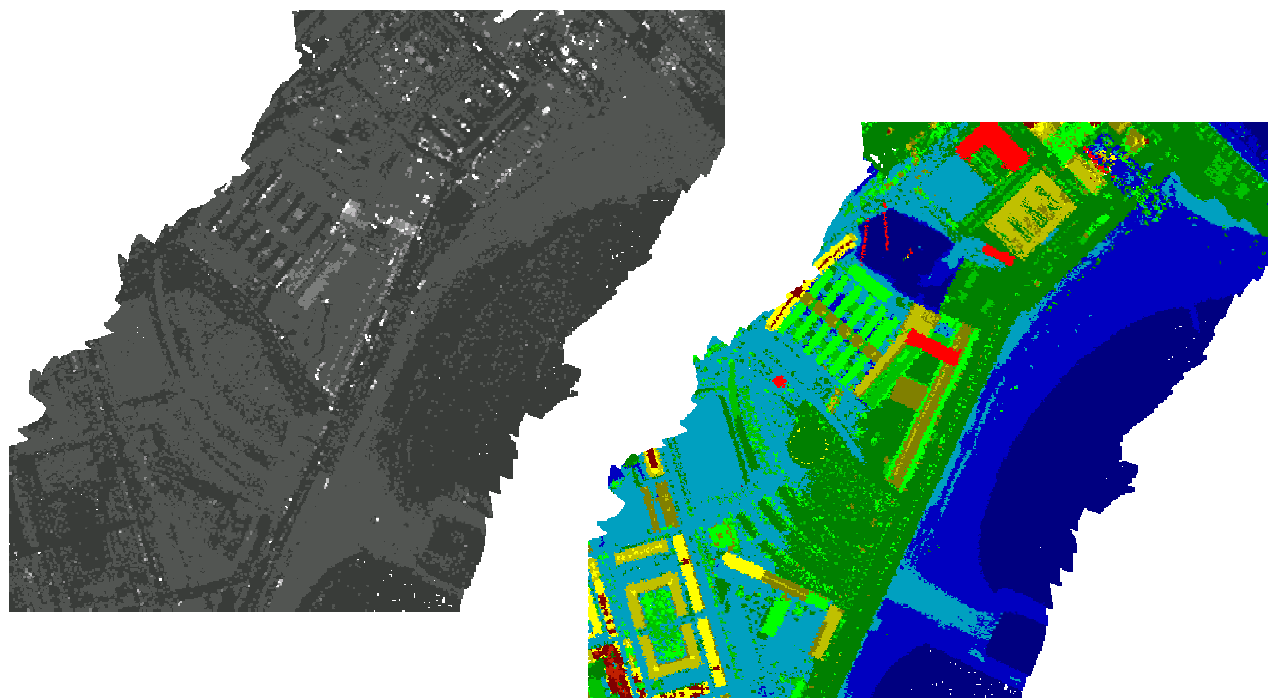


**RESEARCH, DEVELOPMENT
AND TECHNOLOGICAL INNOVATION
PROJECTS**

**INSTITUT CARTOGRÀFIC
DE CATALUNYA**

Progress report 2001-2002



Generalitat de Catalunya
Institut Cartogràfic de Catalunya

Introduction

The main objective of the Institut Cartogràfic de Catalunya (ICC) is to carry out technical tasks for the development of cartographic and geological information in Catalonia. In the research area, this involves tasks such as the preparation, reproduction and distribution of basic cartographic works; the densification and conservation of the lower order geodetic network and its integration in the Integrated Geodetic Positioning System of Catalonia; the execution of thematic cartography development programmes (geological, avalanche, geodesy, land uses, transports and communications, etc.) and cartography directed towards the evaluation of resources (the state of vegetation, areas affected by fires, snow coverage, subsidence, etc.) through the use of remote sensing techniques; the creation, structuring and organisation of the Cartoteca de Catalunya (map library), which coordinates the collection and study of existing geographic and cartographic documentation; the formation of a cartographic database with the objective of using automatic systems in the creation of cartography, which not only allows the obtention of basic cartography, but also the immediate exploitation by services like public works, the land register, etc.; the development and perfection of the seismic network of Catalonia, interconnected with the Spanish, European and world networks; the deployment of the network of nivo-climatological stations that facilitate making avalanche hazard predictions; and the publication and distribution of the works considered of public or scientific interest that are created by the ICC.

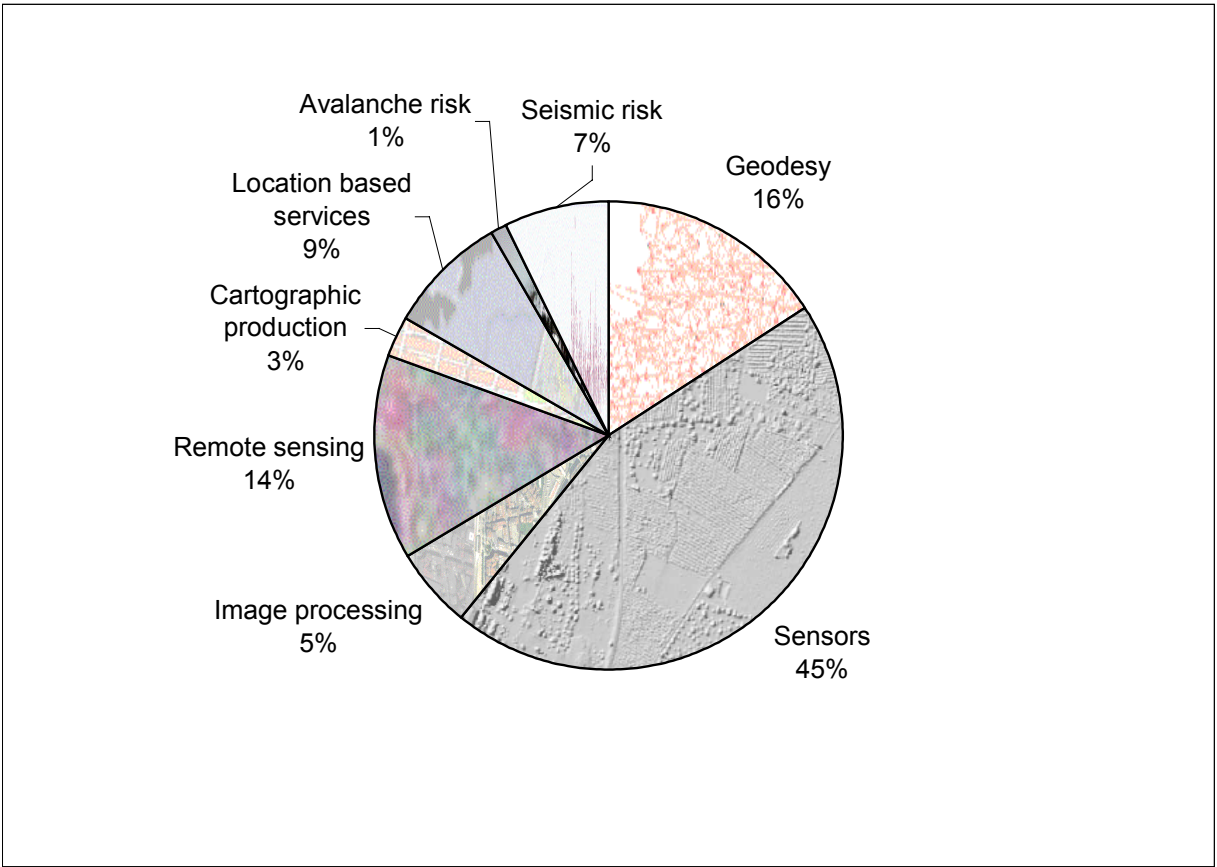
Since its creation, the ICC has placed the accent on the necessity for a symbiosis between cartographic production and the development of tools created with our own means from research, development and technological innovation. This allows us to attain capacity, versatility and efficiency in our productive standards, and also the capacity to compete technologically on an international level.

Likewise, we work on the development of proprietary software in areas like geodesy and digital photogrammetry in order to have a totally digital production installation; computer assisted data capture systems and cartographic processes; geographic information systems and their applications; data fusion between spatial remote sensing, information systems and aerial photogrammetry, and also experimentation with both passive and active sensors with photogrammetric and cartographic criteria.

This document is a progress report for years 2001-2002 of the development and technological innovation projects that were carried out within the different technological areas.

For more information: www.icc.es

May 2003



Distribution of the budget for development projects according to technological areas

GEODESY

1. GEOTEX. GEODETIC CALCULATIONS
2. NOSA. NAVIGATION AND ORIENTATION OF AIRBORNE SENSORS
3. SPGIC. INTEGRATED GEODETIC POSITIONING SYSTEM OF CATALONIA
4. DEVELOPMENT OF THE GAST SOFTWARE

SENSORS

5. DIGITAL CAMERAS
6. GEOVAN SYSTEM
7. MULTISPECTRALS SENSORS: CASI
8. EXPERIMENTAL SERIES: REMOTE SENSING

IMAGE PROCESSING

9. AUTOMATIC EXTRACTION OF OBJECTS
10. IMAGE PROCESSING: ALGORITHMS
11. CORREA. RADIOMETRIC CORRECTION OF ATMOSPHERIC AFFECTS
12. TRUEORTHO. PRODUCTION OF TRUE ORTHOPHOTOS

REMOTE SENSING

13. THEMATIC REMOTE SENSING APPLICATIONS
14. DINSAR. ANALYSIS OF SUBSIDENCE PROCESSES
15. DECIL. DETECTION OF CHANGES WITH LANDSAT 7 IMAGES
16. DEVELOPMENT OF NEW ALTM APPLICATIONS
17. SAR INTERFEROMETRY

CARTOGRAPHIC PRODUCTION

18. AUTOMATIC GENERALISATION

LOCATION BASED SERVICES

19. PARAMOUNT

AVALANCHE RISK

20. ALUDEX. IDENTIFICATION OF CATASTROPHIC AVALANCHES THROUGHT DENDROCHRONOLOGICAL AND NIVOMETEOROLOGICAL APPROACHES

SEISMIC RISK

21. POTSIS. SEISMIC POTENTIALITY OF THE EASTERN PYRENEES
 22. RISKUE: SEISMIC RISK SCENARIOS IN EUROPEAN CITIES
 23. EUROSEISRISK
 24. NEW SEISMIC NETWORK
-

GEOTEX. Geodetic calculations

Thematic area:

Geodesy

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Finalisation date:

Continued activity

Description:

GeoTeX (geodesy, remote sensing and networks) is a general adjustment system for geodesy, photogrammetry and remote sensing, suitable for both production and research, with which it is possible to adjust any type of functional model.

