THE DIGITAL IMAGING CARTOGRAPHY (DIC) AS BASIC CARTOGRAPHIC INFORMATION SYSTEM. THE SPANISH NATIONAL PLAN FOR LAND OBSERVATION (PNOT): COLLABORATIVE AND DECENTRALIZED MODEL OF PRODUCTION

Autor:
Author: Dr. Antonio Arozarena Villar
Assistant Deputy Director for Cartographic Production
INSTITUTO GEOGRÁFICO NACIONAL
General Ibañez de Ibero, 3
28003 Madrid, España
aarozarena@fomento.es

Co-Author: Lorenzo García Asensio
Deputy Director for Cartographic Production
INSTITUTO GEOGRÁFICO NACIONAL
General Ibañez de Ibero, 3
28003 Madrid, España
lgasensio@fomento.es

Co-Author: Guillermo Villa Alcázar
Head of the Remote Sensing Department
INSTITUTO GEOGRÁFICO NACIONAL
General Ibañez de Ibero, 3
28003 Madrid, España
gmvilla@fomento.es

INTRODUCTION

The continuous and precise knowledge of the territory is fundamental in order to carry out coordinated decisions about Territorial and Environmental Policy. These decisions requires an integrated Information System, temporal, spatially and semantically with the appropriated exactitude, updated, consistent, adapted to the international geographic standards, shared between all the administrations, accessible for the users and integrated in the Spatial Data Infrastructures (GSDI, INSPIRE, IDEE,…) and in the European and global networks of earth observation (GMES, GEO). This Information System helps different institutions to take coordinated decisions based on the same information, avoiding duplicities, sharing costs and applying Inspire principles. The Information and observation System implemented by national and regional institutions includes satellite image coverages with different resolutions, orthophotos, and a land cover information system that helps to take coordinated decisions based on the same information.

Up to now, the production and dissemination of geographical information in Spain has been very decentralized in two aspects: geographically, as both regional or local administrations took care of it, and thematically, as it was produced by different thematic departments at national or regional level.

The insufficient coordination in the generation of this information is a source of problems in different fields. For example, in economic resources optimization, this insufficient coordination causes duplicity of efforts, force many plans to be abandoned due to the lack of budget and lead to a distribution of costs not according to the budget capability of the different organisms. In information production the lack of coordination generates "holes" of information, low rhythm of work (what means that databases are not properly updated), etc. In the use of databases and products, the insufficient coordination generates incompatible data, difficulties in interoperability, diversity of data models, scales, resolutions, precisions, dates, formats, etc. The lack of coordination causes problems also in the data dissemination because of the restrictive access to data property of different organisms.

COLLABORATIVE AND DECENTRALIZED MODEL OF PRODUCTION

The PNOT is a model based in the cooperation in the management, quality control and in productions among national and regional administrations. The information obtained must satisfy the requirements of participant institutions, European Union (Corine Land Cover, GMES…) and other social agents.

The main objectives of the PNOT are to obtain an integrated Information System (spatially, temporarily and semantically) that helps different institutions to take coordinated decisions (based on the same information), to share costs of information and avoid duplicities, so we can obtain better and more "up to date" information and to apply INSPIRE principles to information on Land Use/Land Cover.

Also, there are other very important objectives derived from these, for example, to improve and optimize the economic resources invested by the participant organisms in the geographic information capture, to take advantage of the potential use of data and products, promoting the greatest diffusion and use by all the social agents or to support and contribute to the implementation of the global and European policies.
It is also interesting to take advantage of the convergent interests of the different administration levels (European, national, regional and local) or to promote the cooperative and decentralized production between the different producers instead of competition.

Finally, the PNOT also tries to allow the efficient explotation of the information by scales and resolutions and promote the expansion of the private sector companies in the

geographic information sector making them contributing with better quality, efficiency and reducing costs.

