# **National Report of Spain**

# Spanish National GPS Reference Stations Network: A new network for high precision network in Geodesy, Geodynamics and Cartography

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IGNE, by its Geodesy Department, is carrying out since 1998 the establishment of a GPS Reference Station Network of Spain (ERGPS) delivered all around Spain which allows millimetric coordinate results, as well as velocity fields in a Global Reference System (ITRFxx), serving as support for the other geodetic networks and for technical and scientific works. These stations are being integrated in EUREF (EUropean REference Frame) Permanent Station Network, which consists of more than 100 double frequency receiver stations.



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The main objectives of ERGPS are:

- High precision coordinate results and velocity field of all points of the network.
- To provide GPS users with data for surveying, cartographic, mapping, geodetic and positioning works which require a high precision differential GPS work.
- Contribution to the new Global Reference Systems (ITRFxx).
- To became EUREF permanent network stations and contribution to its reference frame (European Reference Frame).
- Generally speaking, to supply with continuous data in geodynamic, atmospheric, ionospheric, tropospheric, mean sea level and any other related studies.

IGNE installed March 1998 the first ERGPS station in the tide gauge station of the Harbour of Alicante. Today eight stations are working; Alicante and those placed in: tide gauge of La Coruña, Astronomical Observatory of Yebes, Geophysical Observatory of Almería, University of Valencia, University of Cantabria, Geophysical Observatory of Málaga and the Spanish Oceanographic Institute in Palma de Mallorca. It is planned to install twelve more stations in León, Burgos, Zaragoza, Salamanca, Vigo, Cáceres, San Pablo de los Montes, Albacete, Córdoba, Huelva, Ceuta and La Palma; eight will be installed during 2000 and those left in 2001.

#### **Regional Network Processing**

ERGPS data obtained (24h files every 30 s.), are stored daily and send to IGNE central facilities in Madrid (EUREF Local Center) automatically by Internet or, if not possible, by phone line.

IGNE processes raw data, performs a quality check test and stores them in a data bank and are analyzed, producing daily and week solutions of all stations. At this moment data are sent daily via Internet to EUREF Regional Data Center in Frankfurt (BKG, Bundesamt für Kartographie und Geodäsie) for public availability (www.igs.ifag.de).

Data will be also available free through web site of National Geographic Institute (Dirección General del Instituto Geográfico Nacional).

IGNE is processing data available of the Iberian Peninsula and other European stations with satisfactory results.

After this experimental step, IGNE intends to became an European Local Analysis Center, offering an Iberian Subnetwork weekly solution to the EUREF Network Coordinator. This solution together with those of other European local analysis centers will define the European Solution.





#### **RECORD** project (GPS Differential Correction Network of Spain

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The RECORD project intends to broadcast GPS differential corrections through RDS non-audible sub-carrier (Radio Data System, Sistema de Datos en Radio) of Radio Nacional de España (RNE) broadcasting stations.

The code differential GPS correction, obtained from pseudo distance observable smoothed with phase, is available in RTCM SC104 format. Further on, it is analyzed and compressed in RASANT 2.6 format (Radio Aided Satellite Navigation Technique). It is in this format in which it is sent to RNE, who send it incorporated to the FM signal broadcasted. A FM/RDS/RASANT receiver decompresses and provides the original RTCM SC04 corrections, which are integrable in most GPS receivers.

Since middle of 1997, the IGNE in cooperation with "Radio Nacional de España (RNE)" has made several tests to

broadcast differential GPS corrections, as requested by quite a lot of users, to manage fleets, to control special public services (burning forests, ambulances, public transport, traffic, and so on.). To do that, the IGNE uses software licenced by LVA of Nordrhein-Westfalen, under agreement of exclusive use by IGNE and RNE as free official public service.

The main objective of setting up DGPS/RASANT system (named RECORD) is establishing and implementing a public service to terrestrial positioning available to Spanish community of GPS users with usual criteria of precision, integrity and availability in this kind of systems.

The given service by DGPS/RASANT system will be based upon broadcasting RTCM differential corrections in

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RASANT format through sub-carrier not audible RDS of RNE broadcasting stations.

The attainment of the objective establishes on a basis of formalization of technical cooperation agreement between IGNE and RNE subscribed to that motive, thus differential corrections will be broadcasted by FM broadcasting stations of the "Red Técnica de Difusión" of RNE. This corrections will be delivered following international accepted formats (RTCM and UIT's Recommendation nr. 823), compressed in RASANT format, with free access to all users who have a FM/RDS/RASANT receiver.



