
Web Map Services publishing Ancient Maps. Merging past and new technologies

Keywords: Web Map Service, Web Map Tile Service, cartographic heritage, first editions, orthophoto, historic PNOA, National Geographic Institute, ancient cartography

Summary: The Geographic Information National Centre (CNIG in Spanish) carries out two projects in collaboration with the Map Library and the Department of Territory Observation of the National Geographic Institute (IGN in Spanish) working to publish different and interesting resources of our cartographic heritage. The access to the already published resources can be done in different ways: through the CNIG download centre, via Web Map Services (WMSs), Web Map Tile Services (WMTSs) or through web clients of the IGN, published by the CNIG. These ad-hoc tools have been created taking as a basis the requirements and needs reported by users.

The monitoring of these pages and services has shown that, despite not belonging to any INSPIRE theme, the ancient cartography has a great acceptance among different types of users (individuals, companies, universities, National Administration…).

With this motivation we have been working adding new layers to the visualization services of ancient cartography and orthophotos during last months.

This communication presents the updating carried out in the services and their implementation in the IGN viewers, to bring to the users the possibility of watching and knowing this heritage.

Introduction

The Map Library and the Topographic Archive guard the ancient cartographic and documentary collections of the National Geographical Institute (IGN in Spanish). The Map Library manages a collection of printed maps from the sixteenth century to the present, which includes: maps made by the IGN, old maps, thematic maps, population maps... The Topographic Archive is responsible for the documents generated in the cartographic production processes carried out by the IGN and its predecessor organizations, generally handwritten documentation.

Likewise, the Department of Territory Observation of the IGN has stored the different photogrammetric flights that have been made in Spain since 1956 to the present.

In the same way, the Photo Library preserves the negatives of flights made throughout the twentieth century by a set of a variety of entities, as the Army Map Service of EE. UU. or the Spanish Ministry of Agriculture.

Thanks to the new technologies, these huge repositories of information can be made accessible to the public through Web Map Services and/or Web Map Tile Services, implemented by the Geographic Information National Center (CNIG in Spanish).

The Web Map Services (WMSs) and the Web Map Tile Services (WMTSs) are tools of great
utility, both for the users and producers of geographic information since they allow the publication, visualization and consultation of the data by means of a standard protocol defined by the Open Geospatial Consortium (OGC, 2012) that allows to visualize the geographic information through the Internet, overlap it with other maps from other sources and consult its associated attributes.

The data policy determined by the IGN is based on Ministerial Order FOM/2807/2015 of December 18th, which states: article 4: “The use of the digital geographic data products of the IGN will be open and free, provided that the origin and ownership of the data is mentioned, with the scope and form that authorizes the corresponding use license”. This restriction is compatible with the Creative Commons Attribution license, version 4.0.

Map Library

The creation of web services of ancient maps, which began in 2008 with the publication of the First Edition of the National Topographic Map 1:50,000, emerges from the need of the Map Library to publish different resources of the cartographic heritage which are of interest to the user, so that can be consulted from the web.

The data has been scanned and georeferenced by the Map Library team and subsequently the CNIG is responsible for its publication through viewing and downloading services. The available information, which is summarized below, is offered in three different ways: Web Map/Map Tile Services, comparison and visualization online tools and direct download through the Download Center (http://centrodescargas.cnig.es/CentroDescargas/index.jsp).

The following lines describe the data from which WMS/WMTS services have been created.

The service of Hojas Kilométricas (HK) offers topographic maps of cadastral nature at a scale of 1:2,000 generated between 1861 and 1870 by the General Board of Statistics, predecessor body of the IGN. It was intended to cover all Spain, but the project was interrupted and only the territory of the Metropolitan Area of Madrid was mapped. Associated to the HK are the Cedulas Catastrales (CC), literal and graphic information of each of the plots represented in the HK (Figure 1).

![Figure 1. Aranjuez, Madrid. Hojas Kiometricas.](image-url)
Planimetrias holds a layer that shows the manuscript plans of the Spanish municipalities. They were made between 1870 and 1950. They are works prior to the completion of the National Topographic Map 1:50,000, in some cases with several decades of difference between these works and the sheet of the area. They are handwritten maps that were made for each municipal term, between the years 1870 and 1950, from measurements on the ground. These measurements are collected in the field notebooks kept in the Topographic Archive of the IGN. These maps were prepared at a scale of 1:25,000 and contains planimetric information such as: transport network, hydrography, populations, cultivation masses of more than 10 ha, boundary lines of municipal boundaries and landmarks that indicates the boundary line described in the demarcation certificates (Figure 2).

Figure 2. Toledo, Toledo. Minutas Cartograficas.