The PNOT is structured in the different components described in the table:

<table>
<tr><th colspan="11">SPANISH NATIONAL PLAN FOR TERRITORY OBSERVATION (PNOT)</th></tr>
<tr><td rowspan="6">1st PHASE
Capture and processing of aerospatial images</td><td colspan="3"></td><td colspan="4">National Plan for Aerial Orthophotography (PNOA)</td><td colspan="4">National Plan of Remote Sensing (PNT)</td></tr>
<tr><td colspan="3"></td><td>PNOA 10</td><td colspan="2">PNOA 25-50</td><td>Historical PNOA</td><td>High resolution</td><td>Medium resolution</td><td>Low resolution</td><td>Historical PNT</td></tr>
<tr><td colspan="3">Spatial resolution</td><td>10 cm
Coast and urban zones</td><td>25 cm</td><td>50 cm
(Alternate coverages)</td><td>variable
historical flights</td><td>Pancro: 0,5 - 10 m
Multispectral: 4 - 30 m</td><td>Pancro: 10 - 15 m
Multispectral: 20 - 50 m</td><td>Multispectral:
100 - 1.000 m</td><td>variable</td></tr>
<tr><td colspan="3">Temporary frequency</td><td>4 years</td><td colspan="2">2 years</td><td>variable</td><td>3 - 12 months</td><td>16 days</td><td>2 - 30 days</td><td>variable</td></tr>
<tr><td colspan="3">Estimate cost (euros / Km^2)</td><td>350</td><td>55 (accuracy methods)
19 (fast methods)</td><td>29 (accuracy methods)
7,5 (fast methods)</td><td>10 (scanning)
72,42 (ortho)</td><td>4 (for 2,5 meters)</td><td>1,34 (annual)</td><td>0,25 (annual)</td><td>3,21</td></tr>
<tr><td colspan="3">Platforms / Sensors</td><td>Digital Aerial Photography (4 bands) with GPS-IMU
Lidar</td><td colspan="2">Digital Aerial Photography (4 bands) with GPS-IMU
Lidar</td><td>Panchromatic Aerial Photography</td><td>SPOT 5 (HRG)
Formosat</td><td>Landsat 5 (TM)</td><td>Terra (MODIS)
Envisat (MERIS)
SPOT (Vegetation)</td><td>Landsat 1-7
(MSS, TM, ETM+)</td></tr>
<tr><td rowspan="6">2nd PHASE
Extraction of the information</td><td colspan="2"></td><td colspan="9">Scales / sample (s)</td></tr>
<tr><td>Thematic Area</td><td>Organisations</td><td>1: 500 to 1: 2.000 /
s=5 cm -15 cm</td><td>1: 5.000 to 1: 10.000 /
s=25 cm - 50 cm</td><td colspan="3">1: 25.000 to 1: 50.000 /
s=1.25 m - 2.5 m</td><td>1: 100.000 to 1: 200.000 /
s=5 m - 10 m</td><td>1: 1 Million
s >50 m</td><td>1: 100.000 to 1: 200.000 /
s=5 m - 10 m</td></tr>
<tr><td rowspan="2">Topography</td><td>National Administration (AGE)</td><td></td><td></td><td colspan="3" rowspan="2">BTN25 (Numerical Topographic Database 1:25.000)</td><td>BCN200 (Numerical Cartographic Database)</td><td>BCN1000 (Numerical Cartographic Database)</td><td rowspan="3">backward update database</td></tr>
<tr><td>Regional Administrations (CCAA)</td><td></td><td>♦</td><td></td><td></td><td></td></tr>
<tr><td>Cadastral</td><td>Local Administrations
National Administration (AGE)</td><td>♦
Urban areas</td><td>Rural areas</td><td colspan="3"></td><td></td><td></td></tr>
<tr><td>Land cover</td><td>United Nations
European Union
National Administration (AGE)
Regional Administrations (CCAA)</td><td></td><td>SIGPAC (European Agricultural system)
Regional Databases of Land Cover Use</td><td colspan="3">Land Cover and Use Information System of Spain (SIOSE)
MCA (Agricultural information)
MFE (Forest information)</td><td>Corine Land Cover 2006
HR FTS (European Union - High Resolution Fast Track Service)</td><td>GlobCover</td></tr>
<tr><td>Enviromental</td><td>European Union
National and Regional Administrations (AGE / CCAA)
Universities</td><td></td><td></td><td colspan="5">Environmental indicators for remote sensing</td></tr>
<tr><td>3rd PHASE
Dissemination of the information</td><td colspan="10">Spatial Data Infrastructure: INSPIRE, IDEE, local IDEs,...
Image servers: Iberpix, SIGPAC,...</td></tr>
</table>

Figure 1: Structure of the National Plan for Observation of Territory.

