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Geolocating and Georeferencing: GIS Tools for Ancient Maps Visualisation

P. Chias, T. Abad
Dept. of Architecture, Technical School of Architecture and Geodesy, University of Alcalá, Spain
{pilar.chias@uah.es, tabad@ciccp.es}

Abstract

The e-Library on Ancient Spanish Cartography has been created inside the frame set by the European Union about the Europe's digital cultural heritage to give a response to the real demand among citizens and within the research community. With this aim we have applied the most advanced information and communication technologies (ICTs) to make ancient Spanish maps and views accessible through Internet. On a first stage we have built a relational multiformat and multilingual database that included high resolution images of the cartographic documents and that supported the online accessibility structured by levels. This platform has been recently improved by implementing an open GIS based on the data sets of the e-Library. GIS tools have enlarged the usability of the system as the traditional geolocation searches are now completed with the queries based on maps' georeferencing. The GIS on Ancient Spanish Maps suggests a new concept in digital map libraries.

Keywords- GIS, Cartographic Heritage, Digital Libraries, Online accessibility, Multilingual and Multiformat Databases

1. Introduction

According to the strategies of the Council of the European Union about the European Digital Libraries [1] considered as a common multilingual access point to Europe's digital cultural heritage. Assuming that the ancient maps and plans are important cultural materials, in the last decade there have been created several cartographic databases that allow an efficient online accessibility.

This libraries are defined as organised collections of digital contents made available to the public, and are composed of analogue materials that have been digitised as well as of born digital materials. They must also follow several main strands as are:

- The online consultation, stressing the importance of exchanging information and publishing the results, in order to maximize the benefits that users can draw from the information [2].
- The preservation and storage of this digital collections to ensure that future generations can access the digital material, and to prevent losses of contents.

Maps represent an important part of the richness of Europe's history and its cultural and linguistic diversity, and can be increasingly accessed through local libraries websites based on open-access models settled on the principles of free, worldwide access to the information, following the trend of voluntary sharing.

The online presence of this cartographic material will make it easier for citizens to appreciate their own culture heritage as well as the heritage of other European countries, and to use it for study, work or leisure. It will be a rich source of raw material to be re-used in different sectors and for different purposes and technological developments.

As a first stage of the Project we have built a relational multilingual database of the Ancient Spanish Maps that could be accessed through Internet [3]. As a second stage we have implemented an open GIS based on this e-Library that includes all the capabilities due to the GIS tools and the geocoding.

The GIS based e-Library on Ancient Spanish Cartography has then considerably enlarged its usability. It also proposes a new paradigm in digital libraries [4].

2. A new concept of a map library

The e-Library of the Spanish ancient cartography that we have built, introduces new approaches to the documents within the traditional ones of the librarians [5]. By supporting the points of view provided by an interdisciplinary team of searchers, the old formats have turned into new ones that bring together both scientific and technical approaches to the history of cartography with humanistic and historical methodologies. The e-Library tries to gather together and synthesize disparate fields through a clearly articulated focus on digital technology in the context of Cultural Heritage.

Our project of a digital cartographic database accessed through GIS is related to, but distinctive from the history of cartography, and looks for the integration

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of digital technologies with the cartographic heritage providing new approaches to, and new audiences for the history of cartography.

We have designed a methodology that applies all those digital technologies to the history of cartography and helps to establish new relationships, provides an easy access to images to make analysis and comparisons, shows the map distribution on the different archives, and finally allows to reconstruct the historical landscapes and the history of the territory through old maps. This is one the main targets of our project, but the final one is to spread the old cartographic treasures that compose a relevant part of the Spanish cultural heritage, that actually remains unknown to the public and even to a great number of specialists [6] [7].

Briefly we can expose our main targets as follows:

- To spread and relate the contents of the various Spanish archives to provide the study of the old maps and plans giving a broad overall view, to be applied to the deep study of the historical evolution of the territory and the landscape at different scales.
- To enlarge the available information about the ancient cartographic documents, not only through the metadata of each image, but also with other contents that are located in particular or non digitised collections.
- To enlarge the possibilities of the traditional searches on the databases through the queries that are useful through the GIS tools, that include issues as metric and geometric accuracy.
- To use the new technologies to study and diffuse the cartographic heritage through Internet.
- To explore new visualisation methods, tools and algorithms, the multiple view techniques (including multiform views and multiple representations) as well as dynamic and rapid interactive visualization techniques, and the use of coordinated views, tight coupling or linked views.
- To search for data transformation and re-expression for exploratory visualization.

