National Report of Spain

Spanish National GPS Reference Stations Network (ERGPS).

A new high precision network in Geodesy and Geodynamics.

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The Instituto Geográfico Nacional of Spain (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. Most of these stations are being integrated in EUREF Permanent Station Network.

The main objetives of ERGPS are:

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

IGNE installed March 1998 its first ERGPS station in the tide gauge of the Harbour of Alicante. It was integrated in EUREF Permanent Network (EPN) in 1999 (ALAC). Today eleven more stations have been installed in:

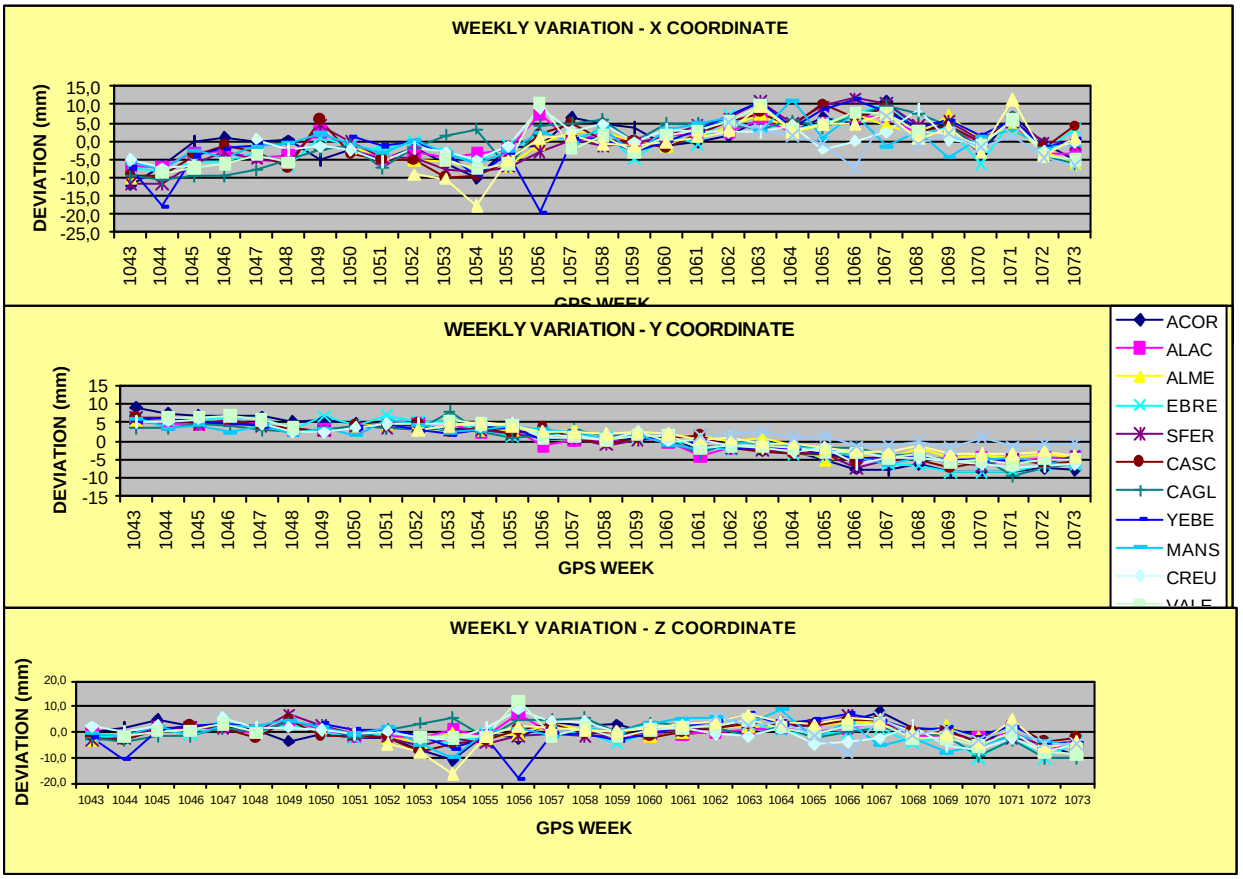
- Tide gauge of La Coruña (ACOR), Sept 1998.
- Astronomical Observatory of Yebes (YEBE), May 1999, wich belong to IGS network and provide nrt hourly data.
- Geophysical Observatory of Almería of IGN (ALME), Dec 1999.
- Politechnical University of Valencia (VALE), Jan 2000, nrt hourly data.
- University of Cantabria, Santander (CANT), Mar 2000, nrt hourly data.
- Geophysical Observatory of Málaga of IGN (MALA), Mar 2000.
- Spanish Oceanografic Institute in Palma de Mallorca, Balearic Islands (MALL), May 2000, nrt hourly data.
- Sysmological Observatory of Sonseca of IGN (SONS), Dec 2000.
- University of Extremadura, Cáceres, (CACE), Dec 2000.
- Geophysical Observatory of Logroño, IGN (RIOJ), Apr 2001.
- Astrophysical Institute of Canarias, Roque de los Muchachos Observatory in La Palma, Canary Islands, (LPAL), May 2001.

