

# A FULLY INTEGRATED INFORMATION SYSTEM TO MANAGE CARTOGRAPHIC AND GEOGRAPHIC DATA AT 1:25,000 SCALE

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## ABSTRACT

IGN Spain has produced and currently updates at the 1:25,000 scale two basic geographic datasets, reference data in INSPIRE sense, according to two different approaches: *Mapa Topográfico Nacional* (MTN25) as a cartographic document in both digital and paper form; and *Base Cartográfica Numérica* (BCN25), a collection of GIS oriented datasets. Its production and updating processes has been merged and reengineered to have a unique IS, integrated at feature level, containing objects with both geographic and cartographic geometry and attributes (simbology).

The objectives of the new system are: to support an unified updating; to be able to deliver MTN25 as well as BCN25; to be compliant with the relevant standards in use (specially ISO19100 and OGC specifications); to support geospatial analysis and queries; to be integrated in Spanish SDI.

This short presentation describes the model and architecture defined for this purpose, summarizes the implementation of this project, underlines the problems emerged, shows the results obtained and extracts some lessons learnt.

*“The objects forms the structure of the world.”*  
Ludwig Wittgenstein, 1917

## 1. THE SPANISH NATIONAL TOPOGRAPHIC MAP 1:25,000 (MTN25).

In 1870, the National Geographic Institute of Spain (IGN-E) began the production of the National Topographic Map of Spain at 1:50,000 scale, MTN50 for *Mapa Topográfico Nacional* 1:50,000. This long and hard project culminated at latest 60's leaving behind a lot of changes as result mainly of the continuous evolution affecting the cartographic techniques during those years. From 1975 map updating was making at the same time to the production of a new series at 1:25,000 scale, MTN25 for *Mapa Topográfico Nacional* 1:25,000, with the proposal of complementing MTN50 in some areas of special interest. However, in the 80's this new series became a national coverage project too.

In 1985 a new Spanish law titled Cartographic Ordering Law (*Ley de Ordenación de la Cartografía*) qualified the old stager project MTN25 as the State Official Basic Cartography, and assigned its production and conservation to IGN-E, something that actually has become a reality. Just a year later, in an only apparent cause/effect relationship, IGN-E began the adaptation of its photogrammetric equipments to capture rough spatial data in digital media.

However, processes after data capture were not still advanced from an IT point of view, so map production remained as a too slow process for some years. As a consequence, in the first phase of MTN25 project, between 1975 and 1993, there were only a 40% of map sheets published.

The MTN25 Feature Catalogue assigns to each element a set of graphic parameters (level, colour, weight and style) which describe DGN simbology in a biunivocal way. It includes codes, which we call “visual codes” (over 200), of elements used only for the correct data visualization and plotting.

In 1994 such a dramatically strong technological advance took place that in practice some kind of crack happened in the MTN25 history. Essential parts of the production chain were transformed to digital procedures, as selection, updating and edition processes. The whole project began to be executed as a consecutive set of digital procedures (except,

obviously, field survey for data capture). Soon some effects of that emerged dramatically: by one hand, the average production ratio increased by a factor of 4; on the other hand, MTN25 became a digital series, a very relevant fact from any point of view, mainly considering next exploitation possibilities [1].

## **2. THE CARTOGRAPHIC NUMERIQUE DATABASE 1:25,000 (BCN25)**

In 1997 a new series named Numerical Cartographic Data Base (BCN25 for *Base Cartográfica Numérica 1:25,000*) was designed as a derived product from MTN25, in order to get the 1:25,000 cartographic information complying the required data specifications to be exploited inside GIS environments. Therefore, BCN25 contains essentially the same information that MTN25 with some additional geometric and topological properties, following a specific DB oriented model and Feature Catalogue.

Nowadays, MTN25 and BCN25 series are completely finished. See [2] for a more detailed description. Both series are composed by more than 4,123 units/sheets, and offers a complete coverage of Spain, realizing a continuous and homogeneous vectorial dataset of the whole territory with an average accuracy (RSME) of 3 m, following a sufficiently versatile model to fulfil all kind of users' requirements.

The current conservation ratio affecting MTN25 and BCN25 series are also being reengineered to be adapted to social demand, to conform a deeply reformed National Cartographic System, which consider the updating of our Official Basic Cartography as a shared and decentralized project where cooperation with Autonomous Governments in Spain plays a central role.