2.1. The context

The First International Workshop on Digital Approaches to Cartographic Heritage hold in Thessaloniki, May 18-19. 2006 [8] has been the inaugural meeting of the near-eponymous ICA Working Group. Founded in La Coruña in July 2005, it complements the Working Group on the History of Colonial Cartography, as well as the five existing ICA Commissions named:

- Maps and the Internet.
- Theoretical cartography.
- Education and training.
- Map projections.
- Visualisation and virtual environments.

In Spain, the interdisciplinary Working Group on Cartographic Heritage (GTI PC-IDE) in the SDI (Spatial Data Infrastructures), inside the Comisión Especializada en Infraestructuras de Datos Espaciales (CE IDE) of the Consejo Superior Geográfico, aims to promote the publication of historical geographic documents through the SDI.

This Working Group is composed by several members of the IBERCARTO Working Group of Spanish and Portuguese Map Libraries, whose first meeting was recently hold in the Institut Cartogràfic de Catalunya in Barcelona, June 25. 2008.

Among its main targets are:

- The publication of geographical and historical data and documents & metadata and registers in Internet, through the SDI strategy, searching the interchange among the MARC format and the metadata format ISO 19115.
- The optimisation of the Web services of localisation, visualisation, downloading, transformation and geoprocessing.
- The data and documents generation (with the associated metadata).
- The client applications that allow the use of this services.
- And the provision of a general framework.

Also in Spain the AVANZA plan for the development of the Information Society has started a first digitisation and online publishing programme for the 2006-2010 period, in accordance with the national standards in an OAI-PHM protocol compatible system.

Although the main Spanish cultural offices are making a strong effort to digitise the public collections of historical documents, that at the beginning of 2006 included 109 collections of Spanish libraries, the particular case of ancient maps carries up problems such as those posed by the different locations, techniques, sizes and preservation conditions, as well as the high costs that are delaying the prompt achievement of their diffusion. And we have to mention another problem associated to the difficulties of finding those maps, because they are frequently included into other documents or inside bundles of old papers, and remain yet undiscovered.

Among those important initiatives we will emphasize the digital libraries created by the Institut Cartogràfic de Catalunya [9], the Instituto Geográfico Nacional and those of the Portal de Archivos Españoles (PARES) that is participating in the MICHAEL project; they not only show free low-resolution images of each map, but provide an accurate description of the document and the conditions of use.

2.2. The use of the new technologies

The digital technologies were formerly used by other disciplines (archaeology and historical geography) and had practical non-academic applications (town planning, librarianship).

Among the possibilities of the digital images, the new computerized methods and digital technologies have brought an explosion of the scope and potential of the digital cartography, allowing and encouraging the interaction with early maps with the aim of furthering our understanding of their content in all its aspects. But they also introduce new ways of connecting early maps with other kinds of information, inviting us to use new forms of presentation and making easy a speedier transmission of images the world over. This is particularly interesting for the creation of the European Space of Information.

On the other hand, the digital cartography is not a loss, but a useful tool in the traditional scholar research [10]; but it must remain as a central theme of discussion the ways in which the digital technologies may be of particular value to historians of cartography, deepening on subjects as:

- How digital technologies are already providing access to early maps (and related materials) through a range of methods, including: improved reproduction, electronic facsimiles, websites, new forms of presentation and integration, and new forms of digital preservation and archiving (for instance, by using photogrammetric techniques in seaming together images of large maps to create more authentic facsimiles), dynamically integrating maps with other information using the web, applying new ways of visualising and presenting early mapping, and associating new metadata as structured summary information about a cartographic source to encode data on and about historical maps.
- The digital technologies that are allowing new ways of understanding the content of early maps, allowing the digital analysis of map geometry and the use of digital transparency techniques focused on the cartometric analysis of early maps, the reassessment of the projections used in 15th and 16th centuries nautical charts, based on a study of navigational practices, technologies and texts, or the use of precise methods and mathematics behind the transformations of old maps in various geo-referencing projects.
- How digital technologies and particularly Geographic Information Systems (GIS) are allowing new ways of integrating early maps with other information making the 3-D visualisation more accessible, realistic and impressive, or combining historical maps and associated textual and numerical information to get a spatial analysis of agricultural productivity and its relationship with the landowners through integrating cadastral and statistical information; two examples can be quotated: the *Gregoriano Cadastre* [11] and the old cadastral maps of Utrecht [12], both focused on a deep knowledge of the reconstruction of the old properties.