GeoTeX has the following characteristics:

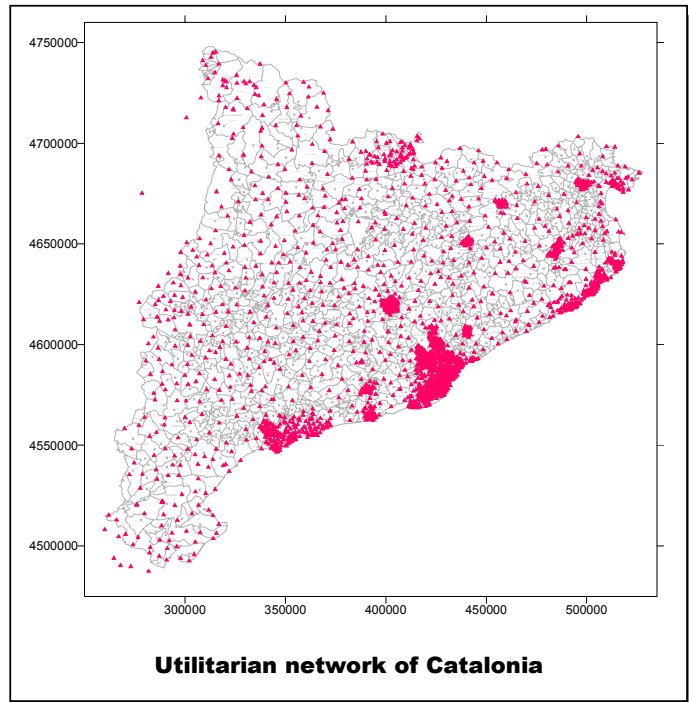
- It is universal, and can be used in both geodesy and photogrammetry.
- It is portable to different operating systems while maintaining a simple user interface.
- It is flexible, as far as both the introduction of new geometrical models and the different working modes are concerned.

The GeoTeX system is formed by:

- ACX (combined network adjustment software). This is the nucleus of the system; it calculates and adjusts any type of network (geodetic and photogrammetric observations, GPS, etc.) by least squares adjustment.
- Utilities. These are miscellaneous tools for data treatment (format conversion, transformation of coordinates, etc.).
- Calculators. These are tools directed towards specific processes. Normally they are interactive point to point versions of the utilities.

Output:

This system of calculation facilitates the integration of new mathematical models for the orientation of sensors and geodetic data processing.



NOSA. Navigation and orientation of airborne sensors

Thematic area:
Geodesy

Leadership of the study:
Institut Cartogràfic de Catalunya (ICC)

Finalisation date:
Continued activity

Description:

The aim of this development programme is the direct georeferentiation of the data measured by active (radar, lidar) and passive (multispectral and optical, including photogrammetric cameras) airborne sensors. Direct georeferentiation determines orientation by integrating the GPS (Global Positioning System) observations and those of the inertial systems with the data captured by the sensors. The specific objectives are:

- The integration of the GPS/INS data for the positioning and orientation of the sensors.
- Establishing the work flows necessary for orientation from GPS/INS data.
- Integrating the data acquisition process with the georeferentiation process.

The first operational system has been SISA, which is used to orientate the CASI (Compact Airborne Spectrographic Imager) multispectral sensor. It consists of a Litton LTN 101 inertial system, a dual frequency GPS receiver and synchronisation devices with the sensor. The second system put into production has been a commercial system for the direct orientation of one of the photogrammetric cameras of the ICC, and the third, the direct positioning system for the GeoVan (see the file on the GeoVan project).

Output:

Quasi real time direct orientation data of mobile sensors (airborne and terrestrial).

Technical publications:

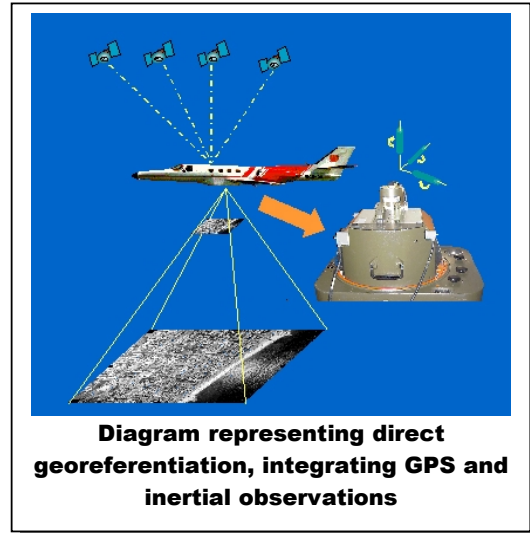
Alamús, R., Baron, A. and Talaya, J.: "Integrated sensor orientation at ICC, mathematical models and experiences", in *Proceedings of the OEEPE Workshop: Integrated Sensor Orientation*. Hanover, 2001.

Colombo, O. L., Hernández-Pajares, M., Juan, J. M., Sanz, J. and Talaya, J.: "Resolución de ambigüedades en tiempo real a escala regional con ayuda de tomografía ionosférica", in *2a Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Portugal, 8-12 February 2000.

Alamús, R. and Talaya, J.: "Airborne sensor integration and direct orientation of the CASI system", in *ISPRS*, vol. XXXIII. Amsterdam, 2000.

Colombo, O. L., Hernández-Pajares, M., Juan, J. M., Sanz, J. and Talaya, J.: "Resolving Carrier Phase Ambiguities On The Fly, At More Than 100 km From Nearest Reference Site, With The Help Of Ionospheric Tomography", in *ION GPS'99*. Nashville, Tennessee, USA, 14-17 December 1999.

Alamús, R., Talaya, J. and Colomina, I.: "The SISA/0: ICC experiences in airborne sensor integration", in *Joint Workshop of ISPRS WG I/1, I/3 and IV/4: Sensors and Mapping from Space 1999*. Hanover, 27-30 September 1999.



SPGIC. Integrated Geodetic Positioning System of Catalonia

Thematic area:

Geodesy

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Finalisation date:

Continued activity

Description:

The Integrated Geodetic Positioning System of Catalonia (SPGIC) is a group of permanent geodetic stations, networks, procedures and data that permits the determination of coordinates over the territory of Catalonia.

The concept of the SPGIC evolved from the classical concept of the geodesy network towards a more modern system, which is based on geodesic networks, on the geoid and on the GPS (Global Positioning System). The term "integrated" highlights the fact that the positioning system itself is three-dimensional integrating the horizontal and vertical reference systems and also the information on the gravimetric field contained in the geoid. This is possible thanks to the deep knowledge of the geoid of Catalonia and to the fact, that the majority of the observations are in 3D.

The SPGIC system consists of:

1. A permanent network (CATNET). The establishment of permanent GPS stations for georeferentiation, which comprises:
 - 1.1. The distribution of CATNET observations of the permanent GPS stations (Geofons service).
 - 1.2. The broadcast of the CATNET positioning corrections of the satellites obtained from the reference stations for real time navigation of vehicles. It includes the RASANT services allowing for 1 to 3 metre precision, RTK (Real Time Kinematic) with precisions between 0.02 and 0.1 metre, the RASNET service (RASANT positioning using CATNET) with precisions from 0.3 to 1 metre, and the CATPOS service (positioning using CATNET) with precisions from 0.02 to 0.2 metres.
2. An utilitarian network. The densification of around 4,000 geodetic points located near population centres, which allow for the easy access to coordinates with the precision of some centimeters for cartographic purposes.
3. The geoid of Catalonia. To reduce the density of the levelling network to only about 2,000 kilometres of levelling, using the network of the Instituto Geográfico Nacional (IGN).
4. Transformation programmes. A parameter set and/or transformation programmes for transforming the WGS84 system to the official ED50 Spanish state reference system.

Output:

A constant improvement in the public positioning service for topographic work or studies that require maximum exactitude in localisation.

Technical publications:

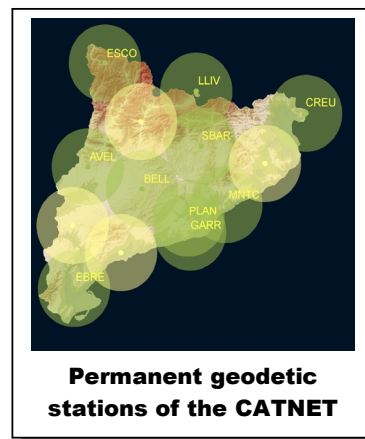
Parareda, C., Bosch, E., Térmens, A., Ortiz, M. À. and Talaya, J.: "CATNET: Servicios de posicionamiento de alta precisión y su integración en las nuevas tecnologías de la información", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.

Bosch, E.: "Nuevas tecnologías para el establecimiento de servicios de correcciones diferenciales GPS", in *Proceedings de la 4a Setmana Geomàtica de Barcelona*. Sitges, 3-6 April 2000. "Jordi Viñas" Award.

Talaya, J., Bosch, E., Ortiz, M. À. and Parareda, C.: "CATNET: una red de estaciones permanentes GPS con capacidades de tiempo real", in *Proceedings de la 4a Setmana Geomàtica de Barcelona*. Sitges, 3-6 April 2000.

Talaya, J.: "Robust GPS kinematic positioning for direct georeferencing", in *ISPRS*, vol. XXXIII. Amsterdam, 2000.

Talaya, J. and Bosch, E.: "CATNET: A permanent GPS network with real time capabilities", in *ION GPS'99*. Nashville, Tennessee, EUA, 14-17 December 1999.



GAST: Airborne gravimetry

Thematic area:
Geodesy

Leadership of the study:
Institut Cartogràfic de Catalunya (ICC)

Other participants:
Institut de Geomàtica

Finalisation date:
2003 (first phase GAST-01)

Description:

The knowledge of the variations in the gravitational field is highly important for geodesy, geophysics and navigation, especially since the introduction of satellite based positioning systems. The efficient and precise modelling of these variations, specifically the determination of the geoid, is one of the main activities of present day geodetic research.

The gravitational field can be determined by different types of measurements: satellite/land-based gravimetry and gradiometry, the combination of GPS heights with levelling, airborne gravimetry, satellite altimetry, astronomical deflections from the vertical, etc. Airborne gravimetry is based on the differences between inertial accelerations and GPS to obtain anomalies in gravity: the inertial sensors allow for the determination of the sum of the acceleration due to gravity and the acceleration due to the dynamics of the aeroplane, while the GPS receiver only provides the acceleration due to the dynamics of the aeroplane. Subtracting both data sets results in the gravity acceleration with a precision of approximately 2-3 mGal, sufficient for the determination of a precise geoid.