Precision given by this system will be better than 5 m 2dRMS (95% of probability). In more restrictive conditions concerning to distance to correction generating point and data availability, the system will reached about 1 m precessions.

The DGPS/RASANT system will be a network that consists of stations DGPS/RASANT and a Control Centre. The DGPS stations that will work in redundant mode by double reverence receiver will have the tasks:



- RTCM differential correction generation, evaluation and compression to RASANT format.
- Data deliver to RDS net server of RNE through phone line point to point, optical fibre link or equivalent.
- Working Integrate Monitoring in each station DGPS by decoding RASANT format to RTCM by a FM/RDS/ RASANT receiver.
- Observable store setting up a GPS Database.



On its own, the control centre placed in the IGNE facilities in Madrid, will have the following tasks:

- To assure intercommunication with DGPS stations.
- To monitor and control DGPS parameter, assuring system homogeneity.
- To integrate metric precision controls in future peripherical stations.
- To download daily, or by request, of GPS information towards the Spanish National GPS Reverence Station Network.

The fact of being in the peninsular periphery inside a radius of 500 km and positions obtained during the period 1997/98 guarantees that the first part of the network set up will be deal with one control centre and two reverence stations, one in Madrid (IGNE) and the other in Sta. Cruz de Tenerife (Geophysical Centre of Canary Islands of the IGNE).

Integrity monitoring tests are being made during 1999-2000. For this reason a triple GPS equipment (2RS+IM) has been set up in IGNE facilities, assuring correction's reliability, continuity and integrity for Canary Islands and Peninsula. A forth GPS equipment in Prado del Rey facility to reinforce the array is also working.

The equipments have been set up in Tenerife similar to that in Madrid station and connected to IGNE Control Center in Madrid through RDSI (TCP/IP).

During 1999 a GPS receiver in broadcasting station of Palma de Mallorca has been installed to get an independent solution for the Balearic Islands region apart from that of the peninsula. This solution is available for RNE2 broadcasting stations (Radio Clásica) of Alfabia and Pollensa.

A remote monitoring service is being installed from Prado del Rey by RNE, in which data and audio broadcasting are verified. IGNE has equipped different regional departments with FM/RDS/RASANT+GPS receivers to get a redundant monitorization.

We are working to develop and give a WADGPS peninsular solution type through VSAT links and an analysis center. This solution will better the service quality to a great extent.

This year Digital Audio Broadcasting (DAB) tests will be carried out for the transmission of real time differential phase corrections.

## **REGENTE Project**

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In order to establish a unified European cartography, it is essential a conversion of coordinates of National Reverence Systems to ETRF89, which is possible through determination of transformation parameters from one to the other frame. Such a determination requires the knowledge of both types of coordinates in a high number of stations regularly arranged, and this number must be higher as the irregularities of present Local Frame arise.

IGNE decided to solve the problem in the Iberian Peninsula and archipelagos through REGENTE Project (Red Geodésica Nacional por Técnicas Espaciales, REGENTE), which consists of a dense high precision GPS network that coincide with National Geodetic Network points and NAP leveling stations. Mean density is fixed in one station per sheet of MTN scale 1:50.000, i.e., one station every 300 km<sup>2</sup>.

REGENTE will be perfectly linked to ETRF89 European reverence network, thus IBERIA95 and BALEAR98 stations are also REGENTE stations. REGENTE for Canary Islands

is linked to VLBI Maspalomas station as ITRF93 reverence station.

### Objectives

The main objectives of REGENTE are:

- Implementation, observation and coordinate determination of a basic tridimensional geodetic First Order Network for Spain with an accuracy of 5 cm or better.
- Obtainment of precise transformation parameters between National Geodetic Network, ED-50, reverence system and REGENTE, ETRF89.
- To provide with qualified data for the refined centimetric Spanish geoid. For this reason gravimetric observations are being made by relative method with LaCoste-Romberg gravimeters in each REGENTE station.
- To support the high number of GPS users. Thus any point in Spanish land will be within a maximum of 15 km. Circle, with a station of REGENTE as center.

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#### Structure

REGENTE will consist of 1078 stations in Peninsula and Balearics, one every sheet of National Topographic Map, MTN, at scale 1:50.000, which implies a mean distance of 20-25 km. In the Canary Islands, REGENTE of Canaries, REGCAN95, consists of 92 stations delivered to the seven islands with a maximum of 21 in Tenerife and a minimum of 5 in El Hierro and La Gomera.