Finally, the spatial portal or geoportal is designed with the aim of being a website access to the cartographic documents not only for searchers, but also to the whole society. It provides different functionalities and search tools that are useful to manage the datasets about the ancient cartography, to get spatial information and to ease online approaches to the geo-knowledge.

3. The cartographic databases

The design of a Digital Map Library (DML) must consider some particularities about its specific contents and the great variety of potential users.

The usability principle and the application of clear search and browsing functionalities must help to spread this essential part of the cultural heritage.

3.1. The classification of the ancient cartographic documents

To define the contents of our cartographic database we have decided to apply the ICA's Working Group broad definition of cartographic heritage as "anything of cultural value inherited from maps and accessible to a broad public community", as well as the wide sense concept of a cartographic document of Harvey [13] and Harley and Woodward [14] that includes all kinds of maps, plans and charts at different scales (architectural, urban and territorial scales), as well as pictures and bird's-eye views [15] [16], with no restrictions due to techniques, functions or origins.

Ancient cartography, as well as old pictures, drawings and photographs, has not been used traditionally as a reliable source of information about the history and the evolution of the land- and the townscape. Those graphic materials have been usually considered as 'second order' documents, mainly because of the difficulties that their interpretation can sometimes involve [17] due to the different conventions that are applied in each case by the cartographer. Nowadays the "digital cartography and the history of cartography are not yet comfortable bedfellows" [18].

But this is not the only reason why cartography is so seldom used in the historical searches, because there are other problems related to the difficulties of their localisation and visualisation that have to be considered.

Obviously, it is not easy to access to an original big size and small-scale map that is sometimes composed by several printed sheets; and it is also complicated to see properly the symbols employed in the map and read its texts when it is imposed to handle a reduced hardcopy or a low resolution digital image.

3.1.1. International standards about catalogues as the ISO Norm 23950 and the Open Archive Initiative (OAI), are well defined and use similar data collecting procedures. As we are members of the above mentioned interdisciplinary Working Group on Cartographic Heritage (GTI PC-IDE) in the SDI (Spatial Data

Infrastructures), we are applying an interchange among the MARC format and the metadata format ISO 19115.

3.1.2. Catalogues and metadata. Although we find it is not essential to have an exhaustive knowledge of the context of each map to get a meaningful interpretation of it [19] [20], it is necessary to achieve some basic specific concepts on the theory of the cartographic expression and design (about map projections, symbols or representation of relief, for instance), because the lack of them can difficult the right interpretation of the document and twist the results of the investigations [21]. For this reason we provide for each document both the archivist contents and the metadata

3.2. Contents and structure

As we must also restrict the temporal and the geographical subject of the contents of the cartographic databases, we firstly decided to include all the historic documents that have been drawn before 1900, mainly because along the 20th century the cartographic production and techniques have very much increased in many senses and its study should be carried separately. Secondly, the spatial restriction has been imposed to the search and we decided that the cartographic database should concern the actual Spanish territories.

Assuming all those circumstances, the former stages of our search are focused on finding, studying and cataloguing all kind of cartographic documents that are preserved in the main Spanish collections, archives and libraries as the Biblioteca Nacional de España (Madrid), Biblioteca del Palacio Real (Madrid), Biblioteca del Monasterio de El Escorial (Madrid), Biblioteca de la Universidad de Barcelona, Biblioteca de la Universidad de Salamanca, Real Academia de la Historia (Madrid), Real Academia de Bellas Artes de San Fernando (Madrid), Archivo Histórico Nacional (Madrid), Archivo General de Simancas (Valladolid), Archivo de la Real Chancillería (Valladolid), Archivo del Centro Geográfico del Ejército (Madrid), Instituto de Historia y Cultura Militar (Madrid), Instituto Geográfico Nacional (Madrid), Museo Naval (Madrid) and Archivo de Viso del Marqués (Ciudad Real) among many others, as well as in local and ecclesiastical archives.