Within the Plan we can consider 3 phases: the capture and treatment of aerospatial imagery (PNOA and PNT), the extraction of information (SIOSE, SCN and PNI) and the dissemination of information.

1st phase: Capture and treatment of aerospatial imagery

In this phase, the aim is to obtain aerial and satellite coverage with resolutions and optimum rhythms of updating from the economical point of view, and also optimum for the applications in which they would be used. These coverages are organised in different levels of spatial resolution and temporal resolution and carried out in two work plans.

The first of these work plans is the National Plan of Aerial Orthophotography (PNOA).

Now is taking place the second implementation of this project, planned from 2007 to 2010. This second phase is more ambitious than the first one (2004-2007), in which the aim was to obtain photogrammetric flights updated every two years. From these photogrammetric flights a digital elevation model and a surface model with a 2 m precision in high (mse) and digital orthophotos with pixel size 50 cm and planimetric precision 1 m (rmse) were generated. Now, the aim is to obtain a rigorous ortho-photo every four years with a pixel size of 25 cm and a quick ortho-photo with a pixel size of 50 cm also every four years, but with 2 years of gap, that is to say, it would be produced a rigorous ortho-photo with pixel size 25 cm the first year, two years after a quick ortho-

photo with pixel size 50 cm. The plan also provides for the production of an ortho-photo with a pixel size of 10 cm for the urban areas that will be done the year in which there is no production of ortho-photo. Includes DTM obtained by Lidar techniques.

Figure 2:Natural color ortho-photo with 50cm spatial resolution.

The production is decentralised and is being done by the regional administrations with a financing of the national general administration (66% National general administration and 34% Regional administrations).

The second work plan used to carry out the coverage is the National Plan of Remote Sensing (PNT).

The National Plan of Remote Sensing coordinates the acquisition and treatment of the coverages of satellite images of our territory, in such a way that they are acquired and processed once, and can be used by all the organisms of the different Spanish administrations that need them. The responsible of the acquisition is the National Institute of Aerospatial Techniques (INTA), dependant from the Ministry of Defence.

This Plan provides regular coverage of the Spanish territory with satellite imagery of high, medium and low resolution, current and historical, as well as geometric and radiometric processing consensus by experts from the scientific community, making it possible massive use of remote sensing applied to all government agencies and public universities in Spain. Three levels of spatial and temporal resolution are considered:

The high resolution images provide coverages with satellites from 2 to 10 m of spatial resolution in panchromatic mode and 10 to 30 m in multispectral mode (satellites SPOT5, Formosat, Ingenio, etc). The planned periodicity is one year with a summer image.

From 2005 to 2009 the high resolution sensor chosen was the HRV (Hight Resolution Visible) satellite aboard SPOT5. The images captured by the image sensor is 2.5 m pixel size in panchromatic mode (single band) and 10 m in multispectral mode (4 bands). Several coverages are available throughout the Spanish territory that will be available for all the Spanish administrations for different applications.

Figure 3: SPOT5 image form the PNT 2005 coverage. Infrared false colour. Pixel size 2,5 m ("Pansharpened").

The medium resolution images provide coverages with satellite images from 10 to 15 m in panchromatic mode and from 20 to 50 m of resolution in multispectral mode (SPOT4, Landsat5; LAndsat7, IRS, Aster,…). The planned frequency of acquisition is 4 coverages per year in the different phonological periods but since May 2008 there is a continuing subscription to satellite data Landsat5, TM sensor (covering approximately 16 per year on average).

The main applications are multitemporal analysis, seasonal and year on year, automatic classifications of land covers, crops identification, or detection of irrigated lands. Also it has been proposed a project to compile and to inventory all the historic Landsat images of our territory existing since its launch, 35 year of images. Also in order to be shared.

Figure 4:Landsat 7 ETM+. Infrared false colour. Pixel size: 12,5 m ("Pansharpened").

Finally, the low resolution images provide coverages with multispectral images from 50 to 1000 m of spatial resolution (AQUA/TERRA, MODIS, ENVISAT Meris,…) and with a periodicity of 1 to 30 days, and other alternative complementary of lower resolution, are: NOAA AVHRR, SPOT Vegetation ...