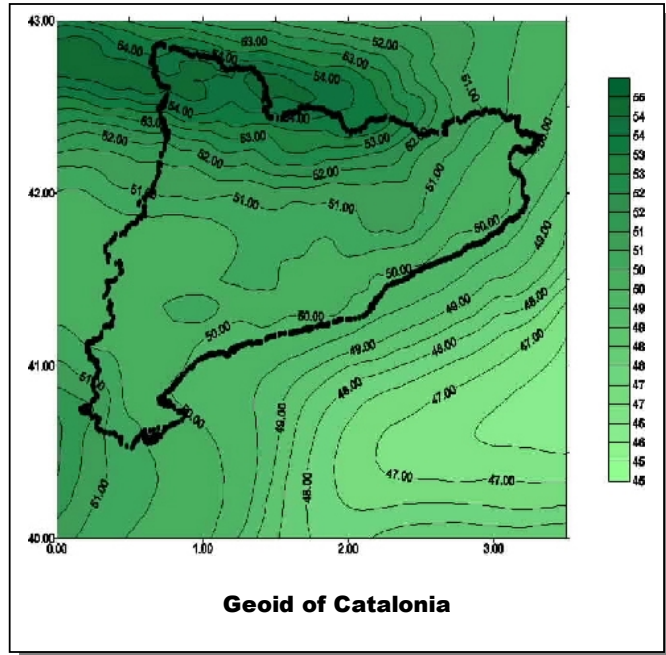
The first phase of the project (GAST-01) consists in developing the software for inertial trajectory determination (positions, velocities and attitudes) from the observations of inertial systems assisted by position and velocity observations obtained from the GPS system.

Output:

Given a certain level of precision, airborne gravimetry is superior in economy and efficiency to the land-based methods, above all in remote areas and in case of difficult access.

Technical publications:

Creixell, F., Colomina, I. and Baron, A.: "GAST-1: Determinación precisa de trayectorias con sistemas inerciales y GNSS", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.



Digital cameras

Thematic area:

Sensors

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Other participants:

NTE

Finalisation date:

2005

Description:

The objective is the design of a large format digital aerial camera for cartographic purposes. The use of digital cameras in photographic flights implies increased quality and reduced costs, as it is possible to by-pass completely the manual laboratory processes and the scanning of the frames, while avoiding the geometric distortions, radiometric degradations and imperfections due to the processes mentioned. An additional benefit is the possibility of taking images with less light, in terms of extending the daily flight window as well as increasing the length of the flight season.

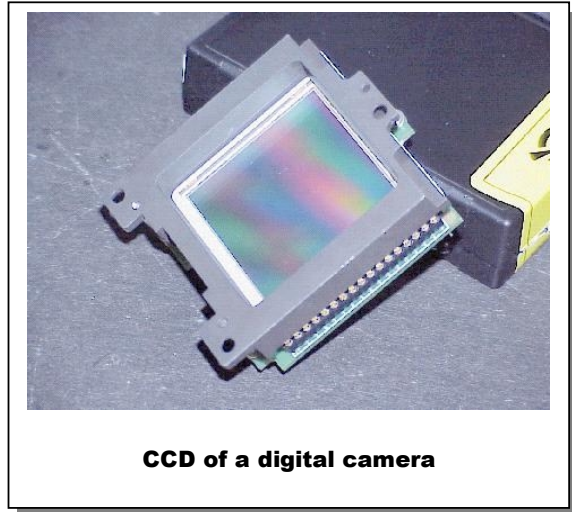
In the design of large format systems, the principal problem arose from the fact that the CCD (Charge Coupled Device) arrays are small compared with traditional 23 x 23 cm image format of aerial photography. The use of just one CCD array implies a lack of economy in the practical use due to the related increase of the number of flight passes.

The solution to the problem has been tackled in two different ways: 1. by linear CCD arrays, which scan the terrain line by line during the forward motion of the aeroplane and 2. by hooking up four cameras, each with a relatively large aerial CCD array (7,000 x 4,000 pixels, for example) or other more or less ingenious solutions.

Two designs have been studied in the ICC's work programme: 1. a digitisation *kit* coupled to the optics of a photogrammetric film cameras. Here, the image is concentrated over a distribution of several CCD arrays in the focal plane by optical techniques, and 2. a complete camera design including the optical section. The projects include the validation of the concept, the determination of critical points, the design of the calibration tools, software development and the validation of a prototype.

Output:

Emphasis on large format to substitute the actual metric analogue cameras.



GEOVAN. Primary information capture and orientation system from a vehicle

Thematic area:
Terrestrial sensors

Finalisation date:
2003

Description:

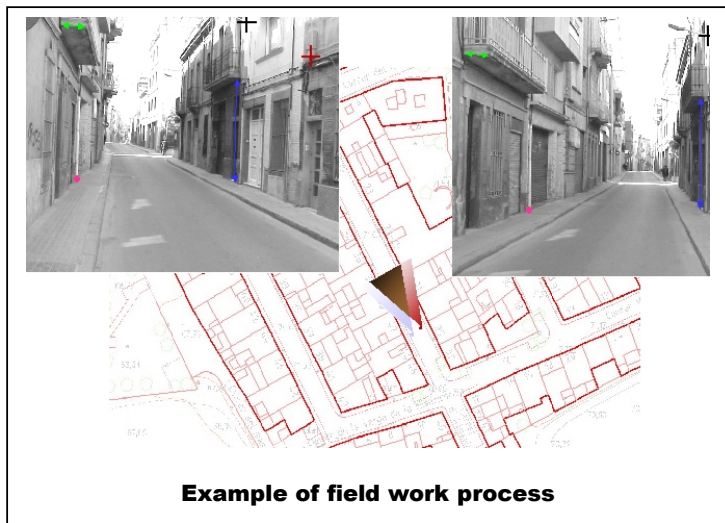
The GeoVan is a system for continuous image capture from a land-based vehicle in movement. Beside the sensor systems (two optical cameras and a terrestrial laser scanner) it includes a direct orientation system (see the NOSA project) and also the software necessary for the georeferentiation of the images and the subsequent interpretation and capture of information. As the system is based on images taken from a vehicle in movement, field capture is very fast. The same images can be used to capture different objects according to the type of application, without the need to return to the field.

The systems for the capture of digital images pairs are integrated with the elements for the direct orientation of the images which is based on the integration of GPS (Global Positioning System) and IMU (Inertial Measurement Unit) observations.

The software includes the calibration of the different sensor elements as well as the exploitation of the images, including a.o. selection and visualisation functions, the determination of the position coordinates of selected objects and the selection and drawing of identified objects to store them in a geographic information system. The exploitation system can be personalised according to the particular type of application. The system gives a precision of better than 1 metre in the determination of coordinates, a precision that is compatible with cartography of 1:5,000 scale.



**General view of the
ICC's GeoVan**



Example of field work process

Output:

A new development in the Spanish state that facilitates field data gathering tasks for multiple applications and areas: street furniture, road furniture, architecture, etc.

Technical publications:

Bosch, E., Alamús, R., Serra, A., Baron, A. and Talaya, J.: "GEOVAN: El sistema de cartografía terrestre móvil del ICC", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.

Serra, A.: "Subsistema de adquisición de datos del sistema Geovan", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.

Multispectral sensors: CASI

Thematic area:

Sensors

Leadership of the study:

Institut Cartogràfic de Catalunya
(ICC)

Finalisation date:

Continued activity

Description:

A work programme for the development and exploitation of airborne multispectral sensors, especially the CASI sensor (Compact Airborne Spectrographic Imager) in operation in the ICC.

The CASI is a multispectral sensor that captures images in 288 spectral channels selectable from within the visible spectrum and the near infrared spectrum, and which can be applied to a whole range of thematic applications related to land coverage and uses. The forerunners of these applications are the satellite sensors, and especially, those of the Landsat TM family of satellites that began in 1972 and which were the genesis of the concept of global Earth observation satellites. Both the greater spatial and spectral resolution of the CASI make it highly appropriate for very specific applications: precision agriculture, water quality, forestry diseases, etc.

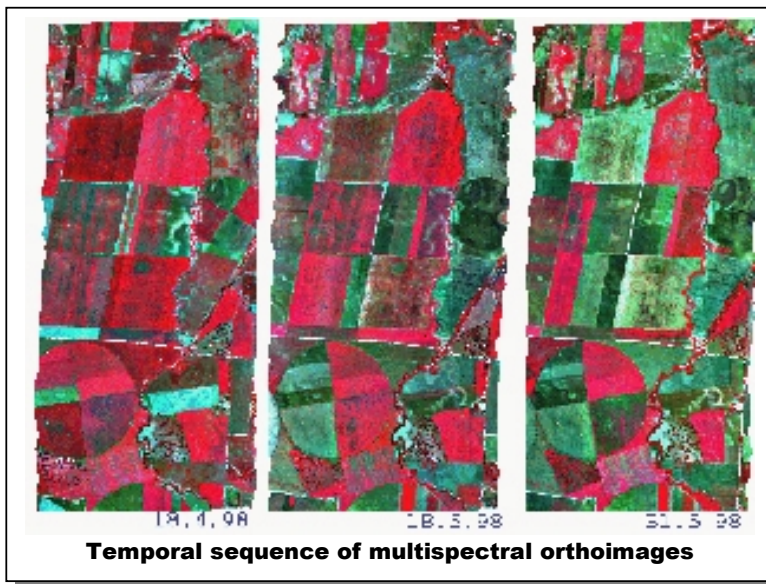
The CASI sensor sweeps the terrain line by line and each of these is affected by the movement of the aeroplane. Geometric correction and georeferentiation is carried out through the SISA system developed at the ICC in the framework of the NOSA orientation and navigation programme.

Output:

The CASI is the only low cost multispectral sensor available in the Spain and it has been used in numerous thematic applications. Of these, we should highlight the coastal and continental water quality analysis applications, and those used in precision agriculture to give farmers quantitative values for the fertilisers that should be applied to crops. It is planned to carry out forestry control experiences together with laser altimetry data.

Technical publications:

Palà, V., Alamús, R., Pérez, F., Arbiol, R. and Talaya, J.: "El sistema CASI-ICC: un sensor multiespectral aerotransportado con capacidades cartográficas", in *Revista de Teledetección*, No. 12, pages 89-92. Asociación Española de Teledetección. December 1999.