The next step was to construct the relational databases over a commercial compatible platform. They have been designed as multilingual (there is already an English and a Spanish version) and open ones to allow including new registers in the future and even adding new fields or tables, to update the contents to the new needs without damaging the existing ones. Moreover the concept 'relational' implies the possibility of crossing the data of the different tables and reducing their weights, making easier the data management and the queries.

According to this, our methodology includes three main tables, that are the following:

- 'Cartography', that contents all the registers concerning the cartographic documents and follows the ISBD Norms of cataloguing.
- 'Bibliography', that includes the complete bibliographical references that appear in the field *Bibliography* of the table 'Cartography'.
- 'Libraries, Archives and Map Collections', is the table that includes the complete references of the collections that have been visited, and that appear just as an acronym in both *Collection* and *Signature* fields of the table 'Cartography'.

The three tables have been designed sharing at least one field that allows crossing the data files and economizes data length in the databases.

3.2.1. The table 'Cartography' joins both the descriptive and the technical data about each document, joining the perspectives of the historian and the cartographer. The items that have been included are the following:

- *Place or Subject* (text field): Refers to the geographical place that is represented in the document and the province it belonged to, since the reform of 1831. To define clearly the territorial limits, the old councils or boundaries are also included. And to determine the original uses of the map, it is also specified if it is a general, thematic (geological, military, statistic, cadastral, etc.) or a topographical map or plan.
- *Date* (numerical field): as precise as the document can be dated. If it is only an approximated date, it is quoted among square brackets.
- *Kind of Cartographic Document* (text field): it defines if it is a map or plan, a chart, a portolan or a view, or even a terrestrial globe.
- *Size* (text): width and height of the image in mm; it is also included the total size of the sheet(s) (or other supporting materials) and the number of pieces or sheets that compose the ensemble of the document.
- *Collection* and *Signature* (text): the collection that preserves the document and the signature; the first one is quoted through an acronym and the second one is abbreviated according to the norms (its total extension can be consulted in the table 'Libraries, Archives and Museums'); if possible, it includes the link to other e-libraries or references.
- *Original Title* (text): quoted among inverted commas if it is literal, as it is written in the document; otherwise it is defined among square brackets through its main features.
- *Author(s)* (text): names of the author(s) if the map is signed; in case of ascription, the name(s) appear among square brackets; they can be also 'unknown'.
- *Scale* (text): it is defined graphically or as a fraction, detailing the different units employed; when there is no definition scale, appears 'without scale'.

- *Projection* (text): details the projection employed with its different elements: grid, references, orientation; it is also referenced the use of different projections, for instance profile or section added, axonometric or perspective views, with their own distinctive elements, and even the case of large scale plans.
- *Technique* (text): makes a distinction between manuscripts and printed maps, as well as the drawing surfaces and techniques, specifying the uses of color.
- *Short History* (of the map, text): place of edition, editor, or if it is a part of a big compilation or atlas. It is also mentioned where it comes from or the precedent owners, and the date of purchasing.
- *References* (of the map, text): abbreviated and following the international system for scientific quotations ISO 690-1987.
- *Image* (object/container field): it is included a low resolution raster image in highly compressed jpg format of the cartographic document. By clicking on the image, it is possible to display a high resolution one in a *tiff* format that allows to see the details and to read the texts. If the map is composed by several sheets, it is possible to see each one separately (and to compose it apart) (see below, *The GIS implementation*).
- *Other Remarks* (text): in the case of a printed map, includes other collections that have a copy, or variations of the plate, as well as manuscript notes, etc.
- *Date* (of the catalogue, aut.).
- *Operator* (for future updates).

3.2.2. The table 'References' defines completely the abbreviations and acronyms used in the other tables. The quotations follow the ISO 690-1987 Norm. The fields are in this case:

- *Author(s)* (text).
- *Date* (of edition, numerical).
- *Title* (of the book, text).
- *Article's Title* (text).
- *Periodical or Book* (in case of articles or book chapters, text or link).
- *Publisher* (text).
- *Place* (text).
- *Volume* (numerical).
- *Pages* (text).
- *Quotation* (text): as it appears in the other tables.