The Primeras Ediciones del Mapa Topografico Nacional (MTN) service allows to visualize:

- The first edition of the MTN, a work that began in 1875 and ended in 1968, divided Spain into 1109 sheets at a scale of 1:50,000. It is the first complete map of Spain supported by a geodesic and leveling networks. Between 1870 and 1940 the work were carried out entirely by classical topography. However, as photogrammetry progressed, this technique was incorporated into the cartographic process.
- The MTN Minutas were used in the technical process of photomechanical reproduction of the map sheets 1:50,000, between the years 1915 to 1960. All the planimetric and altimetric information that covered the MTN 50,000 sheet that was printed was drawn before at 1:25,000 scale.
- The first edition of the MTN at scale 1:25,000, began to be created in 1975 and ended in 2003. It is composed of 4123 sheets.
The WMS service of *Planos Historicos de Madrid* is composed of seven layers. Each one of these layers is a representation of Madrid at a specific time and resolution, with a different purpose.

- Plano de Mancelli de Madrid, 1622 (scale 1:4,500).
- Plano de la Villa de Madrid made by Pedro Teixeira in 1656 (1:1,850).
- Plano topographico de la Villa y Corte de Madrid made by Espinosa de los Monteros in 1769 (1:1,900).
- Plano de Nicolás Chalmadrier, 1761 (1:3,600).
- Plano Geométrico de Madrid, made by Tomás López in 1785 (1:5,500).
- Plano de Madrid, created by Madóz y Coello in 1848 (1:5,000).
- Plano Parcelario from Ibáñez Íbero, executed in 1875 (1:2,000).
- Plano de Facundo Cañada, 1900 (1:7,500).
- Plano de Nuñez Granés, 1911 (1:10,000).
- Mapa de Madrid completed by the Town hall in 1929 (1:2,000).
- Mapa Parcelario of Madrid, 1940-1950 (1:1,000).

**Territorial Observation**

The first photographic flights in Spain date from 1920 and were made by the Hydrographic Confederations and the Provincial Councils. But it is in the mid-twentieth century when the use of this type of flight intensify, especially for creating and updating the Spanish Cadastre.

The total number of frames stored by administrations is unknown, only in the IGN there are more than 420,000 negatives, of which 120,668 are in digital format (Martinez Luceño, 2016).

The WMS service of *Ortofotografia Historica* is composed of six layers. Each of these layers correspond to a different project of aerial photography on the territory.

- American flight, B series. Made between 1956 and 1957, is the second flight of three, carry through by the Army Map Service of the Armed Forces of the United States in collaboration.
• Interministerial flight. Reports date this work, carried out by the CSG, between 1976 and 1986. The flight coordinated different cartographic agencies, with the goal of obtaining the most possible benefit.

• National flight. An agreement between representatives of several ministries, decided to carry out this flight with a scale of 1:18,000. The assignments were carried out between 1981 and 1983.

• OLSTAT flight. The Ministry of Agriculture made this flight over the olive provinces between 1997 and 1998. It was caused by the interest of the European Union in accounting the number of olive trees in the Spanish territory for better control of community aid.

• SIGPAC flight. It covers the entire Spanish territory and was carried out by the Ministry of Agriculture with the aim of serving as a reference for the Identification System for Agricultural Parcels (SIGPAC in Spanish acronym). The job was carried out between 1997 and 2003.

• PNOA flights. The National Plan of Aerial Orthophotography (PNOA in Spanish) contemplates the flight of the entire national surface, at least, every three years. Until the moment of the creation of this service in 2008, the previous flights data, of great value for the user, were not available. For the moment, the data included covers from 2004 to 2016.

Figure 4. Móstoles, Madrid. Diferentes ortofotos historicas.

**Spatial Data Infrastructure**

The IGN Spatial Data Infrastructure node was created with the intention of publishing its information interoperably and following the principles that the Inspire Directive would later establish in 2007. The CNIG publishes the geographic information of the IGN, in order to do it, it has its own servers and is in charge of its management and maintenance. These servers support both storage
and processing to the different services published online (Web Services Maps, portals, tools…).
To improve agility and service quality to the user, it also has an Amazon auto-escalable server, which users connect through.
The map web services created in the CNIG are supported by Open Source Software. Typically, MapServer is used for WMS raster data services and WCS. Vector WMS services, WMTS and WFS are usually implemented with GeoServer.
The tiling of the WMTS services is done with the GeoWebCache application of GeoServer.
All these implementation platforms of Web Map Services are hosted in Linux virtual machines and make use of the GDAL library.

**MapServer**

Installed on an Apache server, MapServer is an open source platform, developed at the University of Minnesota aiming to the publication of spatial data and interactive mapping applications to the web. It works on the main operating systems (Windows, Linux, Mac OS X).