Stations fulfil the following requirements:

- To belong to the National Geodetic Network or a VLBI or SLR station.
- GPS station normal requirements: easy vehicle access, free horizon above 101, and far from multipath or interference objects.
- More than a 10% of REGENTE (ellipsoidal GRS80 heights) stations have also high precision orthometric height through NAP Network, in order to be linked to National Geodetic Network ED-50, which has heights linked to mean sea level.
- Laplace stations and astronomical second order stations will be included in REGENTE if GPS station requirements are fulfilled.
- IBERIA95 and BALEAR98 extensions belong also to REGENTE.
- To serve as a reverence frame for local networks for geodynamic or geophysic control related to faults and tectonic plates.

#### **Reconnaissance and observation**

In field a reconnaissance is made to test that stations fulfil the requirements for a good observation. Once the station is selected, a force centering device is installed on the top of pillar for the tribrach of the receiver antenna in order to practically remove the station errors in different observation sessions, and in each case, in different sets of observations.

In each set, at least one station is linked to the High Precision Levelling Network (NAP) through two NAP site observation or ancillary sites linked to these with a high precision levelling branch if the NAP points are not stationable. Distance between two NAP points and GPS points should not be higher than four kilometers. This levelling observation is simultaneously made with each set observation, being set up two monofrequency receivers in each of NAP or ancillary points.

#### Development

Field works of REGENTE begun in 1994 and should have ended in 1997. For this reason the whole project was divided in four annual campaigns, approximately similar in number of stations and budget.

As can be easily seen in figure, 1994 campaign was named REGENTE Centro, and consists of 143 sheets of central region, and REGENTE Canarias, which consists of 92 stations, 66 principal and 26 ancillary ones in all islands, which allowed to expect the project finished in five years. But already in 1995, budget was cut and only 159 sheets, 182 GPS stations were observed. In 1996 budget cut was rather drastic reducing to 65 new sheets, 88 GPS stations, 16 of them in France for the link with Réseau Géodésique Français RGF, REGENTE french equivalent. In 1997 there were no REGENTE observation due to a total budget cut. In 1998, 218 sheets were observed, including 234 GPS stations in the Peninsula and 15 stations in Balearic Islands. In 1999 218 sheets were observed (203 GPS stations). This year 171 sheets are being observed, which means 209 GPS stations.

Once followed the work development, we could conclude that such an important network for the future projects of Spanish national cartography will be finished next year 2001. It should be considered that OACI's air navigation cartography should be available before the end of the century in GRS80, and the VIII CERCO Working Group has recommended that official cartography of members should be in ETRF89 in 10 years, in order to get an unified European cartography, under MEGRIN responsibility. Besides, other institutions and duties demand a definition of this type, the Maritime Signals Network in navigation, radio buoys and further elements of air navigation, mining georeferencing, etc, due to use of systems operated by GPS.

REGENTE conclusions influence is great in two works:

- Precise determination of gravimetric peninsular geoid scale (M. SEVILLA et al.)
- Adequate determination of transformation parameters and interpolation surfaces between ETRF89 and ROI ED50 for every region in the Peninsula and Balearics.



# **INTERREG** Project

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As a result of Working Committee of the Pyrenees and with European Union and Spain funding, the IGNE is carrying out the geodetic tasks to develop the Pyrenean Region, under INTERREG-II Project, including the french and Spanish network homogenisation by GPS, High Precision Levelling and Gravity techniques.

These unified networks as well as a precise Geoid suitable in the region will provide a better land exploitation and will serve to help a more accurate cartography.

A total of 1864 NAP sites through 1500 road kilometers of the Pyrenean Region. The network consists of 29 lines, 26 nodes and 8 branches, 3 of which are border points. The link point number to France has increased from seven to eight, and a brand new link to Andorra has been set up. Gravity value in 1391 has been observed, which means a 75% of total percentage, and simultaneously WGS84 coordinates of each point through GPS observation (fast-static) were obtained with a horizontal precision of 10 centimeters and height precision of 15 centimeters. GPS observation was based in REGENTE stations and with double frequency receivers. Maximum distances between REGENTE and NAP stations were 20 kilometers.

High precision levelling is carried out 70% by private enterprises provided with digital and conventional equipment, and it is expected to obtain a 2 mm ok (km) precision. INTERREG Project will have to finished at the end of this year and final results will be reported to EU during 2001.

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