3.2.3. The table 'Libraries, Archives and Map Collections' makes possible to identify the acronyms used in the *Collection and Signature* field. It contains the following fields that complete the location of the documents:

- *Library (Abbreviation)* (text).
- *Collection (Extended Name)* (text).

3.3. Digitisation and preservation

3.3.1. Digitisation. Sometimes digitisation has been primarily used to preserve the existing original and analogue materials (that can be degrading), but digitisation and preservation are strongly interrelated and therefore have to be considered together. Specially in case of rare works (as several maps are), consultation of the digital copy can replace the physical manipulation of the original, which will add to its longevity.

The risk of losing digital material has been taken in account in our digitisation programme, because digitisation without a proper preservation strategy may become a wasted investment.

Some technical specifications about digitisation that have been used in the project are the following:

- The name of the image files: FFFXX_NNNNNNNN_T.EXT, where:
  - FFF: Archive ID, max. length 5 characters; provided by each archive.
  - XX: Internal ID of the collection; length 2 characters.
  - NNNNNNNN: File ID that includes a geographical reference (province); variable length from 1 to 20 characters, from A to Z or from a to z, without accent, includes (-) but not the rest of characters including (_), that is used to separate the different ID groups of the image.
  - T: image format on screen: V = illustration, T = 1/3 screen, P = full screen, 2 = high definition (2.000 x 3.000 pixels), 4 = high definition 4.000 x 6.000 pixels, H = high definition (more than 4.000 x 6.000 pixels).
  - EXT: extension of the format: JPG, GIF, TIFF, PCD…

Example for an image of the Biblioteca Nacional de España, BNEM_002348CR_V.jpg

- Image formats: open formats based upon norms and standards whose specifications are public. We have only considered both formats of preservation and diffusion when images are born digital material in the University of Alcalá, and can be diffused in a high definition version because there are no copyright problems. We always indicate the file format, including the version (for example, TIFF version 6).
- Image file metadata: is a dataset that informs about other data in order to support their search, management and preservation (Dublin Core Norm). They can be descriptive (Subject, Description, Author, etc.), technical (Format, Digitisation options, etc.) and administrative (Copyright, etc.). There are two possibilities of relating the metadata and the image file that are the external storage or the inclusion of the metadata in the file. We have decided to

combine them by maintaining the essential metadata (as are the image ID, Title, Archive and Date of digitisation) inside the digital file, while the rest of the metadata are stored in other external databases.

- Storage supports and infrastructure: we have chosen the optical devices because of their capacity, durability, reliability, accessibility, volume, stability, and cost, among other qualities.

3.3.2. Preserving digital content. A digital copy of a document does not necessarily guarantee its long-term survival: all digital material has to be maintained in order to keep it available for use.

The main causes for the loss of digital content are the succession of generations of hardware that can render files unreadable (although the solution is the development of systems capable of accessing the disks using emulation techniques), the rapid succession and obsolescence of computer programmes and the limited lifetime of digital storage devices. Unless data are migrated to current programs or care is taken to preserve the original source code, retrieval of information may become very costly, if not impossible. This is specially hard for the 'closed' data formats (those whose source code is not publicly known), that we have avoided.

That is why we have decided to use simultaneously two platforms (PC and Mac) and compatible software for both, as well as open systems, always according to the PREMIS (Preservation Metadata for Digital Materials) Working Group Report (version 2.0).

4. The GIS implementation

The open vector GIS is supported by a commercial platform (GeoGraphics©) that includes a complete and easy to use computer-aided mapping module in a vector format (MicroStation©) and that is a standard with the maximal compatibility, although the connection with the database (ACCESS©, FileMaker©) must be established through an ODBC protocol.

We have tried some other possible GIS platforms that:

- Integrated both the databases and the computer-aided mapping (ArcInfo©).
- Or imported the cartography in and exchange and export format such as the *dxf* (MapInfo©).