**GeoServer**

GeoServer is a Java-based software server that allows users to view and edit geospatial data. It uses open standards established by the Open Geospatial Consortium (OGC).
Allows to create maps in a variety of output formats.
Incorporates several free libraries of integrated maps (such as OpenLayers).
GeoServer is built on Geotools, an open source Java GIS toolkit.
Operates on a Tomcat server.

**GeoWebCache**

GeoWebCache is a web application developed in java, enables to cache map tiles from diverse information sources.

**GDAL**

GDAL is a translator library for raster and vector geospatial data formats offered through an OGC open source license.
It has a raster data specification and a vector data specification for the supported formats.
Comes with a variety of command line tools for data processing and processing.

**Web Map Services**

The OpenGIS® service interface standard WMS provides a simple HTTP interface for making map requests (from one or more distributed geospatial databases) through GET requests. A WMS request defines the geographic layer or layers and the area of interest to be processed.
The standard defines three operations: one returns the service metadata (GetCapabilities); another returns a map (GetMap); and the last operation (optional) returns information about the selected elements on the map (GetFeatureInfo).
WMS requests (in URL form) can be done through a web tool or a GIS program.
Web Map Tile Services

The WMTS standard complements the WMS. It is focused on giving flexibility and speed to client's requests, allowing them to obtain the image they seek with greater caspacity. This is accomplished by pre-generating the images that will be displayed and storing them waiting for requests. The standard defines: GetCapabilities, GetTile and the optional GetFeatureInfo operations; established to obtain the service metadata, the map image or the information of a specific point, respectively. Like WMS services, WMTS services work through HTTP GET requests.

![Figure 5. Plaza de Oriente, Madrid, Madrid. Plano Parcelario de Pedro Texeira.](image)

Data digitalization

The data from the Map Library have been digitized by a professional scanner, at 400pp and georeferenced using GIS tools. For data generalizations (intended to larger scales), they are scanned at 254 pp. On the other hand, the data from Observation of the Territory Department, collected and stored by the different public organizations participating in the aerial photography projects, were in the negative form (obtained directly from the cameras). These negatives have been digitized by photogrammetric scanners and georeferenced using GIS tools. Because of the scarce availability of this type of machinery and the cost of the works, a large part of the available negatives have not yet been digitized.

Data store

Once digitized, the data must be migrated to the CNIG's publication servers. They are copied directly to the WMS servers or stored on an external disk that is referenced from the publishing servers, depending on the size of the data.

Web Map Service creation

The Hojas Kilometricas service was created with the GeoServer platform, the rest of the WMS were created with MapServer.
The definition of a service in the MapServer platform is encoded through a text file with .map extension with the definition of:

- At service level
  - extent
  - max size
  - reference coordinate system
  - units
  - background color
  - metadata
- at layer level (specify the configuration for each layer, in case they are not the same as the general ones of the service)
  - data type (raster, shapefile...)
  - data processing tools (MapServer offers various tools to process the data before loading them in the service: resampling, masking ...)
  - extent
  - reference coordinate system
  - default data style
  - metadata

When the information to be published is larger than 2 Gb, it is advisable to consider this procedure for publication:

- chop the data into more manageable files
- using the GDAL library, make a "tileindex" of those files (a tileindex is a shapefile format file that contains the contour of the geometry and the route to the referred data only, so it serves as a link to all the files chopped to show with a much smaller size)

It has sometimes been necessary to make generalizations or resampling of data at larger pixel sizes to facilitate rendering on small scales of visualization.

**Web Map Tile Service creation**

For the generation of WMTS historical data services, the GeoWebCache extension (integrated in the GeoServer platform) has been used.

The process consists of two well differentiated parts:

- WMTS layer creation
- Pre-caching or pre-generation of the tiles the service will offer

In GeoServer, the platform offers a web tool that is used to create and manage the layers to create.

![GeoServer web platform main page.](image)

Figure 6. GeoServer web platform main page.
Modifying and deleting layers is usually a sensitive issue working with GeoServer cached services, because the platform automatically discards and deletes the stored cache from the modified layer considering it as invalid. To avoid these problems, when working with cached layers, the process is performed with the tomcat server stopped. The XML configuration files created by GeoServer for the layers are edited by hand once the server is stopped.

To carry out the WMTS layers pre-caching, a development environment consisting of 15 servers is used. They are responsible for generating the images or tiles that the WMTS service will offer. These pre-caching tasks have been automated through a self-developed web tool that makes calls to the GeoServer in the 15 servers in which the service has been replicated, in order to generate and store the tiles before users request them. The tiles are stored on a disk shared by all the machines.