It is planned to install three more sations in the next two months in Ceuta (Africa), Huelva, Vigo and Cordoba and four more stations will be installed beginning 2002, completing the planned whole Spanish GPS Reference Station Network (ERGPS). A Dataserver (SERDAG) will provide these and other geodetic data to public users through web page of Instituto Geografico Nacional. Other type of data will include the whole Geodetic Network (12000 points) with its coordinates and general information, the REGENTE Network (1100 GPS points), Precise Levelling Network, etc.

Regional Network Processing

ERGPS data obtained (24h files every 30 s.), are stored dayly and send to IGNE central facilities in Madrid automaticaly 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 analized, producing dayly and weekly solutions for all stations. At this moment data are sent dayly via Internet to EUREF Regional Data Center in Frankfurt (BKG, Bundesamt für Kartographie und Geodäsie) for public availability.

IGNE is processing data available of the Iberian Peninsula and other european stations with satisfactory results. After this experimental step, IGN intends to became an european Local Analysis Center, offering an Iberian Subnetwork weekly solution to the EUREF Network Coordinator. At the end of 2001 ERGPS network will be completely operating in facilities, analysis and data deliver.



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) of Radio Nacional de España (RNE) broadcasting stations as a first objective.

The code differential GPS correction, obtained from pseudodistance 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-Westfallen, 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.

Today the service is being adapted to be broadcasted in DAB (Digital Audio Broadcasting) using not only RTCM code corrections even phase ones without RASANT compression. The given service by DGPS/RASANT system is based upon broadcasting RTCM differential corrections in RASANT format through sub-carrier not audible RDS of RNE broadcasting stations. However the DAB service will be through an specific data channel.

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 precision, this results can be improved using channels with more bandwidth, as Dab, to centimetre level accuracy.

The corrections are generated by a triple GPS equipment (2 Reference Station + 1 Integrity Monitor) in Madrid for the peninsula the same for a Canary Islands located at Tenerife and a single Gps for the Balearic Islands. During this year we are working to improve the redundancy of the system adding new reference stations to the project.

Many Dab broadcasting test have been done. The different modes of transmission using this kind of broadcasting allows a big increment of the bandwidth supported by a well defined data transmission standard.

Digital radio allows a more effective use of the spectrum holding seven programs in one frequency. The PAD (Programme Associated Data) associates data to each program but is space limited for our purposes. The data channel no associated to audio (NPAD) can hold more bandwidth. In this channel is where the tests have been done. Such tests were done at RNE headquarters, broadcasting the RTCM phase and code differential corrections, that is type 1, 2, 3, 18 and 19. The data was received at a Grundig Dab200 connected to a laptop computer that output the corrections into a test GPS. Several GPS receivers were test: single frequency, double frequency with and without "on the fly" ambiguity resolution option activated. Both GPS, generator and receptor, used in this test shared the same antenna, and the delay observed was about 2 - 4 seconds.

