EUREF Related Activities in Belgium

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1. Maintenance and densification of the national networks (NGI)

The second general levelling was finished in the beginning of the year 2000. In a time span of 20 years, the NGI used precise spirit levelling to determine over 19.000 benchmarks. The mean standard deviation of these points is 2 to 3 mm. Compared to the previous general levelling, in some cases, considerable changes in height were noted, especially in the former mining areas.

Last year the NGI completed the revision and densification of the Belgian horizontal network. This means that easily accessible, GPS-friendly, ground points (a total number of 4200) with a mean density of 1 point/ 8 km² are now available over the entire Belgian territory.

These geodetic points were linked to the "LUXBD94" network (validated in 1995 as a class B densification of EUREF), leading to a set of ETRS89 coordinates. All of them are also known in the national Lambert72 grid ($\sigma = 3$ cm) and the orthometric height was determined by levelling (no high precision spirit levelling).

Next to these ground markers, about 4500 points situated on top of towers, churches and pillars are also part of the network of Lambert coordinates. They have been determined with the "classical" surveying methods and can still be used for orientation.

2. Maintenance of the EUREF non-permanent network

Referring to EUREF mail no1649, this national report includes the answers to the questionnaire issued by the EUREF president:

- 1. How many EUREF non-permanent stations exist in the country (or region) Six stations: Arlon, Brussel, Dentergem, Dourbes, Oostende, and Waremme
- 2. Average distance between them 60-80km
- **3.** Coherence with the set of stations in the EUREF data base OK
- 4. Internal use (zero order network, densification, implementation of ETRS89, no use) The Belgian zero order network was tied to the LUXBD94 coordinates of Arlon, Brussel, Dentergem, Dourbes, Oostende, and Waremme in order to implement the ETRS89 in Belgium
- 5. Strategies for network maintenance (technical standards, cyclical check and replacement of markers or monuments, availability and update of the information to the users, no strategy) Brussel, Dentergem, Dourbes, Waremme: the markers are still present, but they are not maintained, due to close presence of an EPN station. Arlon, Oostende: the markers are still present, no cyclical check, information available on demand.

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3. Network of permanent reference stations

3.1 FLEPOS

The Flemish government has established a RTK GPS-network based on 37 permanent reference stations (Figure 1). The Support Centre for GIS has set up and operates this public Flemish Positioning Service or FLEPOS since the end of September 2002. The Flemish government aims at an accurate, reliable and uniform positioning for all surveys by offering this service free of charge to all users, public and private. Costs for the user are limited to the communication costs (mobile telephone) in order to receive RTCM-corrections.

The reference stations are located upon buildings and consist of choke ring antennas and Leica 500 receivers. The GPS-data is send in real-time to the control centre located in the offices of the Support Centre for GIS in Brussels through the dedicated network of the Flemish government and leased lines. The positions of the reference stations are embedded in the BEREF network, a densification of EUREF, and were calculated by the National Geographic Institute (NGI). The NGI also provided the transformation parameter sets between ETRS89 and the national grid (Lambert 72).

RTK-users have the choice between a network solution based on the VRS-system (Landau et al, 2002) of Trimble-Terrasat (mode 1) and a single reference solution (mode 2). In April, six months after startup, the operation time is increasing and reaches over 125 hours a week. The network solution is preferred in 70% of the calls. Exchanging real-time GPS-data with the 06-GPS network in the Netherlands will fill the remaining gaps in the FLEPOS and 06-GPS coverage near the Dutch-Belgian border (figure 1).

RINEX-data can be downloaded through a web server (<u>www.flepos.be</u>). One-second interval data is available for 2 weeks, 10 second interval data for 60 days. Post processing integrity monitoring of the GPS-stations is set up with the NGI conform EPN guidelines to guarantee the integrity of the permanent stations.



Figure 1 - FLEPOS, the RTK network for Flanders, active stations and coverage (March 2003)

3.2 ROB network

The ROB has continued in 2002-2003 to operate its network of permanent GPS stations (Figure 2). Due to a receiver problem, the station at Membach is presently inactive. In January 2003, an Ashtech receiver replaced the last AOA receiver, installed at Waremme.



Figure 2 - Permanent GPS network operated by the ROB Belgium

4. Contribution to the EUREF Permanent Network (ROB)

Four of the ROB stations: Brussels (BRUS), Dentergem (DENT), Dourbes (DOUR) and Waremme (WARE) belong to the permanent EUREF network (EPN) since 1996 and submit since January 2003 all hourly data. The station in Brussels belongs also to the IGS network (since 1993).



Figure 3 - Network of permanent GPS stations daily processed at ROB

The ROB continues to operate, since 1996, the "ROB" EUREF Local Data Centre (which has been recently reorganised).