**Implementation**

The CNIG works in three different deployment environments, the SDI node is not an exception. Working in differentiated environments enables to offer a stable product to users, isolating the development of new utilities from the public services. All development, modification and improvement works of the services are carried out in a secure environment accessible only by the IGN SDI technicians. Once the new implementation is operational, it is verified that there is no failure in the service and that it responds as it should. Finally, the proven service is replicated in accessible servers for the general public. It should be noted that both the services and the original cache are kept in the private development machines. The tiles disks presented to the users are not more than copies of the ones in the isolated environment, that is why the new tiles created by users will only be available in the public environment.

**Advertising**

When the works of generation and publication of services are completed, they are disseminated. Services URLs are included in the directory of services of the Spatial Data Infrastructure of Spain, point of reference and consultation of all the services operational within the Spanish SDI nodes.
Through the IGN website and its social networks, a news item describing the new service, its usefulness and the URL for its use is disclosed.

**Results**

After the start-up of these projects, 5 WMS services and 2 WMTS services have been created, which are now available to be loaded and consulted by users.

The GetCapabilities petition to obtain the data of the WMS services are:

- **Hojas kilométricas:**
  http://www.ign.es/wms/hojas-kilometricas?request=GetCapabilities&service=WMS

- **Planimetrías:**
  http://www.ign.es/wms/minutas-cartograficas?request=GetCapabilities&service=WMS

- **Primeras ediciones del MTN:**
  http://www.ign.es/wms/primera-edicion-mtn?request=GetCapabilities&service=WMS

- **Planos históricos de Madrid:**
  http://www.ign.es/wms/plano-texeira?request=GetCapabilities&service=WMS

- **Ortofotos históricas:**
  http://www.ign.es/wms/pnoa-historico?request=GetCapabilities&service=WMS

To obtain the capabilities of the WMTS services:

- **Primeras ediciones del MTN:**
  http://www.ign.es/wmts/primera-edicion-mtn?request=GetCapabilities&service=WMTS

- **Planos históricos de Madrid:**
  http://www.ign.es/wmts/plano-texeira?request=GetCapabilities&service=WMTS

The use and requests received by these services have been monitored since its start-up. Table 1 shows the monthly average of use of the services in 2017.
Table 1. Use of the main ancient web services.

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>TYPE</th>
<th>UNIQUE VISITORS</th>
<th>VISITS</th>
<th>REQUESTS</th>
<th>DOWNLOAD (Gb)</th>
<th>WEB CLIENTS</th>
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<td><a href="http://signa.ign.es/signa/">http://signa.ign.es/signa/</a></td>
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<tr>
<td>Primeras Ediciones del MTN</td>
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<td>4,294</td>
<td>7,605</td>
<td>1,325,209</td>
<td>193,00</td>
<td><a href="http://ideextremadura.com/IDEEXVisor/">http://ideextremadura.com/IDEEXVisor/</a></td>
</tr>
</tbody>
</table>
|                                |      |                 |        |           |               | http://mapadebolsillo.com/visor-de-los-mapas-manuscritos-minutas-del-ign-para-realizar-la-cartografia/  
|                                |      |                 |        |           |               | http://javier.jimenezshaw.com/mapas/mapas.html                             |
| Ortofotos Históricas           | WMS  | 18,092          | 34,118 | 3,801,796 | 676,05        | http://mapadebolsillo.com/visor-de-ortofotos-aereas-de-espana-en-distintos-anos/  
|                                |      |                 |        |           |               | http://mapa_gis.com/                                                      |
|                                |      |                 |        |           |               | http://mapa_gis.com/                                                      |
| Planos Históricos de Madrid    | WMTS | 491             | 957    | 78,843    | 8,68          | http://www.ign.es/iberpix2/visor/                                         |
|                                |      |                 |        |           |               | http://mapa_gis.com/                                                      |
Added value is given to services by showing them in web tools and viewers (both IGN and external developments):

- Old maps comparator
  http://www.ign.es/web/mapasantiguos/#map=5/-1669792.36/4163881.14/0
- IGN digital photo library
  https://fototeca.cnig.es/

Figure 8. Digital photo library visualizator.

Conclusion

The publication of Web Map Services of Ancient Maps are very popular among users, its usage statistics proof this.

It has been proven that those services are used by Public Administrations, Universities, companies and private citizens, considering that it is a very useful tool for understanding the evolution of the territory, with a large number of legal and cadastral applications.

The statistics also show great interest in maps of greater antiquity, more artistic and historical than descriptive of the current state of the areas shown.

Due to the impact of the Ancient Web Map Services, the existing WMS will continue to be supported. Given the success achieved, existing services will continue to be updated and new layers will be created:

- Ortofotos Históricas will continue to be updated every year with out of date flights
- New historical series of cities like Zaragoza, Valencia, Seville and Barcelona will be created

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