The main applications are: extraction of bio-physical and environmental parameters (NDVI, soil temperature, fire risk…), information to obtain the environmental indicators required from different organisations.

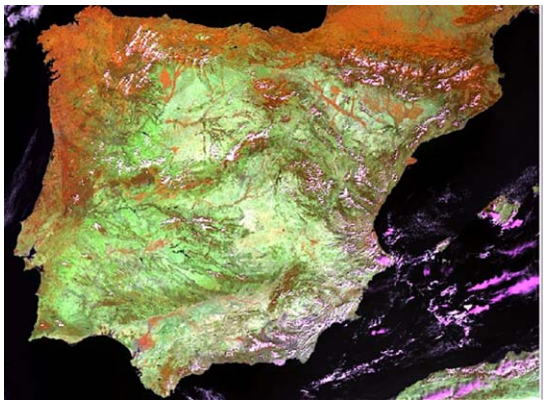

Figure 5: Low resolution image NOAA AVHRR.

Also the National Plan of Remote Sensing the principal contribution to the Spanish strategy of Herat Observation promoted by the group GEO Spain.

2nd phase: Extraction of information

In this second phase we find the Information System of Land cover/Land use in Spain (SIOSE).

As in all PNOT project, SIOSE integrate Regional Administrations in the management, quality control and production. It has a Production and Quality model based in cooperation between national and regional administrations to satisfy Spanish National and Regional Administration requirements on Land Cover and Use information and to satisfy EEA's and EU requirements in future Corine Land Cover versions and on Land Cover and Use information. The main SIOSE objective is to integrate land cover and use databases and information of the Spanish national institutions, to avoid duplicity of data and reduce costs of Geographic Information.

Some of the SIOSE technical features are a cartographic scale: 1:25.000 (according to final geometric accuracy: quadratic mean error (X,Y) $\leq$ 5 m. Screen resolution: $\approx$ 90 pixels/inch) and Geodetic Reference System: ETRS89 (according to INSPIRE and

Spanish Geographical High Council) and Cartographic Projection: UTM, zones 28, 29, 30 y 31.

The different surface minimum unit, according to the cover class in the land, is 1 ha for urban fabric and water bodies, 2 ha for agricultural land and forest and natural areas and 0.5 ha for wetlands, beaches, greenhouses and riverside vegetation. SIOSE is based on images produced by PNT, PNOA and is a Harmonized Object Oriented Data Model, UML notation (multiparameter, multilevel and extensible).

The SIOSE data model must comply different objectives as satisfy requirements of the participating organisms in SIOSE, consider all the necessary land cover/use data minimizing redundancies, organize data so that different users can access data in a view according to their needs or provide a flexible version of the SIOSE Conceptual Data Model, able of being extended in future.

The design guidelines for the SIOSE data model have been chosen taking these objectives into account. Some of these design guidelines are the division between Land Cover (biophysical criteria) and Land Use (socioeconomic criteria) or the fact that there is only one geometric entity class in SIOSE (POLYGON). Taking into account the objectives above, mixed Classes in SIOSE are created by association of singles classes and polygon (geometry and topology) must comply with the Geographical Council specifications (based on ISO19107, ISO19137 standards).

SIOSE Data model will try to keep CLC nomenclature, as long as it contains all the semantic necessary information for the different users (but Mixed CLC classes will not be kept) and will use enumeration type Classes, with prefixed values that could be modified or extended later.

SIOSE Conceptual Data model is an Entity – Relation Data model in UML notation (Unified Modelling Language). It provides normalized notation about classes and relations between them, according to ISO TC211 and Open Gis Consortium recommendations. This standardised notation provides flexibility to the model, so that Thematic Working Groups and future users can modify and extend it easily. The SIOSE Conceptual Data model has considered previous Spanish Land Cover and Use Nomenclatures and Databases, from national and regional institutions.

The organisation of SIOSE project is focused on INSPIRE Spatial Interest Communities (SDIC). The SIOSE project team has set up as a SDIC. Under it we can find the Technical workgroups (created with thematic criteria: agriculture, forest, artificial…) responsible of the elaboration of process methodology, metadata and UML data model and 19 Production groups (by geographic criteria) responsible of the production of SIOSE.