The results obtained for the 2 frequency "on the fly" GPS was the following:

1100 epochs observed		all Fixed RTK positions	
CEP	0.0218		
Horizontal rms	0.0263		
Horizontal 95%	0.0463		
East rms	0.0164	Mean East error	0.0119
North rms	0.0206	Mean North error	0.0067
Vertical rms	0.0387	Mean Altitude error	0.0107
Vertical 95%	0.0740	No outliers outside 0.1000	

These are only first results, new test will be carry out in the DAB field and the improving of the RASANT primitive project.

REGENTE Project.

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In order to establish a unified european cartography, it is essential a conversion of coordinates of National Reference 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 regurlarly arranged, and this number must be higher as the irregularities of present Local Frame arise. At the same time, GPS users needed precise coordinates for support their surveying and cartographic works.

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 (National Surveying Map) scale 1:50.000, i.e., one station every 300 km^2.

REGENTE will be perfectly linked to ETRF89 european reference network, thus IBERIA95 and BALEAR98 stations are also REGENTE stations. REGENTE for Canary Islands is linked to VLBI Maspalomas station as ITRF93 reference 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, reference system and REGENTE, ETRF89.
- To provide with qualified data for the refined centimetric spanish geoid and precise determination of gravimmetric peninsular geoid scale (M.Sevilla et al.) 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 radius of 15 km. circle, with a station of REGENTE as center.

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 10º, and far from multipath or interference objects.
- More than a 10% of REGENTE stations (ellipsoidal GRS80 heights) have also high precision orthometric height through NAP (High Precision Levelling 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 reference frame for local networks for geodynamic or geophysic control related to faults and tectonic plates.

Reconnaisance and observation

In field a reconnaisance 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, beeing set up two monofrequency receivers in each of NAP or ancillary points.

Two different sessions are observed at each station (3 hours, 15 sec data interval, 15º mask elevation) at different time (morning and afternoon), in order to observe in a different satellite constellation. 9 sites and 2 NAP are simultaneously observed at each session, forming the 11 sites a single computing block. Three of these stations are common to the

previous block and other three more will be common to the next one.

Development

Field works of REGENTE begun in 1994 and the complete project will finish in this year, 2001, providing a precision GPS network in Spain (better than 5 cm), necessary and essential for all the exposed purposes.

INTERREG - II Project

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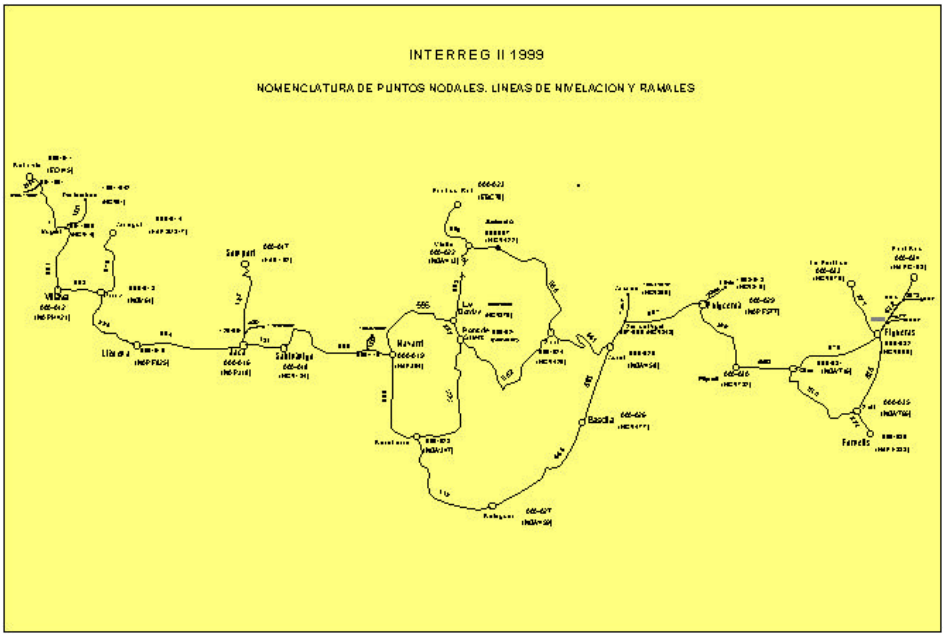
At the end of last year (2000), the field works of the High Precision Levelling Network in Pyrenean Region between France and Spain, were carried out. Whole project has consisted of 1417 road kilometers of implementation and observation of High Precision Levelling Network in the Spanish Pyrenees, consisting in 29 lines and 8 branchs. A total of 1864 NAP sites endowed of geopotential number, orthometric height and ETRS89 coordinates.