BCN25 series has, as mentioned before, specific topological and geometrical properties which allow direct loading and exploitation inside a GIS. The BCN25 conceptual model is based in the "element" concept, that is, a part of a geographic feature maintaining both continuity and uniform cartographic representation inside a MTN25 sheet, owning a particular name (if it exist). As examples we have a river, a road or a population. Elements can be, as typical, a point, a line or a surface, depending on its dimension. The name of each element is assigned using a text which origin fit in one vertex belonging to the element geometry.

BCN25 is nowadays produced and distributed in a variety of spaghetti formats, as far as when the project begun there were not standard formats to interchange topology. It does not exist nodes in BCN25 as its spaghetti structure does not consider them. However, when two or more elements intersect, the crossing point is computed and included as one of the vertex describing each element geometry. This permits to identify nodes without additional calculus, but only finding vertex defined by identical coordinates in different elements geometry.

## **3. A NEW APPROACH**

To produce and maintain MTN25 and BCN25 as two separated series has a lot of problems and inconveniences, mainly due to the fact that it would be necessary to update both datasets separately trying to guaranty the consistency between them. In order to have a better management of 1:25,000 data, a new project has been analyzed and designed during past year 2004 and has been launched in the beginning of 2005, based on the idea of having a unique GIS system, storing all the information needed to produce BCN25 and MTN25 via a merge at feature level of data from both products. The result will be a DB of features with a set of attributes (geometry, codes and names) oriented to BCN25 and a set of attributes (map geometry, texts, symbols, colours,...) oriented to MTN25 production. This would allow us to perform an unified updating process to maintain both datasets.

DBMS is being Oracle and Geomedia is going to be the GIS tool to perform data management, updating and exploitation. This environment keeps a total interoperability with the current productive environment in IGN-E, based mainly on Microstation environment and DGN format, in such a way that we will be able to avoid drastic changes when the new interfaces and procedures were introduced. Connection support between Oracle and Geomedia exists from both sides, making easy a client-server architecture implementation.



**Figure 1: Integration of MAP (MTN25) and SIG (BCN25) data in an unified System.**

Data model has been developed to manage 1:25,000 series information, considering an application schema including: geometric primitives (point, line and surface), topology on-the-fly, names, attributes, portrayal, lineage and quality descriptions. It will try to have the ability to provide, without any modification, generalization assistance to derive MTN50 series. As a new aspect, with regard to the original series, data model offers a 3d description of the whole cartographic information maintaining kept topological integrity.

The same approach is applicable at 1:200,000 scale taking into account the two main digital products of IGN-E at this scale: BCN200, for *Base Cartográfica Numérica* 1:200,000 and Maps 1:200,000.

#### 4. PROBLEMS TO BE SOLVED

Therefore, the new Information System (BCN/MP) must be designed to store geographic data from BCN as well as cartographic data from MTN, at two different scales 1:25,000 and 1:200,000 , and need to manage information in two different ways: seamless database for query and analysis and sheet divided data for updating, printing and delivery.

The schema is based on the concept of element (Elemento), continuous portion of a feature completely contained in one sheet and with an uniform cartographic portrayal. There are punctual, textual, linear, perimetral and superficial elements (Elemento\_textual, Elemento\_puntual, Elemento\_lineal, Elemento\_perimetral, Elemento\_superficial). The complete UML (Unified Modelling Language) schema is shown in figure 5.

The main problems to be solved in this new model arises because:

- Some elements are moved in the map from its original position because of legibility, and this makes mandatory in some cases to store a BCN-geometry and a MTN-geometry. To reflect this aspect, each element affected for this problem has two different geometric description via two different geometric primitives, one for BCN and another one for MP (see figure 2).

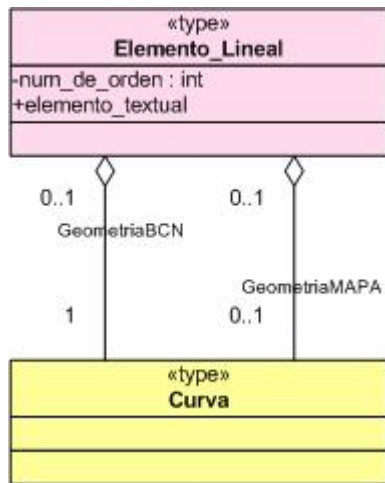


Figure 2

- The unit of data capture, edition, publication, lineage, quality and metadata is the MTN sheet, and is not possible to forget that fact. To have data partitioned in sheets must be made compatible with seamless analysis in a GIS. To model this situation we have two different levels in the schema: simple objects (Objeto\_Simple) are features with a well defined dimension (points, texts, lines, perimeters or surfaces) that can overlap several sheets, and they are composed by elements, which are always contained in an individual sheet (Hoja) (see figure 3).

