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## **From gazetteer to bounding box: using SDI standards to build a geoportal for ancient maps in Catalonia.**

Old maps, catalogues, metadata, spatial data infrastructure

Old maps catalogues are coming out of map libraries to join the world of distributed geoinformation. Adapting cataloging standards from map libraries to cataloging standards used in Spatial Data Infrastructures has facilitated the creation of geoportal Cartocat.cat that connects cartographic heritage with current maps. This has been possible jointly on the one hand by advances in digitization and georeferencing of old maps, on the other by the partnership of several collections of maps from different institutions and by the dialogue between cartographers and map librarians that converge at the Institut Cartogràfic i Geològic de Catalunya (ICGC).

This paper describes briefly the necessary steps taken to develop the portal by aggregating and consolidating metadata, and uploading it into the SDI following well established ISO standards.

### **The catalan map heritage: confederated catalogue**

In Catalonia there is a tradition in collaborative projects to catalogue, digitize and disseminate library documentation as maps among others. In 2006 started the MDC (Digital Memory of Catalonia), a partnership of 28 institutions to create an online collection of all types of materials with the main purpose to increase the visibility and consultation of special and heritage collections of the libraries of Catalonia. There are some cartographic collections on there pertaining to different map libraries. At the same year the Map Library of Catalonia opened its Digital map library project. In 2014, the online map library of the ICGC map library contains almost 60,000 items, out of which some 12,000 are old maps.

The MDC have a confederate search with the ICGC digital map collection. That means that a big part of the Catalan cartographic Heritage can be search online at once.

After some initiatives of georeferencing, the next step has been the opening of a geoportal of ancient maps into the IDEC (Spatial Data Infrastructure of Catalonia) with 3,462 maps coming from 4 public maps collections. A link between map library catalogues and cartographic catalogues was created.

### **The Spatial Data Infrastructure (SDI)**

A Spatial Data Infrastructure is a group of technologies, policies, standards, services and human resources, necessary for the compilation, manipulation, access, distribution and use of geographic data at different levels.

An SDI is a basis for the discovering of spatial data, its evaluation and its use by different kinds of users, either from public, or business, or academic, government or citizens sector. Conceptually the data infrastructure have the same purpose as the roads and highways: improving the communications, making access easier, increasing the commerce, etc. It is an interface able to receive a request, make the process and return the results trough internet with standard network protocols.

We can use a SDI for searching, locating, finding, analyzing and linking with the geoinformation and geoservices which are integrated in the IDEC's network. It's based in metadata about the data and services which are offered by the different providers.

In an optimal scenario any user of an SDI should be able to discover the geographical information related to a certain zone of a given territory, to visualize it and finally, if useful, to download it.

From a technological point of view an SDI has to implement tools to empower users to reach that optimal scenario. One of these applications, possibly the most important, is the metadata catalog: a spatial database with log functions to contain an inventory of all the geographical information available in a specific territory.

A metadata catalog search engine should provide answers to non-expert users who don't know exactly what they are looking for, but also to expert users that know exactly what they are looking for but can not find it. And all these interactions should be performed in a usable, fast and easy way.

### **Map georeferencing**

Prior to the release of the first version of the digital maplibrary all actors on the process acknowledged the need to have coordinates along with the documents, so that digitized maps could in fact be maps again, and because applications like Google Earth are the best "OPAC" so far for geometadata.

In 2008 an early alpha version of an online toolset aimed at georeferencing old maps was presented by Petr Klokán, who later on in 2010 established Klokán Technologies to further develop the concept into a software as a service (SaaS) cloud based product.

Back in 2011 Ramos and Roset, coworkers at the map library, published a brief paper detailing the process and the method to download and georeference the maps available at the map library using open source tools, to make them publicly available online again using tiling processes and geographical aware browser extensions, to combine old maps with modern ones and thus be able to reuse this old contents for many purposes. The process described required some advanced skills on the patrons side and a certain amount of infrastructure to reach the final goal of disseminating georeferenced old maps, making it of limited use for huge online collections.

