiC	http://traffic.houstontranstar.org/layers/layers.aspx?mapname=harris_all&inc=True&dms=True
IDEAS	http://www.cartografia.princast.es/cartositpa/
IDEC	http://www.geoportal-idec.net/geoportal/cat/inici.jsp
IDEE	http://www.idee.es/
IDEG	http://sitga.xunta.es/sitganet/
IDENA	http://idena.navarra.es/busquedas/?lang=
IDERioja	http://www.iderioja.larioja.org/
INSPIRE	http://inspire.jrc.ec.europa.eu/
INTERGRAPH	http://www.intergraph.com/
OGC	http://www.opengeospatial.org/
W3C	http://www.w3c.es/ ; http://www.w3.org/