At present, after a first quality check is made for the observations, a final computation of geopotential number is being made at the 26 nodes wich form the network. In the same way, IGNE is expecting from IGN of France the data about the geopotential numbers of the french lines that will form a common poligon between the Spanish-French frontier.



REDNAP Project

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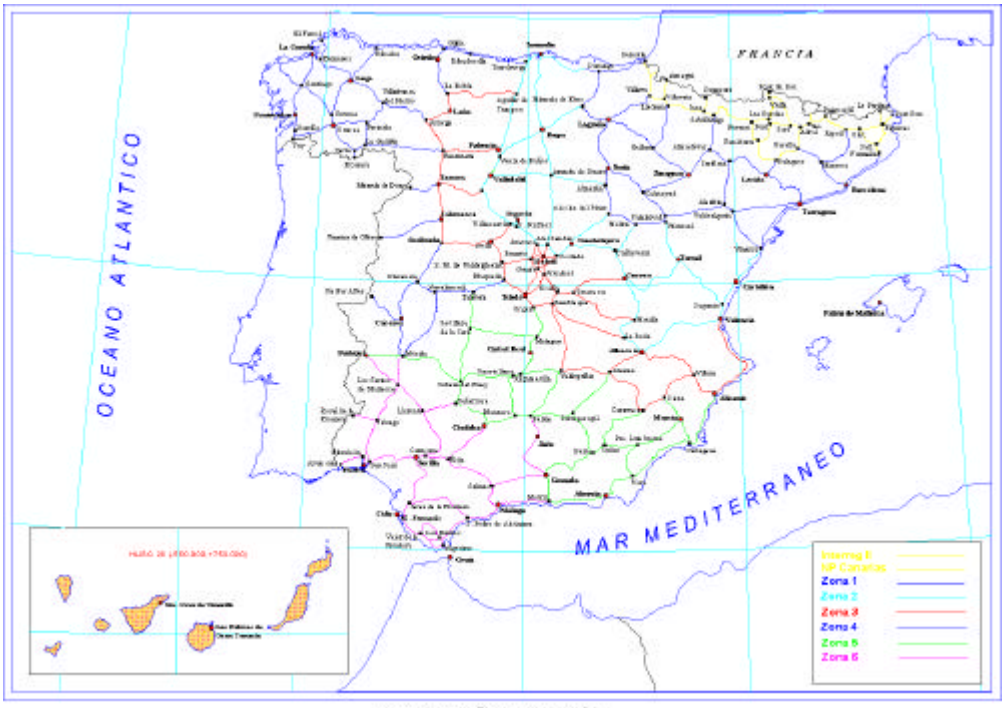
Ended the projects of High Precision Levelling Networks in Canary Islands and Interreg-II in the last year, IGNE has started in 2001 the ambitious REDNAP Project, in order to the stablishment a modern and new High Precision Levelling Network in the whole Spanish territory. The project will be developed along a period of seven years and 17000 road kilometers will be implemented and observed in the Peninsula and Balearic.

In 2008, when the project ends, Spain will have a modern NAP with a total length of 20000 kilometers. The stages will be:

a) Reconnaisance and monumentation.
b) Simultaneous gravimetry and GPS observation (fast-static).
c) Precise levelling observation.

Stages a) and b) will be made directly by Geodetic Department and stage c) will be executed by private companies contraction.



NUEVA RED ESPAÑOLA DE NIVELACIÓN