Based on a newer revision of Klokantech's tool, which was already deployed and successfully tested at the National Library of Scotland (NLS) and also at the British Library (BL), the ICC conducted in 2012 a crowdsourcing pilot of 1000 maps of its digital collections. All these maps were georeferenced by 80 users in less than 20 days, a task which could not have been undertaken with the resources available in the maplibrary at the time. Right now the map library collections showcase almost 1,500 maps georeferenced by crowdsourcing, and a new batch of 500 more maps is being prepared to be released on the wild during 2014.

At the end all the process of compiling maps to digitize them and make them available online, with its geometadata, led to the question: are SDI's the maplibraries of/for the 21st century?

### Metadata for SDI

Since all the institutions participating in this new effort use the same software to display their collections online (CONTENTdm from OCLC), the process of extracting actual metadata of the documents to be integrated in the new portal is fairly easy and straightforward: exporting the records on CSV allows trouble free exchange of data.

Other institutions joining this initiative in the future might serve their digital collections and documents using other platforms and frameworks, but again exporting all the data and metadata in CSV format would make it easy to add the information to the existing set. For this reason a list of mandatory fields with their descriptions and characteristics was defined to be shared among participants in order to be able to create interoperable datasets.

To import all this wealth of geoinformation into the Spatial Data Infrastructure we relied on the CSV exports of the Dublin Core metadata which included the usual fields (Title, Author, Year, Editor, Description, etc.) and, whenever present, also the Geographical Area.

As a result of interfacing librarians on one side and spatial technologists on the other we ended building up a crosswalk to guide us on the process of transferring the textual metadata from the library to the ISO19115 spatial database specification.

ICC	BC	BVB	CEC	ISO19115
Àrea Geogràfica				gmd:MD_DataIdentification/gmd:extent/gmd:EX_Extent/gmd:geographicElement/gmd:EX_GeographicBoundingBox
Títol	Títol	Títol	Títol	gmd:MD_DataIdentification/gmd:citation/gmd:CI_Citation/gmd:title
Autor			Autor	gmd:MD_DataIdentification/gmd:pointOfContact/gmd:CI_ResponsibilityParty/gmd:individualName
Any original	Data del document	Data del document	Data del document	gmd:MD_DataIdentification/gmd:citation/gmd:CI_Citation/gmd:date/gmd:CI_Date
Altres autors				gmd:MD_DataIdentification/gmd:supplementalInformation
Descripció	Font	Font	Font	gmd:MD_DataIdentification/gmd:abstract
Escala	Escala	Escala		gmd:MD_DataIdentification/gmd:spatialResolution/gmd:MD_Resolution/gmd:equivalentScale/gmd:MD_RepresentativeFraction/gmd:denominator
Dimensions	Característiques físiques	Característiques físiques	Descripció	gmd:MD_DataIdentification/gmd:purpose
Registre			Identificador	gmd:fileIdentifier
Tipus de recurs	Tipus de recurs	Tipus de recurs	Tipus	gmd:DQ_DataQuality/gmd:lineage/gmd:LI_Lineage/gmd:source/gmd:LI_Source/gmd:description
Matèria	Matèria (inclou àrea)	Matèria (inclou àrea geog)	Matèria (inclou àrea geog)	gmd:MD_DataIdentification/gmd:extent/gmd:EX_Extent/gmd:geographicElement/gmd:EX_GeographicBoundingBox
Editor digital	Editor	Editor	Editor	gmd:MD_DataIdentification/gmd:citation/gmd:CI_Citation/gmd:citedResponsibleParty/gmd:CI_ResponsibilityParty/gmd:organisationName
Disponible des de	Data de publicació	Data de publicació	Data de publicació	gmd:MD_DataIdentification/gmd:citation/gmd:CI_Citation/gmd:editionDate
Format	Format	Format	Format	gmd:MD_Distribution/gmd:distributor/gmd:MD_Distributor/gmd:distributorFormat/gmd:MD_Format/gmd:name
Resolució	Resolució	Resolució		gmd:DQ_DataQuality/gmd:lineage/gmd:LI_Lineage/gmd:source/gmd:LI_Source/gmd:scaleDenominator
Permis d'ús				gmd:MD_DataIdentification/gmd:resourceConstraints/gmd:MD_LegalConstraints
In	Relació			gmd:MD_DataIdentification/gmd:descriptiveKeywords/gmd:MD_Keywords
Drets	Gestió dels drets	Gestió de drets	Gestió dels drets	gmd:MD_DataIdentification/gmd:resourceConstraints/gmd:MD_SecurityConstraints
Veure i georeferenciat				gmd:MD_Distribution/gmd:distributor/gmd:MD_Distributor/gmd:distributorTransferOptions/gmd:MD_DigitalTransferOptions/gmd:onlineOnly
	Llengua	Llengua		gmd:MD_DataIdentification/gmd:language
	Dispositiu de captura			gmd:DQ_DataQuality/gmd:lineage/gmd:LI_Lineage/gmd:statement
	Compressió	Compressió		gmd:DQ_DataQuality/gmd:lineage/gmd:LI_Lineage/gmd:processStep/gmd:LI_ProcessStep
	Definició	Definició		gmd:DQ_DataQuality/gmd:lineage/gmd:LI_Lineage/gmd:source/gmd:LI_Source/gmd:description
	Història dels canvis	Història dels canvis		gmd:MD_DataIdentification/gmd:resourceMaintenance/gmd:MD_MaintenanceInformation
	Repositori	Repositori	Repositori	gmd:DQ_DataQuality/gmd:lineage/gmd:LI_Lineage/gmd:source/gmd:LI_Source/gmd:sourceCitation/gmd:CI_Citation
	Gestió dels drets	Gestió dels drets	Gestió dels drets	gmd:MD_DataIdentification/gmd:resourceConstraints/gmd:MD_SecurityConstraints/gmd:aggregationInfo/gmd:MD_AggregationInformation
			Tipus de recurs	gmd:DQ_DataQuality/gmd:scope/gmd:DQ_Scope/gmd:level/gmd:MD_ScopeCode