Experimental series: Remote sensing

Thematic area:

Sensors

Leadership of the study:

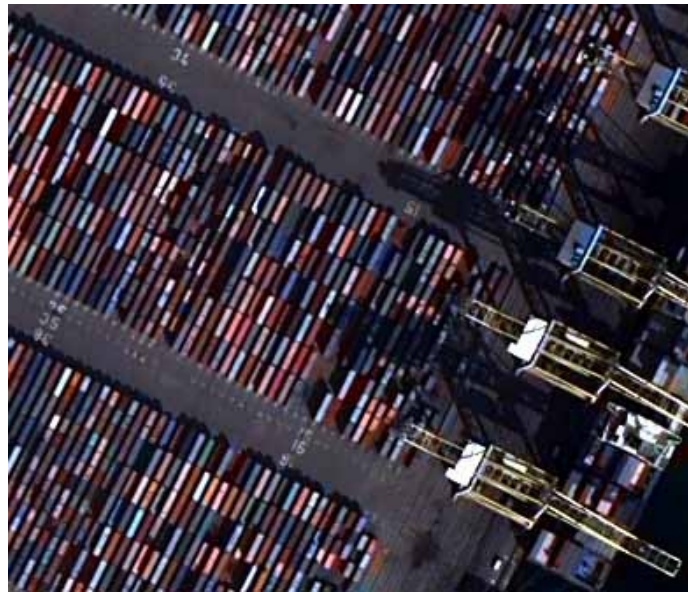
Institut Cartogràfic de Catalunya (ICC)

Finalisation date:

Continued activity

Description:

The programme has the objective of acquiring in depth knowledge of the cartographic possibilities of the new cartography application sensors –especially the stereoscopic sensors on satellites– as well as to prepare and adapt the proprietary and commercial production systems both for the image map production chain and for topographic cartography.



QuickBird Image of the Port of Barcelona

An important part of these tasks involves the study of the geometric model of the sensor that defines the geometry of the image formation process. This model has a series of free parameters that are adjusted through a group of control points of known position on land and pairs of homologous points between images. The adjustment and the determination of the orientations of the images is carried out with the ICC's GeoView/Ajumult aero-triangulation system. Subsequently, a generic transformation is derived from this, that uses the commercial systems of digital photogrammetry for photogrammetric stereoplotting. In the case of orthoimages, the sensor model is implemented in the rectification software.

In this case, the uncertainties are basically linked to the orbit of the satellite and its attitude. At the moment the models of the RadarSat and ERS (radar), Landsat, SPOT, MOMS and Ikonos (optical) sensors are known, and Envisat (radar) and Quickbird, Eros 1A and other similar optical sensors are in the study phase.

Output:

Proprietary technology for using satellite images in cartographic projects, especially stereoscopic projects. This milestone was achieved in 1999 and represents the possibility of being able to use the application of a photogrammetric stereoplotter with any kind of stereoscopic sensor, both optical and radar.

Technical publications:

Palà, V., Calvet, J., García Sellés, D. and Ximenis, L.: "Fotogrametría terrestre en el Glaciar Johnsons, Isla Livingston, Antártida", in *Acta Geologica Hispanica*, vol. 34, No. 4, pages 427-445. Barcelona, 1999.

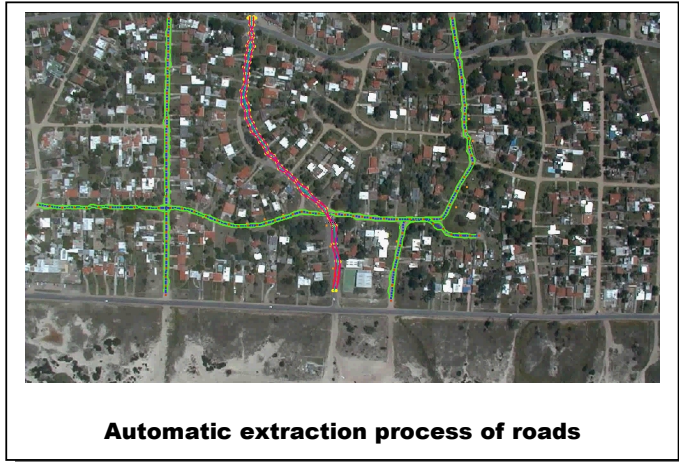
Automatic extraction of objects

Thematic area:
Image processing

Leadership of the study:
Institut Cartogràfic de Catalunya (ICC)

Other participants:
Centre de Visió per Computador of the
Universitat Autònoma de Barcelona
(CVC/UAB)
Departament de Matemàtica Aplicada II
of the Universitat Politècnica de Catalunya
(MA2/UPC)

Finalisation date:
2004



Description:

Generally speaking, the aim of semi-automatic extraction of objects is to capture (delineate) semi-automatically some of the objects present in a digital image. The scientific discipline is based on automatic line following algorithms, outline detection, geometric modelling, artificial intelligence and the creation and exploitation of knowledge bases of the objects and their relationships. Applied to cartography, the objective is to automate tasks in the capture of cartographic information from aerial images. In addition, coincidentally, they have also been applied to detect and repair certain elements that could cause problems in the appearance of orthophotographs (spurious elements, scratches...).



In the present phase, an algorithm and an environment have been developed for the semi-automatic capture of parcels that combine aspects of mathematical morphology and adaptable outline models, and that are capable of delineating the outline of the element identified as a parcel. The implemented parcel extraction algorithms have been integrated into a commercial software, that also takes into algorithms from other developers to extract buildings.

The development of a semi-automatic capture tool for linear elements of homogeneous radiometry with the adaptation of the deformable models and regions competition algorithm that has been presented as an end of career project has also been finalised. The project was developed in collaboration with the Departament de Matemàtica Aplicada II of the UPC.

Also as an end of career project in collaboration with MA2/UPC has been implemented the semi-automatic detection and reparation of spurious elements that can appear in digital images, as fibres. This algorithm is based in locating this elements by using special signal detection, reconstruct them by a graph analysis and repair the located problem taking into consideration the surrounding image information. This application has been integrated into the production orthophoto workflow.

Output:

The semi-automatic extraction of elements in aerial images is an issue that could bring a reduction in interaction, and therefore, increase the reliability of the final product and reduce the time devoted to manual capture.

Technical publications:

Torre, M. and Radeva, P.: "Agricultural field extraction from aerial images using a region competition algorithm", in *ISPRS*, vol. XXXIII. Amsterdam, 2000.

Torre, M. and Radeva, P.: "Agricultural-field extraction on aerial images by region competition algorithm", in *Computer Vision and Image Analysis*, vol. 1, pages 313-316. International Conference on Pattern Recognition. IEEE Computer Society. Barcelona, September 2000.

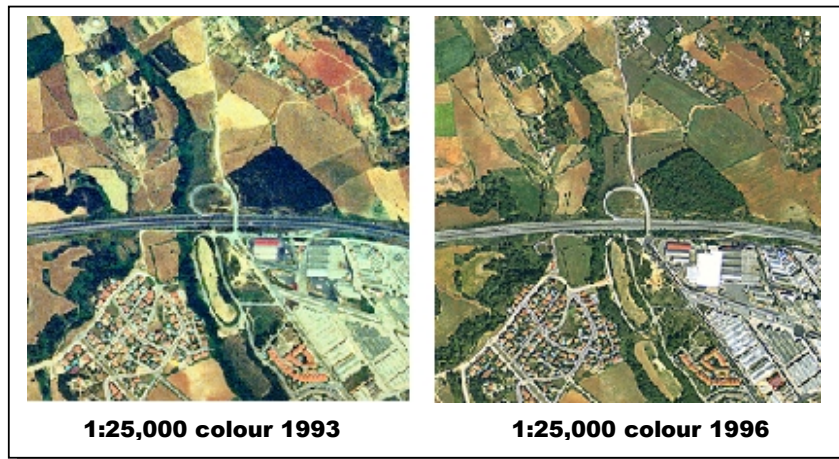
Image processing: Algorithms

Thematic area:
Image processing

Leadership of the study:
Institut Cartogràfic
de Catalunya (ICC)

Other participants:
Departament d'Astronomia
of the Universitat de
Barcelona

Finalisation date:
Continued activity



Description:

A large number of the ICC's projects are based on the processing of digital images and use proprietary software. The ICC is continually developing image treatment tools to improve the images and exploit the information contained in the digital images.

The aim of this project is the development of new image processing tools and algorithms and to adapt the existing tools to the necessities of the productive remote sensing projects.

Output:

The support necessary to obtain optimum quality digital products.

CORREA. Radiometric correction of atmospheric effects

Thematic area:
Image processing

Leadership of the study:
Institut Cartogràfic de Catalunya (ICC)

Finalisation date:
2004

Description:

The analysis, design and introduction of an atmospheric correction system for passive remote sensing sensors –optical sensors– on board satellites and aircraft. The aim is to reduce the impact of gaseous absorption, Rayleigh and Mie scattering, that the atmosphere provokes in the radiometry of the images.

The method is based on the calculation of parameters of the equation of radiative transfer and radiation data in a group of points with simulations of the 6S code, bearing in mind the following factors: the angle of solar illumination (date and time of the image), the angle of observation (FOV), atmospheric profiles (standard or SMC data) and ozone (TOMS data), type and quantities of aerosols (standard or DDV method).

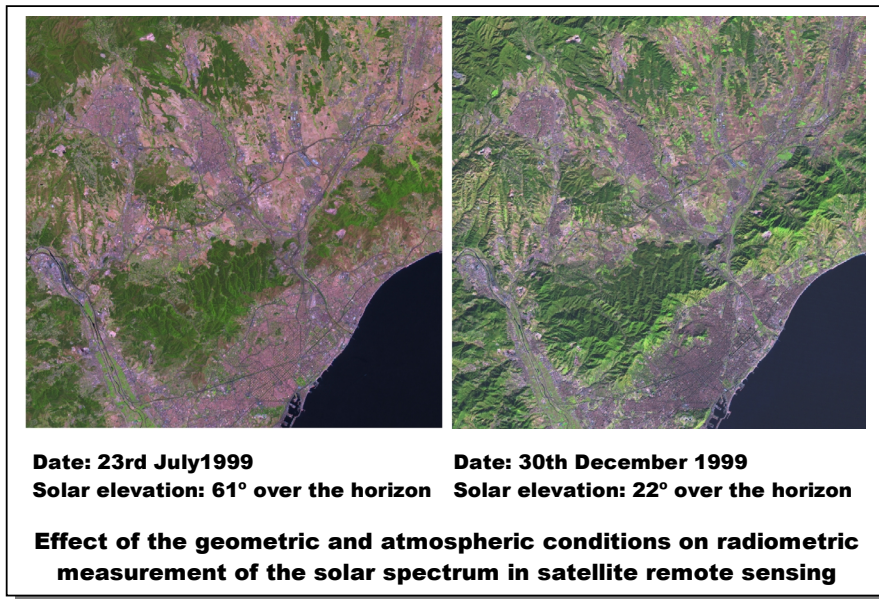
This data permits calculating the reflectance corrected atmospherically through the interpolation of the pixels situated between the points of calculation. The method includes the possibility of recuperating the contrast lost through scattering of the sensor-atmosphere system, the effect of the topography and calculating apparent reflectances.

Output:

This project brings an improvement in the analysis and data treatment processes in different remote sensing processes, both thematic and cartographic.