The ROB has set up a new station named RTBR (Ashtech UZ-12), located in Brussels, for participating to the new EUREF-IP project (http://www.epncb.oma.be/projects/euref_IP/euref_IP.html). The primary objective of this project is to disseminate RTCM corrections over the Internet for precise differential positioning and navigation purposes (see http://www.epncb.oma.be/resolution.html#PontaDelgada2002).

At the present time, RTBR gives DGPS corrections via RTCM messages types 1, 3 and 16.

The ROB processes daily the following EPN stations (see Figure 3): ACOR, BRST, BRUS, BUDP, CANT, CHIZ, DELF, DENT, DOUR, EIJS, EUSK, GRAS, HERS, KARL, KLOP, KOSG, LROC, MANS, MARS, MLVL, NPLD, OBE2, OSLS, POTS, SJDV, SPT0, TERS, TLSE, WARE, WSRT, and processes also the non-EPN stations BREE, MEEU, PLRX (the new PolaRX2 receiver from Septentrio, installed at Leuven), and RTBR (the EUREF-IP station).

ROB analyses all these GPS stations twice. First a rapid data analysis is performed. This rapid analysis is initiated when the IGS rapid orbits become available, which is usually around 20:00 UTC the day after observation. A second analysis is done 2 weeks later when the IGS precise orbits become available. This is the precise analysis submitted to EUREF.

Both the rapid and final analysis uses the EPN processing scheme (with the exception of the orbit information).

The web-page <u>http://www.gps.oma.be/gb/EPN_GB.html</u> makes available the results (statistics of the daily data analysis and coordinate time series, e.g. Figure 4) of the rapid and final processing.



Figure 4 – Left : the number of GPS stations included in the daily ROB processing ; Right: the percentage of fixed ambiguities in the daily ROB processing.

The ROB is also responsible for the EPN Central Bureau.

5. Space Weather

Since April 1 2003, the Royal Observatory of Belgium is involved in an ESA Space Weather Pilot Project called "Solar Influences Data analysis Centre". One of the goals of this project is to develop a service, which informs GPS users about the influence of Space Weather on real-time differential positioning and navigation. Indeed, ionospheric storms due to "bad" Space Weather conditions can lead to large positioning errors. In the frame of this project, the ionospheric and geomagnetic activity will be monitored in near real-time using EUREF GPS measurements, ionosonde and geomagnetic data collected at the Dourbes station (Belgium) which also hosts a GPS receiver. In particular, ionospheric small- and medium-scale Total Electron Content gradients will be computed and their effects on DGPS and RTK applications will be assessed. In a further step, forecasts of the expected positioning error will be produced.

6. Troposphere

Since 1998, the Royal Observatory of Belgium is performing a long-term study of the wet component of the tropospheric error. This study is based on the data collected by GPS receivers, radiosondes and Water Vapour Radiometers (WVR). Microwave WVRs are usually used as "black-box references" in order to validate the integrated water vapour content estimated by means of other techniques like GPS and VLBI. Observers often operate these instruments without adequate calibration or systematic evaluation of the quality of their water vapour observations. For this reason, a group of European WVR operators decided to set up a calibration campaign. During more than 60 days, 5 WVRs from two different manufacturers were operated simultaneously at the Fundamental station Wettzell in Germany. This station was chosen due to the possibility to validate the WVR measurements with water vapour content estimations derived from GPS, radiosondes and VLBI. The analysis of this large data set is no yet totally completed but first results already suggest possible improvements in the instrument software and hardware.

7. Outlook

The RTK network for the southern part of the country called "Walcors" (described in the national report 2002) is under construction. NGI will determine the ETRS89 coordinates of the reference stations in the same way as was done for FLEPOS.

The NGI has ellipsoidal heights at about 3500 markers where GPS and levelling data is available. ROB disposes of gravity data for about 30.000 points. Using the gravimetric data, ROB will compute a new geoid model in the very near future. The new gravimetric geometric geoid will be adjusted to the national height system using about hundred of the 3500 available markers from NGI with both GPS and levelling heights. After this, the difference between the gravimetric geoid height and the remaining 3400 markers will be computed.

The mutual aim is to bring all available data together and to establish an accurate geoid model for Belgium.

For the moment an accurate transformation between the GRS80 ellipsoid and the Hayford1924 ellipsoid (basis for the Belgian map grid) can only be performed using several sets of "local" seven parameter sets. Each set is applicable within a circle of 20 km radius. NGI plans to simplify this procedure and replace it by a seven- parameter transformation with one single set of parameters for the whole country, plus a correction grid to solve for the remaining residuals.

The ROB will continue its participation to the project of real-time data and quasi real-time product generation. The objective is to participate to an exchange of real-time data and quasi real-time products among IGS and EUREF members. Our final goal is to have in place a reliable, robust and manageable system of data and products exchange coming from our network of real-time tracking stations.

8. References

Landau H., U. Vollath, X. Chen: 2002, "Virtual Reference Station Systems", Journal of Global Positioning Systems, 1 (2), 137-143.