Figure 1 Metadata crosswalk between map collections and SDI fields

### Metadata for georeferencing

To obtain the georeferencing information from old maps for its inclusion in the SDI and the geocatalogue three options exist depending on the amount of work needed and the accuracy expected:

- 1) Georeferencing with GIS tools: online or offline.
- 2) Checking place names against an authoritative place names list or gazetteer.
- 3) Drawing a bounding box using online or offline tools.

### *Georeferencing with GIS tools: offline*

Georeferencing maps offline, using QGIS or any other GIS platform, is a task to be undertaken by trained personnel, since there's some advanced skills needed to deal with certain GIS operations. Mastering the tools and concepts of GIS, along with precision and accuracy and basic knowledge of the territory are needed.

Also the equipment available for such tasks should be in the high end, since maps are usually huge documents that take a lot of resources and some of the georeferencing operations are processor intensive. To achieve the best results the base map used as the reference for the georeferencing process must be up to date and have a high level of detail. The operation of georeferencing is accomplished by assigning ground control points to known places in both maps, old and current, and using these GCP to compute the spatial metadata of the old map image.

### *Georeferencing with GIS tools: online*

Installed on top of CONTENTdm, the CMS for the digital collections, Georeferencer from Klokantech allows crowdsourcing the effort of georeferencing online maps. Patrons and visitors to the website of the collections are presented a tool that eases the process of defining ground control points of the old map by comparing it to a predefined up to date base map. At the end of the process a world file is generated that implicitly contains the geometadata of the old map.

But this crowdsourcing process needs trained staff to perform quality control on the results, to identify and correct all the possible errors produced by ignorance or unawareness, but also to isolate malicious users and other intended misuses.

### *Checking place names against an authoritative toponymy list or gazetteer*

Processing the metadata provided in DC fields "Title", "Geographic area" and "Description" a list of terms can be built by filtering out stop words and other non useful text strings. The remaining list of words is then run against a gazetteer to extract place names. By running the extracted place names against a geocoding service the list is standardized and the coordinates obtained are used for map placement and bounding box resolution. This allows both point and area place names, but at the end a decision on the choice of administrative limits and scale must be taken. Gazetteers and geocoding services are not always available or online, and in some cases these kind of advanced services are behind paywalls.