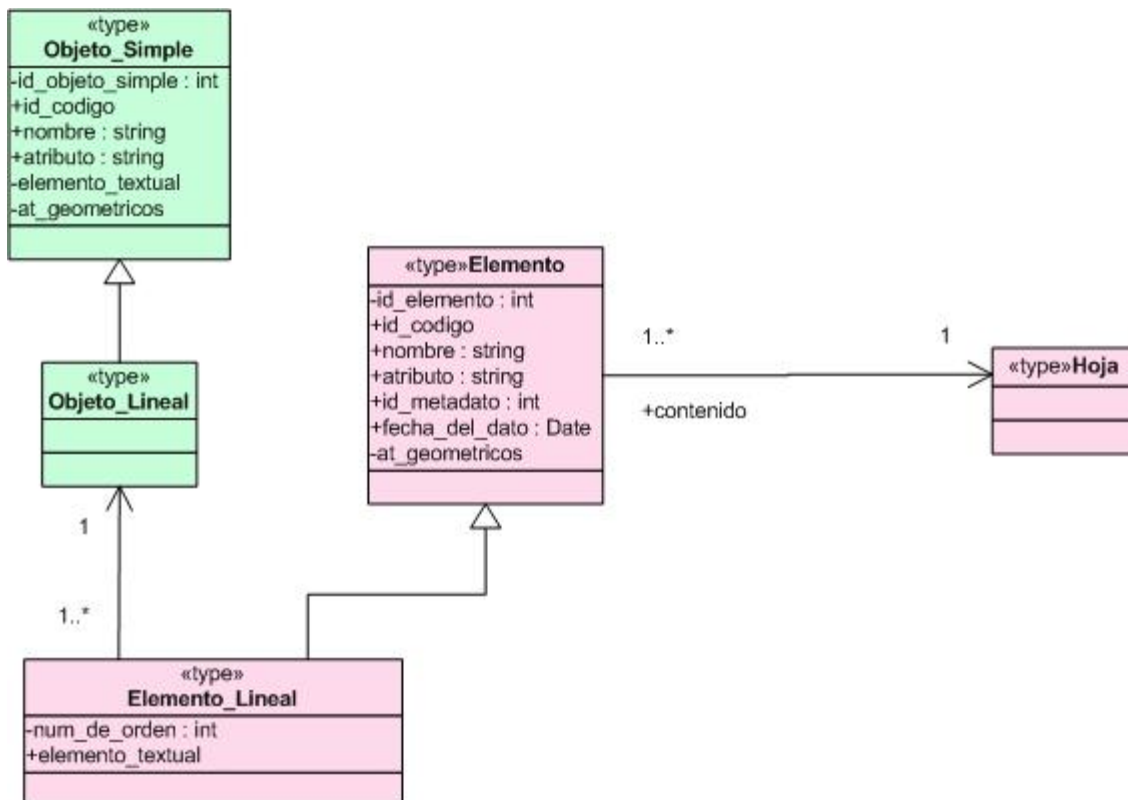


Figure 3

- Some features, like big rivers for example, can have some one-dimension parts (linear), some two-dimension parts (great dams, portion with two separated edges,...). This obliges to consider composite objects (Objeto\_Compuesto) made of linear and superficial objects (Objeto\_Simple) (see figure 4).

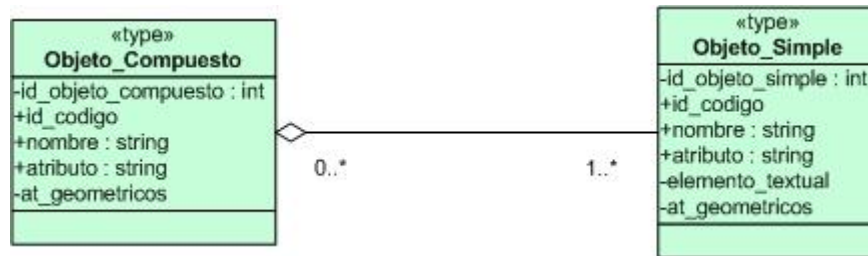


Figure 4

## 5. AN UNIFIED MODEL TO AN UNIFIED SYSTEM

The global schema, describing a model solving all the problems mentioned is shown in figure5.