The fist one were the most complete of all, but the databases were not so easy to manage and it was sometimes difficult to make changes in their structures. The second group of GIS platforms allows an easy and flexible management of the databases, but the problems appear as the cartographic base must be imported, because the exchange formats always suppose a flaw of the information and the integrity of the graphic elements that leads to a hasty process of validation of the digital vectorial cartography [22] [23].

4.1. The cartographic base

The possibility of drawing our own vector cartography inside the GIS not only avoids the problems derived from the import of graphic files through the *dxf* format, but allows an easy definition of the base maps, that only need to make a clear definition of the graphic features that must be digitised and of the strategies that must be followed to compose the base maps.

We have decided not to use the existing digital cartography that is available because it would suppose a hard process to clean, verify and structure it topologically. We found it would be harder to extract and add the features that were interesting to our GIS in the existing cartography, that to draw a new one specifically designed for it.

The new cartographic base has been structured in data layers and sheets at a 1:200.000 scale, and we have selected the graphic formats, the georeference and the symbolism according to:

- The guidelines of the Instituto Geográfico Nacional of Spain, that ensures a proper understanding of both topographic and planimetric data as well as an easy connection to other existing or future GIS.
- The use of visual attributes such as color, texture, orientation and shape in information visualisation (infovis) to convey the proper information in maps [24].
- The attributes of shape through the study of its component dimensions and the cognitive underpinnings that support the suitable use of shape for categoric, quantitative or other kind of data [25].

4.2. The connection to the data bases

Due to the election we made of the GIS platform, the connection of both cartographic, graphic and attribute data storages is made through an ODBC protocol.

Both ACCESS© and FileMaker© are easy to handle and don't require any to give a special training to the operators, but the first one makes 'heavier' databases than the second one, and this is a disadvantage when managing big amounts of data, as we do. FileMaker brings also another important advantage, because the fields of the tables are not limited to 256 characters, and this allows to introduce more information if required.

Each ancient map is referred to a point, a line or a centroid, depending on the territory they represent. Points are used generally in town plans or views; lines are used fundamentally to identify roads, railways and other lineal structures. Centroids are mainly used to identify the maps that represent the different territories.

Obviously, a single centroid can be related to more than a map, and the different possibilities are simultaneously shown in a first screen; afterwards the different documents can be chosen separately.

On the other hand, the contours of the different documents are drawn and referred to their own centroids:

then it is quite easy to see the way the maps and plan overlap each other, what allows to perceive rapidly the portions of land that are covered by different maps and which are the historical periods when they have focused the attention due to different targets.

As it is shown, we have implemented three main kind of datasets: the cartographic base, the tables that contain the features that we have considered as relevant to define each ancient map, and the sets of images, that are divided in high and low-resolution images of the map.

The datasets of the ancient maps include already more than 4.000 files, that are continuously being updated and distributed in the servers by geographical units.

4.3. Searches and queries

Our methodology has increased the possibilities of the usual queries that a GIS brings, just formulating them to the different databases separately or even crossing them; but to ensure the proper display of the cartographical information we have designed a filling card as one of the main printable output ways.

They allow to get the main standard information of the maps and bring a direct access to the low resolution image sets, to prevent problems on handling the different tables if they become too 'heavy'.

Only in the exceptional cases that the copyright owner allows it, the high resolution images are available. This system and structure has been the most useful and fits with the strategies that we have previously planned to get the most varied and personalized information of the GIS.

Obviously, traditional outputs as thematic mapping, statistics, lists or reports are also available [26] [27].

5. The online accessibility and diffusion

Nowadays the web-based digital resources are quite frequent as a way to preserve and diffuse the cartographic heritage as well as to access to the modern cartography [28] [29].

Previous experiences as the one implemented on the Greek region of Macedonia [30] or the GIS-Dufour [31] have shown the potential of GIS and its accessibility through the web.

Under current EU-law and international agreements, material resulting from digitisation can only be made available online if it is in the public domain (in a narrow sense, refers to information resources which can be freely accessed and used by all, for example because copyrights have expired) or with the explicit consent of the right holders. The transparency and clarification of the copyright status of works is very relevant to us.

As a matter of fact, our digital library is in principle focused on public domain material, and as digital preservation implies copying and migration, it has always been considered in the light of IPR legislation [32]: the digitised funds of other libraries are precisely quoted and respect the conditions that have been established for consulting the documents by the right holders; and we must neither set other supplementary caution that restrict the access to the different data sets, nor establish different access levels.