	A	B	C	D	E	F	G	H	I	J	K
969	967	0.16	40.53	0.88	40.78	Montsià	MONTSIA				
970	968	0.56	41.69	1.32	42.13	Noguera	NOGUERA				
971	969	1.99	41.73	2.51	42.18	Osona	OSONA				
972	970	0.68	42.01	1.19	42.56	Pallars Jussà	PALLARS JUSSA				
973	971	0.94	42.26	1.44	42.79	Pallars Sobirà	PALLARS SOBIRA				
974	972	2.64	42.03	2.91	42.22	Pla de l'Estany	PLA DE ESTANY				
975	973	0.73	41.55	1.1	41.74	Pla d'Urgell	PLA URGELL				
976	974	0.66	41.07	0.98	41.37	Priorat	PRIORAT				
977	975	0.37	40.93	0.88	41.34	Ribera d'Ebre	RIBERA EBRE				
978	976	1.96	42.11	2.56	42.44	Ripollès	RIPOLLES				
979	977	1.16	41.56	1.51	41.93	Segarra	SEGARRA				
980	978	0.32	41.28	0.82	41.86	Segrià	SEGRIA				
981	979	2.41	41.65	2.97	42.06	Selva	SELVA				
982	980	1.29	41.76	1.74	42.21	Solsonès	SOLSONES				
983	981	1.1	41.06	1.5	41.26	Tarragonès	TARRAGONES				
984	982	0.2	40.82	0.57	41.24	Terra Alta	TERRA ALTA				
985	983	0.95	41.47	1.22	41.86	Urgell	URGELL				
986	984	0.64	42.59	1.04	42.86	Val d'Aran	VAL ARAN				
987	985	1.86	41.42	2.23	41.72	Valles Occidentals	VALLES OCCIDENTA				
988	986	2.02	41.49	2.61	41.81	Valles Oriental	VALLES ORIENTAL				
989	987	1.760.559	41.569.224	1.863.556	41.635.973	Montserrat (serra)	BAIX LLOBREGAT				
990	988	-1.6	37.77	4.46	42.89	Catalunya, València, Balears (illes)	CAT, VAL, IBL				
991	989	-2.55	37.29	4.46	42.4	Catalunya, Múrcia, València, Balears (illes), Navarra	CAT, MUR, VAL, IBL				
992	990	-1.6	37.77	3.38	42.94	València, Catalunya	VAL, CAT				
993	991	0.3076	405.973	0.9009	412.984	Ebre (riu), Catalunya	EBRE, CAT				
994	992	2.171.173	41.681.118	2.565.308	41.861.379	Montseny (serra)	OSONA				
995	993	0.6441	421.267	22.247	428.719	Catalunya, Pirineus (serra)	PIRINEUS CAT				
996	994	1.884.155	41.599.013	2.091.522	41.749.287	Sant Llorenç del Munt (serra)	BAGES				
997	995	0.1373	405.054	33.659	428.785	Catalunya	CAT				
998	996	2.400.513	41.561.004	271.534	4.173.238	Montnegre (serra)	VALLES ORIENTAL				
999	997	2.028.351	4.175.902	2.145.424	41.893.077	Moianès	OSONA				
1000	998	2.028.351	4.175.902	2.145.424	41.893.077	Bac (vall del), Garrotxa, Ripollès	GARROTXA				
1001	999	1.590.958	41.766.703	1.762.276	41.839.642	Boixadors, Castelllallat (serres)	BAGES				
1002	1000	2.164.993	41.673.938	228.344	41.753.129	Bertí (cingles)	OSONA				
1003	1001	37.473	416.739	33.711	42.442	Costa Brava	CAT				
1004	1002	-1.58	37.76	3.37	42.94	País Valencià, Aragó, Catalunya	VAL, ARG, CAT				
1005	1003	2.07	35.68	14.83	41.51	Barcelona (Barcelonès), Malta (Illa), Maó (Menorca)	MEDITERRANI				
1006	1004	0.6427	418.532	15.271	42.888	Val d'Aran, Alta Ribagorça, Pallars Sobirà, Pallars Jussà	CAT				

Figure 2 List of words and coordinates describing places (both point and area)

### *Drawing bboxes: offline*

In many desktop GIS platforms an option exists to generate bounding boxes from active layers. The whole process begins by locating the vector geoinformation relevant to the old map that needs georeferencing, like administrative limits or other sorts of topographical information, and then adjusting the visualization to the specific area covered in the document.