Technical publications:

Martínez, L., Palà, V. and Arbiol, R.: "Sistema de correcció atmosfèrica en espectre solar por métodos físico-estadísticos", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.



TRUEORTO. Production of true orthophotos

Thematic area:
Image processing

Leadership of the study:
Institut Cartogràfic de Catalunya (ICC)

Finalisation date:
Continued activity

Description:

The digital orthoimage is a widely used cartographic product, either as a complementary element for traditional cartography, or to allow extracting information distinct from what is usually found on a topographic map.

Habitually, the standard procedures of the generation of orthoimages make certain simplifications that have to be taken into account when working with high resolution images over urban areas or over man-made structures. In the first place, the digital terrain models (DTM) that are used are normally derived from existing cartography, which represents the terrain at ground level without showing the structures that exist over it (trees, buildings). Secondly, buildings will normally cause hidden zones, in other words, areas that should be present in the orthogonal projection of the terrain, but are covered by a building in the photograph to be corrected.

The TRUEORTO project is based on a system for the generation of orthoimages that resolves the problem of the non-visible zones caused by the occultations of the relief (for example, very high buildings). The programme requires a triangular elevations model and photogrammetric flights with high overlap.

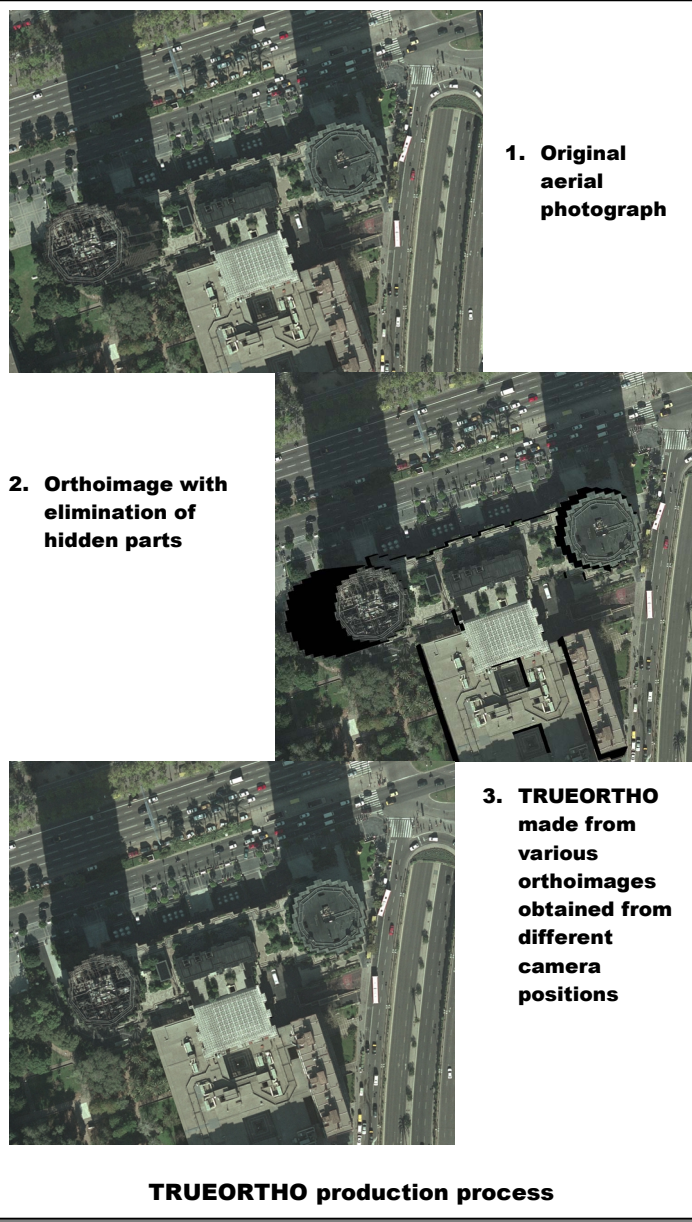
The aim of the project is to develop the software and the methodology for the production of large scale orthophotographs in urban zones and the realisation of test projects.

Output: Improvement in the orthophotograph production process and the quality of the products created.

Technical publications:

Palà, V. and Arbiol, R.: "True orthoimage generation in urban areas", in *Proceedings of the 3rd International Symposium Remote Sensing of Urban Areas*, volume 1, pages 309-314. Istanbul, 2002.

Palà, V. and Arbiol, R.: "True Orthoimagery of Urban Areas", in *GIM International*, vol. 16, No. 12, pages 50-51. Lemmer, 2002.



Thematic remote sensing applications

Thematic area:

Remote sensing

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

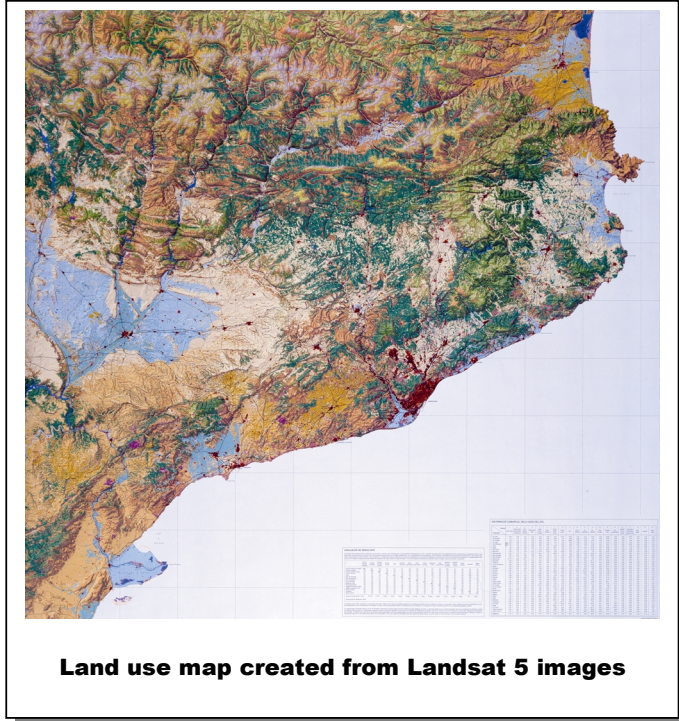
Finalisation date:

Continued activity

Description:

One of the ICC's main activities is the execution of programmes for the development and creation of thematic cartography, directed towards the evaluation of the resources available and of environmental problems, through the use of remote sensing techniques (forest fires, land uses, etc.) or through other techniques (geology, the evaluation of natural risks, etc.).

Within the area of remote sensing, work is carried out on the production of thematic cartography from photo-interpretation work and the classification of the images obtained by remote sensing, with the aim of obtaining land use and land cover cartography.



The objective of the experimental series project is to carry out initial tests with new sensors in order to exploit them for thematic cartography applications (land use, vegetation), as well as to analyse market tools for the improvement of multispectral image classification processes or for the textural classification of high resolution images.

Output:

This project responds to the necessity to have tools and systems that allow controlling and administering the development of the territory and the environment. An example of this necessity is the European Union's GMES (Global Monitoring for Environment and Security) programme.

Technical publications:

Otazu, X. and Arbiol, R.: "Land use map production by fusion of multispectral classification of LANDSAT images and texture analysis of high resolution images", in *ISPRS*, vol. XXXIII. Amsterdam, 2000.

DINSAR. Analysis of subsidence processes

Thematic area of PTOP

Territory and information

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Finalisation date:

2006

Description:

Subsidence is the slow downward movement of the terrain due to different causes. The classical technology for recording this is topography. Recently, however, experiments have been carried out based on differential radar interferometry techniques, which allows following this kind of phenomenon from satellites.

Specifically, the ICC has developed a system to determine the altimetric changes between two sets of data from images from the Synthetic Aperture Radar (SAR) of the ERS satellites of the ESA, using differential interferometry, a technique that permits attaining centimetric precisions from space.

The radar provides two types of information: the intensity of the return of the signal and a phase, related to the distance between the sensor and the object observed. This phase is the information that interferometry uses to derive the terrain elevations from two images taken from slightly different positions. When these positions are practically the same, but taken at two moments separated in time, the differences that have occurred on the terrain due to landslides, earthquakes or subsidence can be measured.

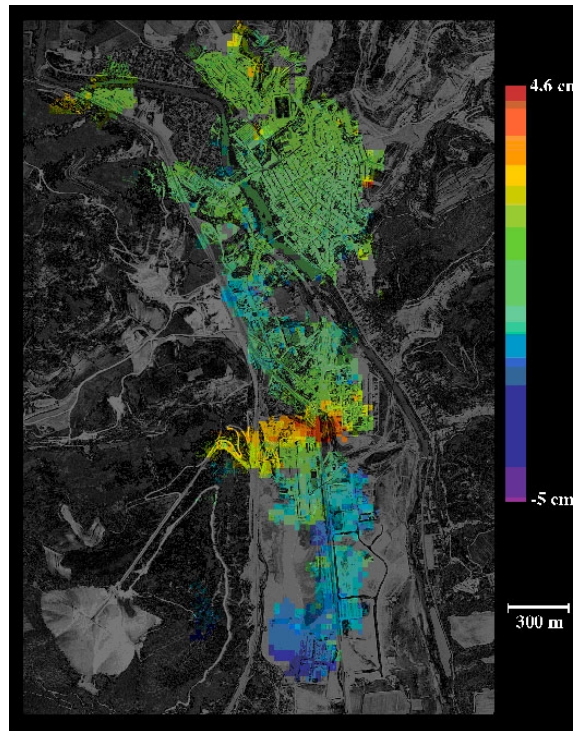
Real cases of subsidence have been studied in the project, comparing the results obtained through the use of differential interferometry with the precision levelling measurements taken in the field. The results have been good enough to be able to combine this technique with the reliable high precision measurements provided by topography and geodesy and to extrapolate the results to the permanent control of a much more extensive territory at a lower cost.

Output:

A high precision operational system for the permanent control of subsidence phenomena.

Technical publications:

Arbiol, R., Palà, V., Pérez, F., Castillo, M. and Crosetto, M.: "Aplicaciones de la tecnología InSar en la cartografía", in *Proceedings del IX Congreso Nacional de Teledetección*, pages 653-657. Lleida, 2001.