5.1. The geoportal

Geoportals are websites that enable the access to several resources related to geoinformation.

Attending to the map resources that must be accessed, our spatial portal gathers the characteristics of both catalogue and application portals [33], by combining the variety and potentiality of catalogue services and the efficient access of the application portals.

The catalogue option creates and maintains indexes or catalogues that allow to make searches based on some metadata parameters. The application option provides efficient access to the datasets according to the user needs, and are structured in User Interfaces that can guide them to the special services they need.

Conclusions

According to the initiative of the Council of the European Union about the European Digital Libraries as a common multilingual access point to Europe's digital cultural heritage, and considering the ancient maps and plans as important cultural materials, we have developed an innovative GIS based methodology in ancient cartographic documents, whose essential values are:

- To create new cartographic relational, multiformat and multilingual databases that organise and unify the information that different archives and libraries have elaborated about their different funds, as well as to incorporate the dispersed and unknown documents that belong to non-digitised collections. This new information follows the ISBD Norm, and joins and completes the different approaches of the librarian, the historian [34] and the more technical of the cartographer.
    - The new databases join both already digitised materials and new information that we have directly produced in a digital format. These circumstances allowed us to get some mechanisms that facilitate the digitalisation of maps, to identify problems and to monitor bottle-necks (as those that appear handling big size maps).
    - They allow also to preserve the original materials, that are usually fragile.
- The open GIS surpasses the usual operability of the traditional multiformat databases as it enlarges through the queries the way to access to the different kind of data. But we have also disposed a new and personalised way to access to high resolution digital images of the documents by applying the hypermedia concept.

- Our methodology provides an easy and successful electronic integration of metadata and text, graphics and numerical information about early maps.
- On-line accessibility and diffusion through the Internet, as a response to a real demand among citizens and within the research community, always paying attention to the full respect to the international legislation in the field of intellectual property.
- This new methodology has been created aiming to be an open one that allows being implemented in all countries of the European Union.

The essential challenges that we have undertaken during the development of the project were:

A/ Those that have impacted the pace and efficiency of digitisation:

- The financial challenges: because digitisation is labour-intensive and costly, and as it is impossible to digitise all relevant material, choices have to be made on what is to be digitised and when.
- Organisational challenges: a 'digitise once, distribute widely' strategy benefits all the organisations involved in digitisation projects; in this sense, ours not only shows the duplicate maps in the different collections, but allows to find the various stages of the plates, following the history of the different prints and editions of a map or the collections, and their origins.
- Technical challenges: we have tried to improve digitisation techniques in order to make digitisation cost-efficient and affordable. To digitise the non-digitised funds we apply both the contact scanning and the non-contact photographic methods [35], trying to minimize the distortion problems by digitising each sheet separately, although this process can not eliminate other problems in the final assemblage of the mosaic image.
- Legal challenges: digitisation presupposes making a copy, which can be problematic in view of intellectual property rights (IPR). We have considered the Directive 2001/29/EC on the harmonisation of certain aspects of copyright and related rights in the information society (European Parliament and Council directive of 22 May 2001, OJ L 167, 22.6.2001, p. 10), that foresees an exception for specific acts of reproduction by publicly accessible libraries, educational establishments, museums or archives. The maps that are yet unpublished or remain unknown (for instance, those of the private collectors) if there is any legal obstacle that allows them to be shown, we offer a link to a high resolution image 1:1 that makes possible to see every detail and to read every name to analyse it properly.

B/ The basic challenges that we have found for digital preservation are:

- The financial challenges: the real costs of long-term digital preservation are not clear yet and depend on storage costs, the number of migrations needed over time, including the efforts necessary to check the integrity of the digital object after migration. Once again choices have to be made as to which material should be preserved (according to the archival or historical value, use, etc.).
- Organisational challenges: an added value can be found in ensuring complementarities and an exchange of good practices.

C/ Technical challenges:

- How to preserve the content so that it can be accessed, trusted and reused in the future, and how to preserve high volumes of rapidly changing distributed information, and how to develop tools, methods and technologies to preserve dynamic content (that changes as a result of user interactions or adding new data), tools for automatic analysis and indexing, and optimisation of GIS tools.
- To improve its cost-efficiency and affordability.