In Qgis the “Polygon from Layer Extent” tool automatically produces a bounding box of the selected features of a layer. The resulting geometry can be exported as a shapefile with attributes like XMIN, XMAX, YMIN, YMAX, AREA, WIDTH and HEIGHT.

### *Drawing bboxes: online*

Bounding boxes as those calculated by GIS programs can also be obtained online by different means. One of the best tools, for its simplicity and export capabilities, is the “BoundingBox” tool provided by Klokantech at <http://boundingbox.klokantech.com/>. Its interface provides a place finder based on Google or Openstreetmap, a map base from OSM and a draggable rectangle covering an area of interest. By adjusting the rectangle on top of the current base map the actual extension of the territory depicted in the old map can be delimited.

Once the area of the old map is defined this tool offers many options to export the numerical values of the geometry, both in textual and spatial formats.

All these processes described here were used at some point in this project, since the maps coming from different collections had different completion levels of the available geometadata. Ideally all maps should be precisely georeferenced using GIS or GIS like tools, since this yields the best accuracy and precision and makes them easily reusable for other projects.

For those maps that can't be georeferenced the second best option is to calculate their bounding box using online or offline methods as described here, and then adding the geometadata to the document both in bibliographic and spatial formats.

Extracting place names from bibliographic metadata and running them against a geocoding service is the option that needs more manual work, it is also the option that takes longer and in the end the results are not always as expected. Besides that there's always a certain degree of uncertainty regarding the final results, which can vary substantially depending on the sources used in each step.

### **Duplicate items**

In this project we gathered maps existing in different collections and thus georeferenced using different methods. A certain map was duplicated in two different collections: at the ICGC, georeferenced by crowdsourcing using GeoReferencer; and at MDC without any georeferencing.

The map from ICC, georeferenced, was added to the SDI without further effort, but the copy coming from MDC entered the manual workflow for place name resolution.

The title of the old map "Olot: ciudad jardín" contains the place name "Olot", a city in the northern part of Catalunya which also gives name to the municipality it belongs to. Thus in the name extraction phase we kept "Olot" as a place name since it correctly appeared in the gazetteer.

Then in the inverse geocoding phase the name "Olot" was resolved to both the administrative level as municipality and as city name. Since the bounding box for the municipality existed, but it did not exist for the city extension, which is a more diffuse concept harder to precisely define, the geographical extension of the municipality was assigned as a bounding box to his old map. In fact the map reflects only the expansion of the city and the housing development made in 1916, a very little portion of the current city and indeed much smaller than the extension of the municipality.

In the end what we have now are two exact copies of the same map that have two really different bounding boxes. Both bounding boxes are perfectly correct in geographical terms, but only the bounding box obtained by the georeferencing process is accurate and precise in terms of overall description.

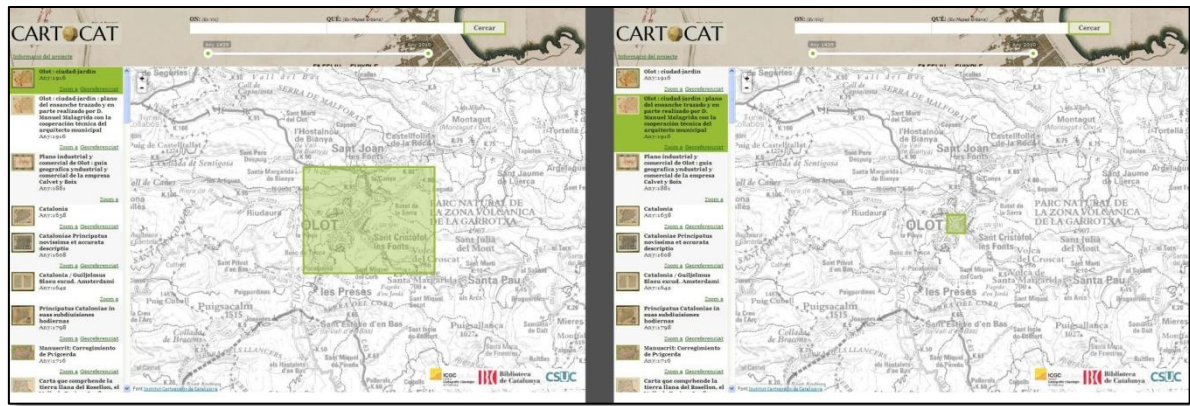


Figure 3 Two copies of the same map georeferenced with different methods

### Old maps in SDI

So far 3,472 georeferenced old maps have been added to the IDEC, the Catalan spatial data infrastructure, originating from five different collections.