Analysis of subsidence in a municipality from differential interferometry

DECIL. Detection of changes with Landsat 7 images

Thematic area:

Remote sensing

Leadership of the study:

Institut Cartogràfic de Catalunya
(ICC)

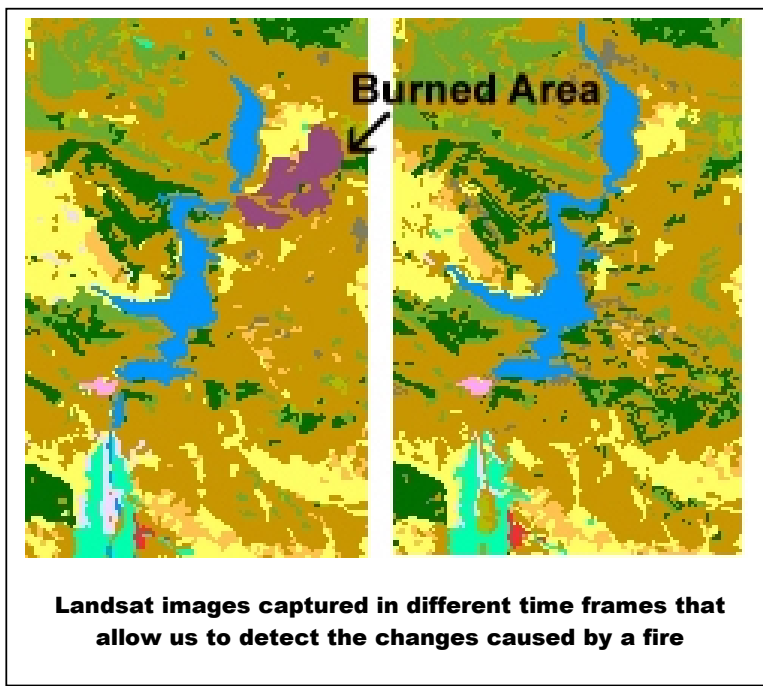
Finalisation date:

2004

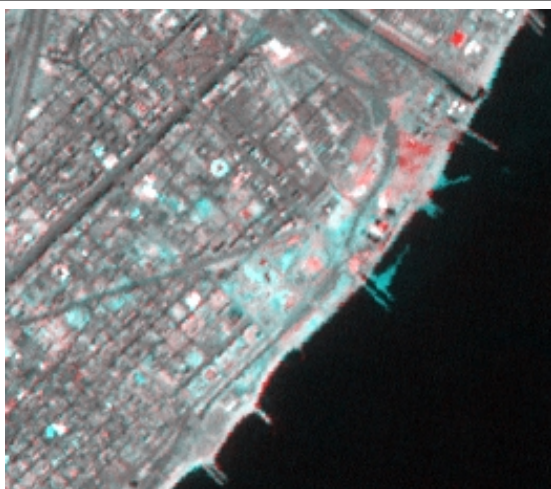
Description:

The objective of the project is to use the images from the Landsat 7 sensor to semi-automatically detect territorial changes that are significant for the rapid actualisation programmes of the topographic cartography of the ICC.

The project was started by determining test areas in order to identify the power and the results of the different methods of change detection that are intended to be tested, which are based on quantitative techniques.



Landsat images captured in different time frames that allow us to detect the changes caused by a fire



**Panchromatic Landsat 7 image.
Multitemporal composition (1999-2001)
in false colour**

Initially, atmospheric corrections are applied to the images with the methods developed in the CORREA project, described previously. The detection of changes is carried out on the basis of temporal series of images from the Landsat 7 sensor.

Output:

Development for the monitoring of territorial changes for cartographic planning applications. We should point out that this technology has the potential to channel economically reasonable territorial monitoring and control programmes.

Technical publications:

Martínez, L., Palà, V. and Arbiol, R.: "Discriminación de nubes, agua e innivación en series de imágenes corregidas y compensadas físico-estadísticamente", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.

Development of new ALTM applications

Thematic area:

Remote sensing

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Other participants:

Centre Tecnològic Forestal de Catalunya (CTFC)

Finalisation date:

2005

Description:

The laser scanner (LIDAR) is an active sensor that emits laser pulses and obtains the 3 point coordinates by measuring the return time of the signal emitted. It can differentiate the first and the last pulse of the rebound, which allows it to discriminate the return from tree tops from the return from the ground, and through the difference, obtain an approximation of the height of the vegetation.

With present techniques, it is possible to measure the distance travelled by the laser to within a centimetre of precision, despite the fact that the GPS and inertial system errors reduce this precision to 15 cm in normal operational conditions.

The ICC's system is capable of measuring 25,000 points per second and operates between 175 and 3,000 metres over the terrain, both by day and by night. The high point density –one per square metre is easily achievable– means that this technology is an alternative to photogrammetry for the massive obtention of terrain elevations. Although the system has mainly been used until now for the generation of high precision terrain models, above all within the PEFCAT project for the determination of flood risks, this technology can serve for other applications, such as:

- Monitoring the coastline.
- Electric power line cartography.
- Three-dimensional models of cities for telephony antenna location applications.
- Quantification of snow volume to estimate water volume through melting.
- Analysis of the vegetation coverage for forestry studies.

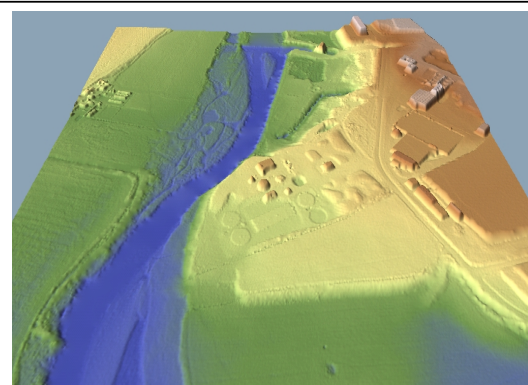
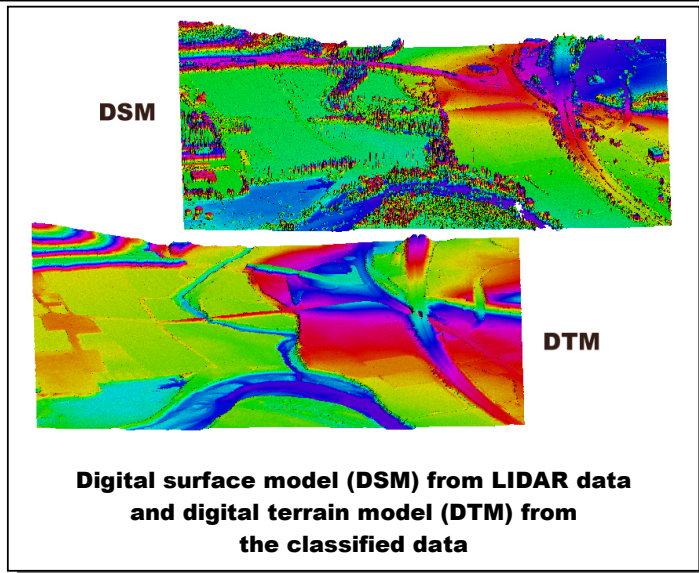
This last application will be developed with the Centre Tecnològic Forestal de Catalunya to determine the characteristics of the vegetation coverage of forests.

Output: Development of new LIDAR applications.

Technical publications:

Ruiz, A. and Kornus, W.: "Experiencias y aplicaciones del LIDAR", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.

Ruiz, A., González, X., Herms, I. and Bastianelli, L.: "Flood Risk Mapping Based on Airborne Laser Scanner Data: Case of the Llobregat River", in *Proceedings of the International Conference on Flood Estimation*. Berna, 2002.



SAR interferometry

Thematic area:
MET Production

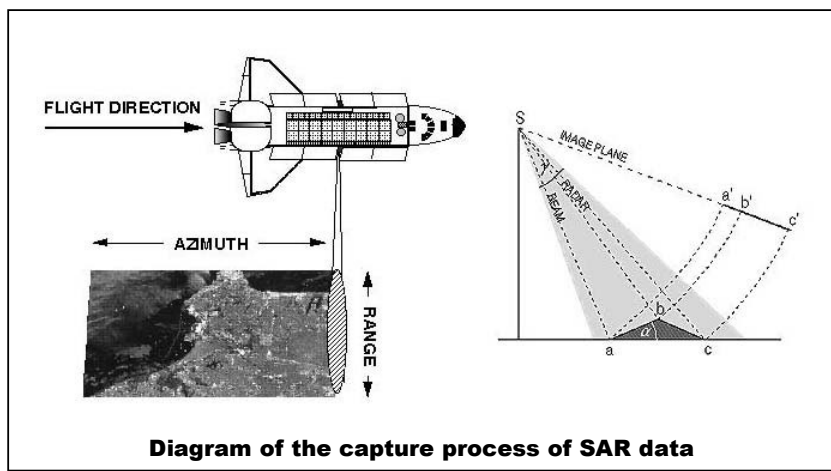
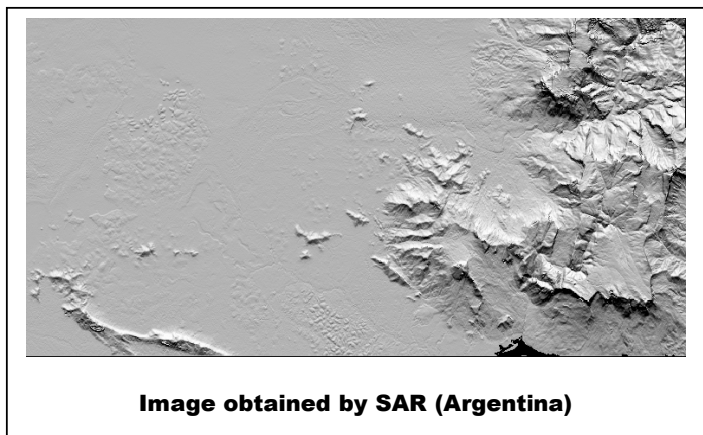
Leadership of the study:
Institut Cartogràfic de Catalunya
(ICC)

Finalisation date:
Continued activity

Description:

Synthetic Aperture Radars (SAR) provide two kinds of information: the intensity of the return of the signal and a phase, related to the distance between the sensor and the object observed. This phase is the information that is used to determine terrain elevations from the interferogram of two images that are captured from positions that are slightly different from each other.

The aim of the work programme is the development and introduction of radar interferometry techniques for the determination of elevations. Specifically, appropriate tools have been developed in order to derive altimetric information from groups of interferometric pairs of ERS images, as well as to develop specific tools for the visualisation of this data and the interactive publication of complex cases.



The ICC has developed its own production chain and has applied these techniques in different development and production projects in boreal zones with almost permanent cloud coverage from images from the European ERS 1 and 2 satellites. The differential interferometry technique for the analysis of subsidence is described in a different place. In the near future this will be applied to ENVISAT images.

Output:

Attain the only viable technology for the determination of terrain elevations in tropical and boreal zones that are almost permanently covered by clouds.

Technical publications:

Arbiol, R. and González, G.: "Map production in Venezuela using airborne InSAR", in *ISPRS*, vol. XXXIII. Amsterdam, 2000.