D/ Legal challenges: the traditional model of library services is not easily transferred to the digital environment, and as digital preservation depends on copying and migration we have introduced a set of new issues as:

- The introduction of technological protection measures to prevent copying.
- We are already studying the possibility of setting a digital rights management system restricting the access to digital material, with the aim to ensure that IPR mechanisms maintain a balance between enabling access and use while respecting the rights of the creators.

As a final conclusion, we can state that the pilot experience about the Spanish ancient cartography accessible through an open GIS and diffused through Internet that we present is a successful example of the full application of the methodology in all its stages.

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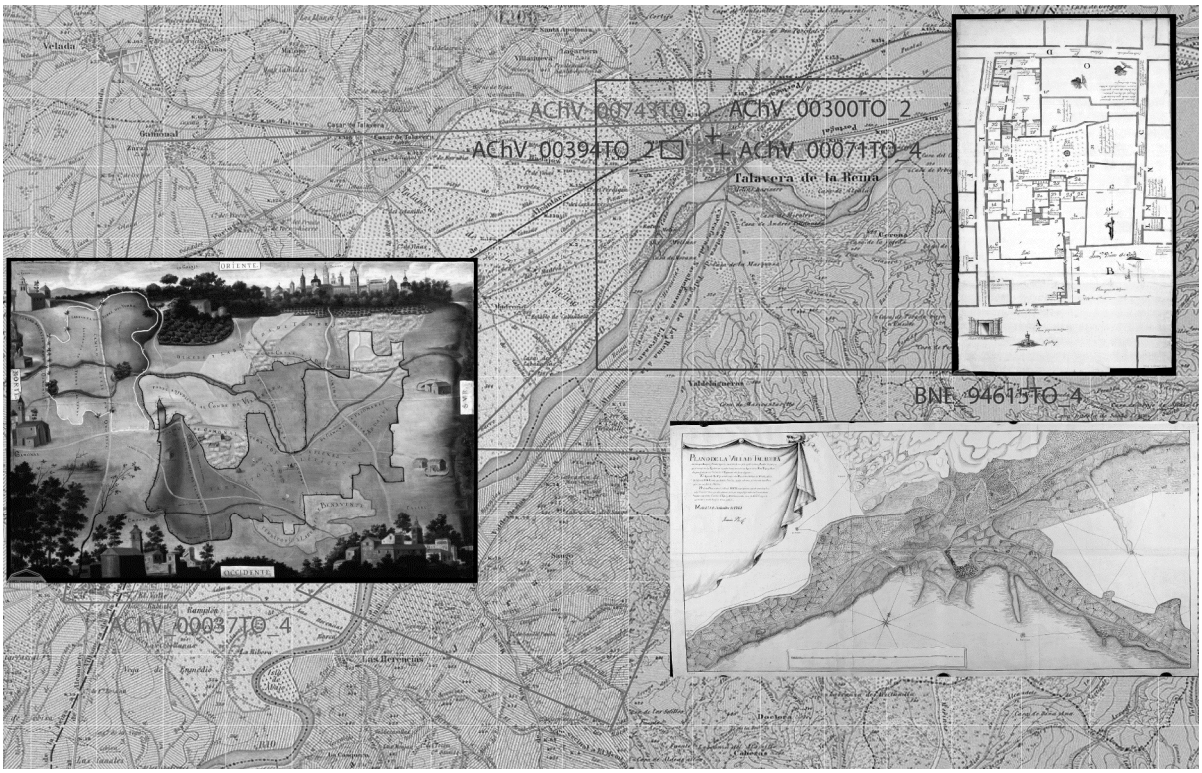

Figure 1 A detail of the cartographic base of the GIS, showing the different areas covered by some ancient maps. In light grey: 17th century maps; in dark grey, 18th century maps. As a background is reproduced a composed map of the same areas dating from the second half of the 19th century. It is taken from the First Series Mapa Topográfico Nacional 1:50.000, from the sets in the Instituto Geográfico Nacional, Madrid. Reference grid, 1° latitude and 1° longitud