Since the SDI is a neutral exchange point dealing with metadata, linking back to the originating collections for browsing of documents, many local organizations are interested in this option for disseminating geoinformation.

This approach has two clear advantages: on one side organizations do not necessarily have to run a local copy of a content management system to deliver documents to their patrons; and on the other lot of cartographic heritage materials, that would otherwise remain unknown, will surface and be made public by their keepers. And another positive side effect of these efforts is the fact that old maps, which were considered valued items for other reasons, will join the trove of geoinformation by their own unique geospatial content.

The screenshot displays the SDI metadata catalog interface. At the top, there is a navigation menu with options like 'All', 'Datasets', 'Services', 'Images', 'Sensors', 'Viewers', and 'Old maps'. A search bar is present with fields for 'WHERE' and 'WHAT'. Below the search bar, there are filters for 'Search by provider' and 'Search other catalogues'. The main content area shows a list of search results for 'Old maps', with 3,462 records found. The results are displayed in a table with columns for 'Sets', 'Types', 'Years', 'Series', and 'Providers'. The table lists various historical maps, such as 'Coves de Riap', 'Plano de la Cueva del Drach', 'Igalada: [plànol de la ciutat]', 'Reus: [plànol de la ciutat]', 'Villafranca del Panades: [plànol de la ciutat]', 'Projecte de reforma de la Plaça Portal de la Pau', 'Croquis de la mina calera término de Vellirana', and 'Ferro carril de Barcelona à Zaragoza: gran viaducto del Buxadell, situado à 42 kilómetros de Barcelona'. Each result includes a thumbnail, a description, and links for 'Description', 'All information', 'Provider', and 'Zoom to'. On the right side, there is a map window showing the geographical context of the results, with a bounding box around the area of interest. The map includes various cities and regions in Spain and France, such as Barcelona, Zaragoza, and Reus. The map is titled 'Spatial search: For information, click the approximate points at which you are interested on the map'.

Figure 4 Old maps from different online collections once integrated into the SDI metadata catalog

### Cartocat portal

Although a lot of effort was put into designing and making straightforward the search and retrieve operations in the metadata catalog of the SDI, a certain degree of complexity remains due to the huge amount of information available.

Thus we decided to access all the geoinformation loaded into the historical SDI from within a friendly interface easy to use and to understand, clearly inspired by the excellent project OldMapsOnline.

The new website was named Cartocat, a contraction of “Cartografia de Catalunya”, is available at the address <http://www.cartocat.cat> and was built using open source tools.

It is divided in three big sections:

- The header, which contains the search box, divided in two different searches one for “Where” terms and another one for “What” terms; and a timeline to restrict results to a certain time period.
- The vertical bar, where the old map candidates are displayed. The column of results reacts to search terms, timeline restrictions and area of map displayed, resulting in a more precise and focused result set.
- The map window, with the usual pan and zoom controls, where the bounding boxes of the candidate results are displayed. It is also the geographical selector for spatial searches in a natural way.





Figure 5 The Cartocat portal created to browse the objects described in the SDI metadata catalog

Providing more elaborated tools to patrons and users results in better understanding of its' usage, which in turn means farther reaching diffusion and thus, we hope, much higher reuse of this type of cartographic heritage materials.

### Improvements and things to do

A lot has been achieved with the sparse resources available, in this current context of crisis, but a lot of things remain on the list of achievements we would like to write off:

- Convince and bring on board more institutions, at all levels.
- Automate as much as possible the tasks.
- Eliminate the need to manually georeference maps offline.
- Teach librarians to add geometadata to all documents.
- Move forward all these catalogs and geocatalogs to Linked Open Data.
- Visualize documents inside bounding boxes.
- Keep all these information layers synchronized and up to date

In this seven years of contributing to this international workshop the ICGC (former ICC) has given a series of presentations that depict the journey it started when it established the digitization project for its map library, to the online map library in 2007 and to this day where a certain degree of interoperability with the SDI has been achieved, enough at least to provide contents to a really specific geodata portal of old maps.

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