Automatic generalization

Thematic area:

Cartographic production

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Finalisation date:

Continued activity

Description:

The objective of cartographic generalization is to produce a clearly legible and interpretable map or cartographic database from information that is considered too abundant and with too much detail for the representation scale. Normally, cartographic generalization is applied to obtain a map or a database from data at larger scales.

Since 1993 the ICC has evaluated commercial software to analyze generalization functions, to quantify the savings derived by using generalization and to define the conditions where the software can be applied. At present, the software Change, developed by the University of Hannover, and our own software are used in the production of the 1:10,000 Topographic Map and the 1:25,000 Topographic Database, both derived from the 1:5,000 Topographic Database.

The ICC has also developed algorithms and editing tools for manual generalization. Algorithms include the collapse of lines for the centerline generation of roads or canals from the margins, the collapse of areas to symbol points maintaining the orientation of the original area, and the generalization of the map names. The editing tools include the alignment of buildings following a street, the alignment of symbols along a road, the orthogonalization of buildings, the detection of polygons smaller than the minimum area and the geometric treatment of elements for the creation of nodes, chains or polygons. For the database generalization, some tools have been developed to maintain the Z coordinates of the original database.

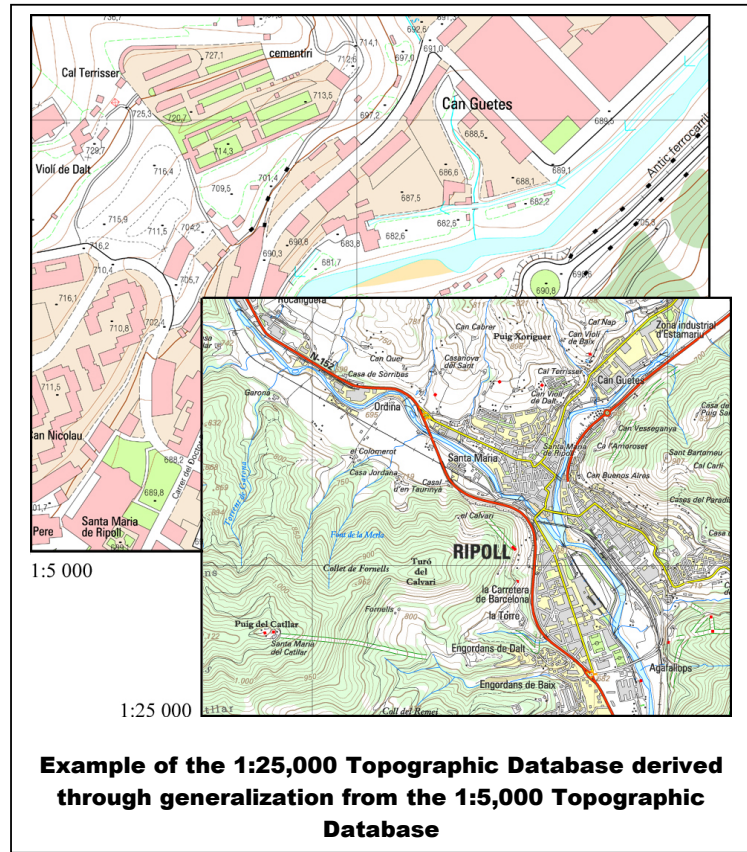
In spite of its these workflows are in production, unsolved problems remain. The existing tools provide solutions to the geometric and topological aspects of the generalization, but the tools to solve the problem of the actualization of the databases obtained by generalization are still lacking. These have to be based on the possibility of establishing links between the original database and the generalized base.

Output: Practical experiences in cartographic production using cartographic generalization.

Technical Publications:

Baella, B. and Pla, M.: "Some generalization practices on relief representation derived from the Topographic database of Catalonia at scale 1:5,000", in Proceedings of the Second Symposium of the Commission on Mountain Cartography of the International Cartographic Association, pages 7-16. Dresden, 2000.

Baella, B. i Pla, M.: "Map generalization to obtain the Topographic Map of Catalonia 1:10,000", in Workshop on Progress in Automated Map Generalization. ICA. Ottawa, August 1999.



PARAMOUNT. Public safety and commercial info-mobility applications and services in the mountains

Thematic area:

Location based services

Leadership of the study:

IfEN Gesellschaft fuer Satellitennavigation mbH

Other participants:

Institut Cartogràfic de Catalunya (ICC), AGIS, University of the Bundeswehr, Munich, Bayerische Bergwacht (Bavarian Mountain Rescue Service), Österreichischer Bergrettungsdienst (Austrian Mountain Rescue Service).

Finalisation date:

2003

Description:

The PARAMOUNT project (Public sAfety & commeRcial info-mobility Applications and services in the MOUNTains) is a pilot project for a localisation, information and navigation service addressed to mountaineers and mountain rescue services, financed by the IST programme of the European Union. The components of this service are:

- Infotour. This provides the user with navigation functions and diverse local information (tourist, meteorology, avalanche hazard).
- Safetour. Provides information related to mountain safety and permits monitoring registered users in dangerous zones, and the alert and coordination of rescue teams in emergency situations.
- Datatour. Involves users in the acquisition and maintenance of the database necessary to carry out these services.

The communication between the servers and the mobile devices (pocket PC with GPS, electronic compass and mobile telephone) is carried out through GPRS technology. The data is transferred via HTTP protocol using XML.

One of the ICC's main contributions to the project is the development of the "cartographic avalanche forecasting", through the combination of the avalanche warning bulletin and the map of avalanche zones.

Output: The combination of satellite navigation and telecommunications with geographic information systems are the basis for the development of new easy access infomobility tools for mountain users.

Technical publications:

Moner, I., Marturià, J., Martí, G., Roca, A., Loehnert, E., Reinhardt, W., Klever, N. and Barbisch, G.: "Desarrollo de un sistema de navegación e información en montaña. El proyecto PARAMOUNT", in *Proceedings de la 5a Setmana Geomàtica de Barcelona*. Barcelona, February 2003.



ALUDEX. Identification of catastrophic avalanches through dendrochronological and nivometeorological approaches

Thematic area:

Avalanche risk

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Other participants:

Grup de Dendroecologia (DENDRIX) of the Departament d'Ecologia of the Facultat de Biologia – Universitat de Barcelona.

Finalisation date:

2005

Description:

To determine the avalanche hazard it is necessary to have data on their intensity and also on their periodicity. The project deals with the determination of the return period of avalanches and is financed by the Spanish Ministry of Science and Technology and the FEDER fund.



Image of an avalanche in the Pyrenees

Different methods can be used to achieve this knowledge: population survey, winter surveillance, the study of nivometeorological situations that develop avalanche episodes and dating through dendrochronological study. The first two methods have already been used by the ICC for the creation of the avalanche zones map series of Catalonia at 1:25,000.

The latter two methods have received scarce development in the Pyrenees as far as snow avalanches are concerned. Their application is of great interest, given the results obtained in related fields. Dendrochronology can supply accurate dating of events. To develop the methods, we will mainly work with the avalanches of the crisis of February 1996. During this period, avalanches of extraordinary dimensions were released, which devastated forests and even inhabited areas. This is, to date, the most important episode known at the south face of the Pyrenees.

Output:

The ALUDEX project represents an advance in the determination of the return period of avalanches. Periodicity, together with intensity studies, will allow a more accurate prediction of avalanche hazard. The temporal and spatial avalanche forecasting in the Pyrenees is a public service offered by the ICC for land planning and risk mitigation, and prevention of high mountain accidents.

Technical publications:

Muntan, E., Andreu, L., Oller, P., Gutiérrez, E. and Martínez, P.: "Dendrochronological study of the avalanche path Canal del Roc Roig, first results of the ALUDEX project in the Pyrenees", in *Annals of Glaciology*, 38, Paper 38A75. Cambridge, 2003.

POTSIS. Seismic potentiality of the eastern Pyrenees

Thematic area:

Seismic risk

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Other participants:

Universitat de Barcelona, Observatoire Midi Pyrenées de Toulouse, Institut de Recherche et Sécurité Nucleaire (IRSN) from Paris and GEOID and GEOTER companies from Montpellier.

Finalisation date:

Continued activity

Description:

The eastern Pyrenees have a moderate seismicity with a known intense period of activity in the Middle Ages (1427-1428).

With the objective of estimating the recurrence periods of destructive earthquakes, aside from seismic activity, recent tectonic deformations are studied from geological data (paleoseismicity) and through geodesic measurements, either with the permanent stations of the ICC or with the repeated measurements of a network of 25 points on both sides of the frontier.

This network was already measured in 1992, 1994 and 1999, with week-long campaigns, in collaboration with other Catalan and French organisations. In the medium term, the comparison of these measurements will permit a quantification of horizontal tectonic deformations, which are the cause of earthquakes.

Output:

The knowledge, study and communication of seismicity and seismic risk are necessary for territorial planning and organisation.

Technical publications:

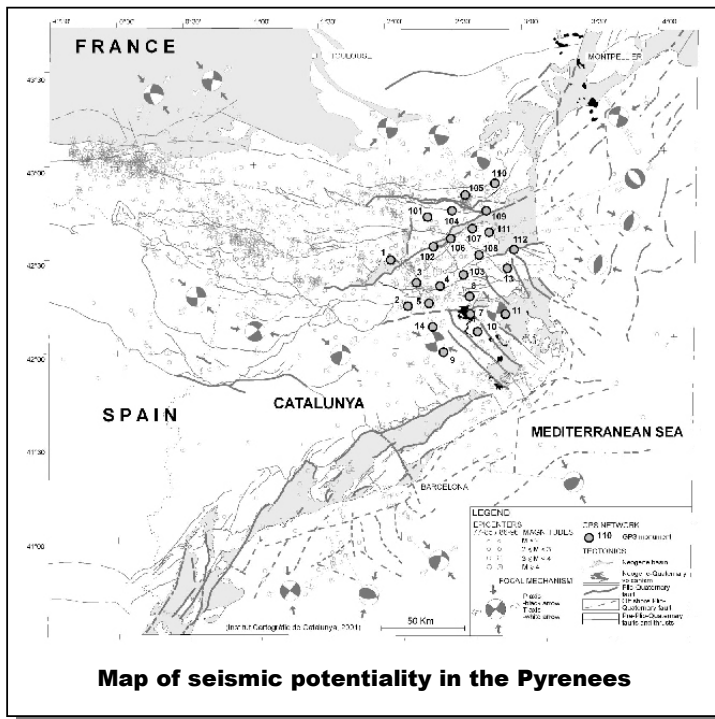
Goula, X., Fleta, J., Castellote, M. and Térmens, A.: "Present deformation and seismic potentiality in the Eastern Pyrenees", in *Workshop on the geodynamics of the western part of Eurasia-Africa plate boundary. Extended abstracts book*. San Fernando, 2001.