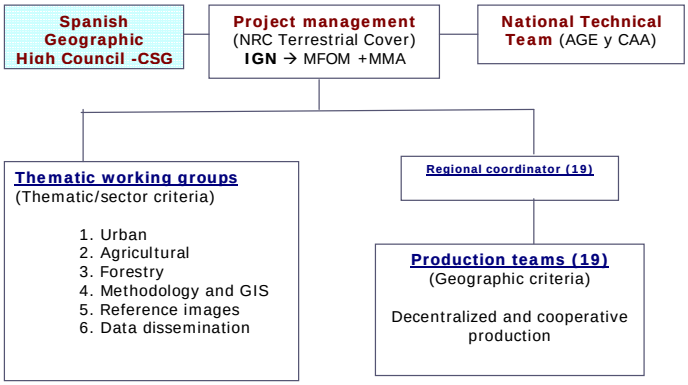

Figure 6. Institutions collaborating in SIOSE

Another component of this second phase is the National Cartographic System (SCN). Its aim is to coordinate the capture of basic topographic information. It works with scales from 1:10.000 to 1:200.000 and a periodicity from 1 to 5 years. It is an agreed data model and is based on PNT or PNOA images. The SNC is based on decentralised production (regional administrations) and generalisation and integration at national level.

A final component of this second phase is the National Plan of Indicators (PNI). The PNI develop studies, in collaboration with some Universities, about the bio-physical parameters and variables that can be used to the generation of indicators required by different regional, national, European or global organisations from medium and low spatial resolution satellite data.

3rd phase: Dissemination of information

One of the PNOT objectives is making all this information easier as well as reducing the time between the collection of data and the moment the information is available. So that is available to all the local, regional and national administrations and, in the same way, to the rest of social agents that may require it (private companies, universities, etc…). In order to get this, there are some mechanisms according to the type of the information to be distributed. For example, for the data published on data servers connected to the different spatial data infrastructures (GSDI, INSPIRE, IDEE, regional IDEE….) standard protocols according to the different type of information (WMS, WFS, WCS…) are used, the publication of data is made through applications and portals of the different organizations, the data transfer between servers of different local networks is made via FPT, data copies are made on different hardware (external USB disks, DVD…) and finally, the distribution to general public is made through different products as books, DVD, CD…

The data policy will be accorded on each regional administration, but it is foreseen that the data are available directly for all the organism participants in the project and have the major diffusion between all the agents for which they can be useful with marginal distribution costs.

CONCLUSIONS

As a consequence of all the themes exposed before we can conclude that the technological changes promote new challenges in the capture, dissemination and use of the information based on a collaborative and decentralized model of production. The European Union acts as a promoter in the assumption of such challenges.

As we have also seen, the new user's requirements need for new strategies and it is necessary the collaboration among all the public administrations and the normalised information in global systems (DS, GMES, Digital Globe, IDE's…). The economic saving achieved with this way of working is significant.

These plans are the beginning of a new cooperative and decentralised way of capture and dissemination of the geospatial information in Spain.

REFERENCES

- *Antonio Arozarena Villar, Lorenzo García Asensio, Guillermo Villa Alcázar, Emilio Domenech Tofiño. Conama 2008. Plan Nacional de Observación del Territorio en España.*
- *Equipo Técnico Nacional. 2005. Especificaciones Técnicas para el Plan Nacional de Teledetección (PNT). Madrid.*
- *Instituto Geográfico Nacional. 2009. Documento PNT versión 2.0. Madrid.*
- *Anderson, R., Hardy, E., Roach, J. T. y Witmer, R. E. A Land Use And Land Cover Classification System For Use With Remote Sensor Data. Geological Survey Professional Paper 964. A revision of the land use classification system as presented in U.S. Geological Survey Circular 671*
-*Di Gregório A., Jansen, L.J.M. Land Cover Classification System. Classification concepts and user manual, Software version (2). Revised by Antonio Di Gregorio. Based on the original software version 1. Food and Agriculture Organization of the United Nations, Rome, 2005*
- *Doc. Técnico Descripción del Modelo de Datos SIOSE versión 1.12 Equipo Técnico Nacional Proyecto SIOSE. S.G. de Producción Cartográfica, Instituto Geográfico Nacional, 2007.*