### BCN/MP SCHEMA

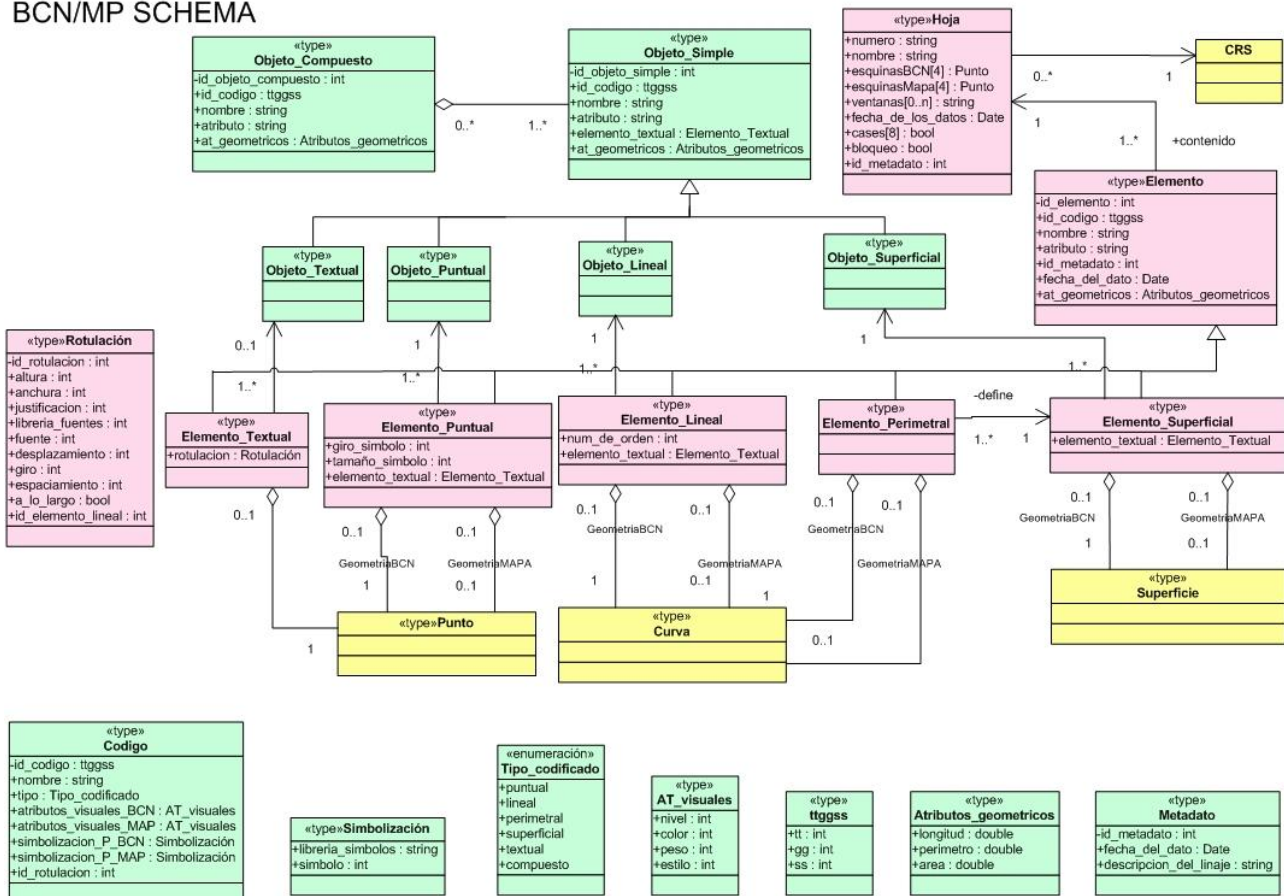


Figure 5: Complete UML Schema for MTN/BCN data.

In this schema, three main hierarchical levels are considered: element level (elemento) representing sheet-divided data for cartographic purposes; simple object level (Objeto\_Simple) to have a continuous vision over sheets; and composite objects (Objeto\_Compuesto) to model complex features with a multidimensional character (linear + superficial +...).

This schema conforms ISO 19109 “Geographic Information – Rules for Application Schema” [3] and ISO19107 “Geographic Information – Spatial Schema” [4]. The class Punto corresponds to the geometric primitive Point, the class Curva corresponds to Curve, and Superficie corresponds to Surface.

Colours are used to distinguish different parts in the model: in yellow, classes corresponding with ISO19107 classes; in pink, objects related to the element level, describing data divided in different sheets; finally, in green, object level showing seamless data crossing sheets from continuous map vision.