Térmens, A., Castellote, M., Soro, M., Fleta, J., Goula, X. and Talaya, J.: "PotSis'99, PotSis'94 and PotSis'99 GPS campaigns to improve the knowledge of seismic potentiality in the Eastern Pyrenees", in *X General Assembly of the WEGENER Project (WEGENER 2000)*. Observatorio de San Fernando. 18-20 September 2000.

Giménez, J., Suriñach, E. and Goula, X.: "Quantification of vertical movements in the eastern Betics (Spain) by comparing levelling data", *Tectonophysics*, No. 317, pages. 237-258. 2000.

Talaya, J., Feigl, K., Térmens, A. and Colomina, I.: "Practical lessons from analysis of a GPS network designed to detect movements of ~ 1 mm/year in the Eastern Pyrenees", in *Physics and Chemistry of the Earth*, vol. 24, No. 4, pages 355-359. 1999.

Giménez, J., Goula, X. and Suriñach, E.: "Cuantificación de deformaciones recientes mediante datos de nivelación de precisión en el sudeste peninsular", in *1er Congreso Nacional de Ingeniería Sísmica*. Murcia, 12-16 April 1999.



Map of seismic potentiality in the Pyrenees

RISKUE. Seismic risk scenarios in European cities

Thematic area:

Seismic risk

Leadership of the study:

BRGM (Fr)

Other participants:

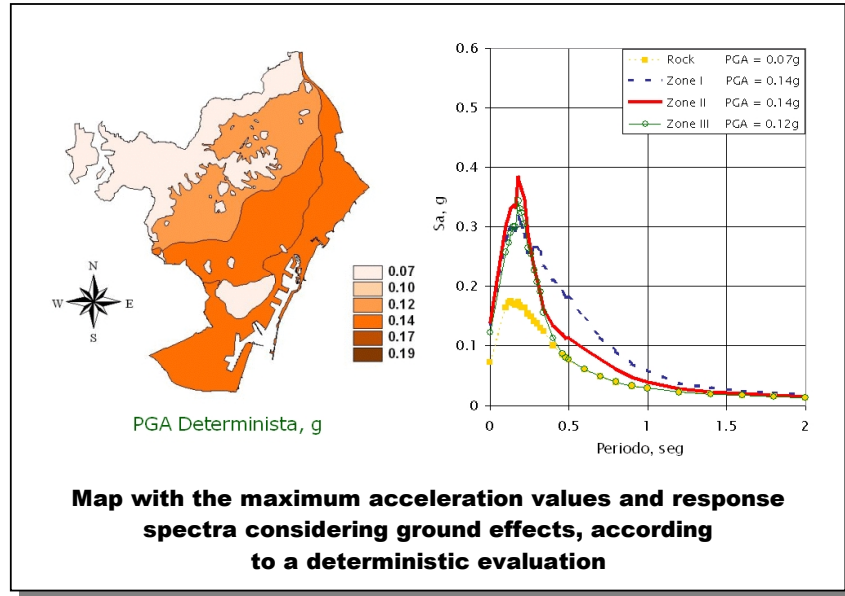
Institut Cartogràfic de Catalunya (ICC), Geoter, Polimi, Unige, UTCB, AUTH, IZIS-Skopje, CLSMEE, CIMNE.

Finalisation date:

2003

Description:

The project is set within the evaluation of seismic vulnerability and risk on a regional scale and its application to Catalonia.



Emergency organisation in case of earthquakes in highly populated cities needs to generate risk scenarios that take the particular characteristics of these cities into account. In this project, we deal with earthquake scenarios based on the evaluation of the seismic hazard, the vulnerability of the urban fabric and of the possible consequences.

The main objective of the project is to develop a general, modular methodology to generate risk scenarios that take the distinctive features of cities in the European area into account, in particular evaluating the risk to the cultural heritage and the economic impact. The methodology has been applied to seven European cities: Barcelona, Bitola, Bucharest, Catania, Nice, Sophia and Thessaloniki.

Output:

The knowledge, study and communication of seismicity and seismic risk are necessary for territorial planning and organisation.

Technical publications:

Chávez, J., Goula, X., Roca, A., Mañá, F., Presmanes, J. A. and López-Arroyo, A.: "Escenarios de daños sísmicos en Cataluña", in *1er Congreso Nacional de Ingeniería Sísmica*. Murcia, 12-16 April 1999.

Chávez, J., Goula, X., Roca, A., Cabañas, L., Benito, B., Rinaldis, D. and Sabetta, F.: "Análisis de daños y de parámetros del movimiento del suelo correspondientes al terremoto de Irpinia (Italia) de 1980", in *1a Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Almería, 9-13 February 1998.

Chávez, J., Goula, X., Roca, A., Mañá, F., Presmanes, J. A. and López-Arroyo, A.: "Earthquake risk in Catalonia: Vulnerability assessment for dwelling buildings", in *1a Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Almería, 9-13 February 1998.

EUROSEISRISK. Evaluation of seismic hazard, soil effects and soil-structure interaction in an instrumented basin

Thematic area:

Seismic risk

Leadership of the study:

AUTH, Tessaloniki (Gr)

Other participants:

Institut Cartogràfic de Catalunya (ICC), IESEE (Gr), LCPC (Fr), RWTH (G), UTRS (It), UTOK (J), UKOM (SI)

Finalisation date:

2004

Description:

The existence of a well instrumented site in a basin, with the presence of seismic activity (Volvi valley-Thessaloniki), where geophysical and geotechnical studies have been carried out and where a dense network of accelerographs has been installed both on the surface and in well bottoms, and the construction of a building model, allows the structuring of a research project for the validation of computing codes, both of the effects of local amplifications and of the soil-structure interaction.

The general objectives of the project are structured around six work packages:

- Complete description of the tridimensional structure of the basin, from experimental geophysics and geotechnical studies.
- Control and study of the regional and local seismicity. Evaluation of seismic hazard.
- The use of “microtremors” (environmental vibration) for the soil characterization.
- Extent of the local network of accelerographs. The experimental and numeric study of the local effects of the basin (1D, 2D and 3D).
- Study of the structural behaviour of a building and the soil-structure interaction.
- Critical evaluation of the results and data dissemination.

Output:

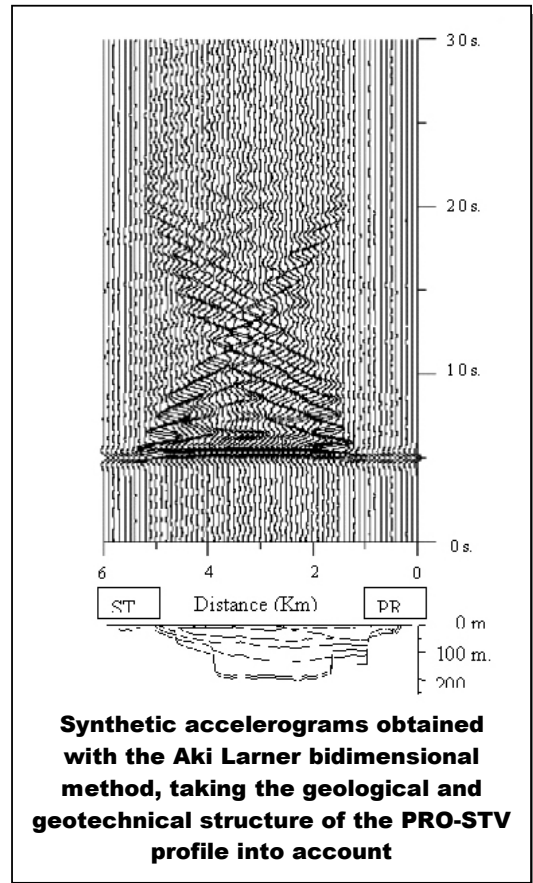
The knowledge, study and communication of seismicity and seismic risk are necessary for territorial planning and organisation.

Technical publications:

Cid, J., Susagna, T., Goula, X., Chavarria, L., Figueras, S., Fleta, J., Casas, A. and Roca, A.: “Seismic Zonation of Barcelona Based on Numerical Simulation of Site Effects”, in *Pure and Applied Geophysics*, 158, 2559-2577. Basel, 2001.

Cid, J., Figueras, S., Goula, X., Susagna, T. and Roca, A.: “Simulación numérica de efectos locales en la ciudad de Barcelona”, in *2a Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Portugal, 8-12 February 2000.

Figueras, S., Cid, J., Goula, X., Susagna, T. and Roca, A.: “Calibración de métodos de modelización de efectos locales: EUROSEISTEST (Grecia)”, in *1er Congreso Nacional de Ingeniería Sísmica*. Murcia, 12-16 April 1999.



New seismic network

Thematic area:

Seismic risk

Leadership of the study:

Institut Cartogràfic de Catalunya (ICC)

Finalisation date:

Continued activity

Description:

With the dual objective of providing rapid information for civil defence organisations, the media and society in general in case of an earthquake, and of obtaining quality systematic seismic data for the scientific community, the new seismic network of Catalonia is under development. The installation of up to 20 seismic stations equipped with broad band sensors of great dynamic range is planned in this network.

The stations have VSAT (Very Small Aperture Terminal) antennae that send the seismic information via satellite in real time and in a continuous mode to the ICC's data reception centre. The data are processed through the use of software that permits the automatic localisation of the earthquakes of interest, filing the data set and the rapid distribution of the basic information on the seismic activity recorded.

Output:

The knowledge, study and communication of seismicity and seismic risk are necessary for territorial planning and organisation.

Technical publications:

Tapia, M., Susagna, T., Goula, X. and Figueras, S. "Reducción de ruido en profundidad a partir de registros broadband", in *Cien años de sismología en Granada*, 4 pages. Granada, October 2002.

Goula, X., Jara, J. A., Susagna, T. and Roca, A.: "A New Broad-Band Seismic Network with Satellite Transmission in Catalonia (Spain)", in *Orfeus Newsletter*, vol. 3, No. 1. Holland, 2001.

González, M., Secanell, R., Susagna, T. and Goula, X.: "Inversión de amplitudes de registros sísmicos para la definición de ML", in *2a Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Portugal, 8-12 February 2000.

Roca, A., Goula, X., Olmedillas, J. C., Olivera, C., Susagna, T., Figueras, S. and Fleta, J.: "Nueva red sísmica de Cataluña con sensores de banda ancha y comunicación vía satélite en tiempo real", in *2a Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Portugal, 8-12 February 2000.

Roca, A., Goula, X., Olmedillas, J. C. and Talaya, J.: "Redes de observación geofísica con plataformas VSAT. Proyecto de red del Institut Cartogràfic de Catalunya", in *Boletín ROA*, No. 5, pages 161-166. Real Instituto y Observatorio de la Armada de San Fernando. 1999.