BCN/MP model is prepared to link metadata information at two different levels: metadata of a sheet, because is the unit of data capture and updating; and metadata of an individual element (Elemento), in case of updating of an element instance.

Following S. Balley, C. Parent and S. Spaccapietra [5] classification of approaches to manage two different spatial representation for geographic features:

- 1) Both representations are integrated into a single multirepresentation element . The element bears two different spatial representation.
- 2) There are two different elements, each one with a different spatial relationship, and linked each other by a correspondence relationship.
- 3) A mix of the previous ones. Two different elements with different spatial representations are considered as subtypes of a single element bearing the identifier of the element.

The solution chosen to have a cartographic and a geographic representation for the same elements can be considered included in the first one.

## 6. THE STATE OF THE PLAY

The BCN/MP integrated system implies a dramatic data reengineering and some critical steps in which big resources and know-how need to be invested. The key-processes involved are (see figure 1):

- Migration and reengineering of old BCN and MTN series to the new integrated system, performing a feature level merging of geographic and cartographic data. The simplest way to do that is to store BCN25 and BCN200 data and add portrayal aspects later on in the updating and map edition phases.
- Data revision, which implies the export of a DGN format file corresponding to a sheet, containing the geometric primitives of BCN with elements and objects identifiers in it and perform the usual processes of updating, checking and editing information. During this process the sheet selected remain blocked for updating in the system.
- Quality control and data updating, based on four steps: first of all, a classical quality and consistency checking of the information corrected and updated, partly manual and partly automated; second, a consistency checking comparing the updated file with the old file contained in the database, looking at new geometry, changed geometry, the mapping between element identifiers,...; three, new data is stored in the database and an edge matching is required; and last, the cartographic data related with the portrayal aspects need to be edited and adapted to the changes performed.
- Map edition to get a directly printable file to get a map sheet from the content of the database. The objective here was to reduce as far as possible manual editing of data.

In this moment, the phases of modelling, software development and tests are completed. All data corresponding BCN200 has been stored in the system and some sheets of maps 1:200,000 have been produced in an efficient timeframe. Regarding 1:25,000 scale, more than 4% of data, 170 /4,123 sheets, has been stored in the database, some maps has been obtained with a sensible cost of time, and the complete process of extract data, updating, check and store again in the database has been performed on several sheets, with some problems to be solved, mainly software bugs, some difficulties in consistency checking and a set of tasks consuming too much time. We expect the complete

migration to the new system to be completed, with all kind of problems solved and to have a well established production process in 2006.

## 7. CONCLUSIONS

National Mapping Agencies are obliged to face the problem of producing and maintaining GIS-oriented data and map-oriented data in a coordinated way, at different scales and combining continuous map and tiles division points of view.

There is no simple solutions and a quite big effort of reengineering people, processes, data,... is needed, while the old portfolio of data and map products must be maintained until the new system is ready. There are hardware and several base software powerful and appropriate available, but a huge investment of energy in customization, correct organization and planning is required.

Sometimes the more complex problems are almost easy to solve, but the more simple ones are extremely difficult. The biggest problems we have found in this project are: the extra time needed to change people's mind to the new way of work; the difficulties in organizing and coordinating such a big and complex reengineering process maintaining during some time old production processes; to underestimate the time and effort required in getting fit processes and reduced times to get a correct timeframe production.

Next steps to be considered are: database version management and only changes updates delivery; computer assisted generalization implemented inside in BCN/MP system; harmonization to other datasets, like Corine-Land Cover, applying confliction and fusion utilities.

## 8. REFERENCES

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- [5] S. Balley, C. Parent, S. Spaccapietra "Modelling Geographic Data with Multiple Representations" *Internacional Journal of Geographic Information Science*, vol. 18, nº 4, June 2004, 327-352. Taylor & Francis Ltd.

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## **Short CV**

- 1983 Physics Grade (specialization in Theoretical Physics) in Complutensis University, Madrid.
- 1986 Enter as Geographical Engineer in IGN Spain.
- 1993 Information Technologies High Official in Public Administration.
- 1994 Head of Geographic Information System Department at IGN.
- 1994-02 Secretariat of AENOR/CTN148.
- 1994 Head of Spanish Delegation in CEN/TC 287 and ISO/TC211 committees.
- 1997 IGN delegate in EuroGeographics Quality Working Group.
- 2002 Secretariat of Geomatics Commission of National Geographic High Council.
- 2002 Member of Working Group for the Spanish National Spatial Data Infrastructure.
- Over 70 publications and conferences.
- Professor in Cartography and Geodesy Engineering, at Polytechnical University of Madrid.