Belgian Report to the IAG-subcommission "EUREF"

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This national report has been prepared based on the contributions of two Belgian Institutes: the National Geographic Institute (NGI) and the Royal Observatory of Belgium (ROB).

1. Status of the National Gravity Network (ROB--NGI)

During the year 2001 the Royal Observatory of Belgium (ROB), in cooperation with the National Geographic Institute (NGI) completed the observation, reduction and compensation of the new Belgian Gravity Base Network (BLGBN98) (see Figure1).

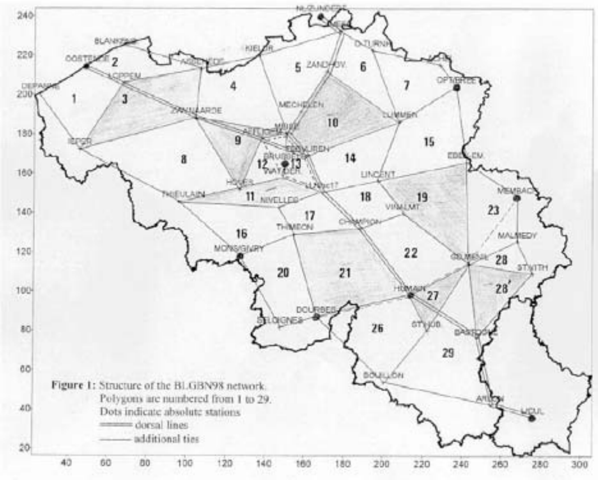

Figure 1: Structure of the BLGBN98 network

It is composed of 41 base points. The scale is well constrained by 8 absolute gravity stations. Nine gravimeters (LACOSTE & ROMBERG and SCINTREX) have been used on the field. The data have been reduced in a common adjustment. A scale factor has been determined for each instrument. The RMS error of the unit weight reaches 19 *μgal*. The RMS error of the gravity points is ranging between 4 *μgal* and 10 *μgal*. More detailed information may be found in Everaerts et al. 2002[4].

During the year 2001 two local surveys have been performed. A first network of 1171 points with a density of 1 point/km^2 was carried out by the Geophysik GGD (Leipzig) for the Geological Survey of Belgium. It covers an area of 1200 km^2 on the topographic map 110 (Hasselt-Waremme). A second network of 122 points with a density of 1 point/5km^2 was observed by the NGI on behalf of the ROB in a region to the North of Hasselt (610 km^2).

2. Belgian geoid model based on GPS/levelling data (NGI)

During the densification of the horizontal network (one of the main tasks of the department of Geodesy of the National Geographical Institute - NGI), about 4200 ground markers have been determined with GPS observations. Almost 80% of these points (3400) spirit levelling was performed. This means that, for (almost) the whole Belgian territory, points with both ellipsoidal and orthometric heights, are available with a mean density of 1 point every 10 km^2. Recently the NGI made a first and promising attempt to derive a geoid model from these data (Figure 2).

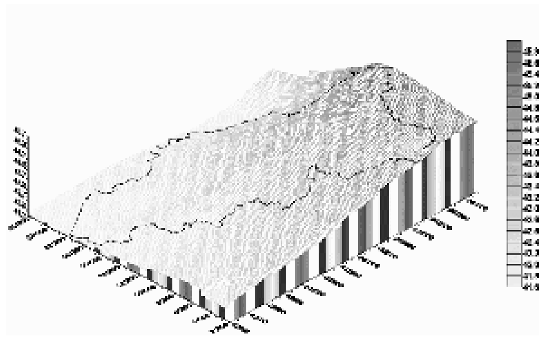

Figure 2: Geoid model derived from GPS/levelling data

Some characteristics of the observations

- Mean baseline length: 5 km;
- Mean GPS occupation time: 40 minutes;
- Baselines computed for 90% with GPSurvey (Trimble) and for 10% with SkiPro (Leica);
- Processed in regional projects with links to BEREF resulting in ETRS89 coordinates;
- Spirit levelling accuracy: F = 1.5 *cm*.

Results

The obtained model has been compared with the EGG97 model.

- Residuals (see Figure3): < Min. -0.150 *m* < Max. 0.127 *m*;
- Adjusted fit parameters: < Standard deviation: 0.032 < Bias (*m*): -2.393 ± 0.001 <NS tilt (*m*/1000 *km*): 0.658 ± 0.013 < EW tilt (*m*/1000 *km*): -0.584 ± 0.010.

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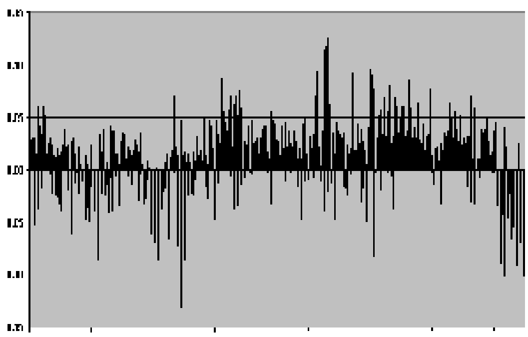

Figure 3: residuals of comparison between GPS/levelling model and EGG97

3. Network of permanent reference stations

3.1 NGI RTK networks

Belgium is a federal state with three regions: Brussels, Flanders and Wallonia. For each of these regions a network of permanent GPS stations is being set up, mainly for RTK purposes. Some characteristics of the networks:

– (Flemish Positioning Service)

- The network will cover the Flemish region (northern part of Belgium);
- The Flemish Government (administration responsible for GIS) takes the initiative;
- Should become operational during the fall of 2002;
- 36 sites situated on rooftops, equipped with Leica RS500 receivers and choke ring antennas;
- Data transfer through dedicated network + some leased lines;
- Control software: GPSNet;
- Free RTK service via mobile phone;
- Data for post processing will be freely available on the internet;
- For more information: info.flepos@vlm.be or http://www.gisvlaanderen.be

– Walcors (Wallonia Continuous Operating Reference System)

- The network will cover the Walloon region (southern part of Belgium);
- The Walloon Government (administration responsible for cartography) takes the initiative;
- Should become operational during the fall of 2002;
- 23 sites situated on steel pillars (height 8 m), equipped with Leica RS500 receivers and choke ring antennas;
- Data transfer through dedicated network;
- Control software: GNSmart;
- Free RTK service via mobile phone;
- Data for post processing will be freely available on the internet;
- For more information: gps@wallonie.be or http://gps.wallonie.be

– GPSBru (Brussels GPS Network)

- The network will cover the Brussels region (in the centre of Belgium);
- The National Geographical Institute (NGI) takes the initiative;
- Should become operational during the fall of 2002;
- 4 sites situated on rooftops, equipped with Leica RS530 receivers and choke ring antennas;
- Data transfer through dedicated network;
- Control software: not determined yet;
- Free RTK service via mobile phone;
- Data for post processing will be freely available on the internet;
- For more information: *pvo@ngi.be* or *http://www.ngi.be*

The position of the reference sites of all three networks will be determined and monitored by the NGI. All stations will be linked to the BEREF network (Belgian densification of EUREF).

3.2 ROB network

The ROB has continued in 2001-2002 to operate its network of 7 permanent GPS stations (see Figure 4). Presently, the network is at the end of a transition phase: the old ROGUE SNR-8000 receivers are replaced by new ASHTECH receivers. In addition, the data download and data transfer software to the ROB is adapted to work with the ASHTECH receivers. Next to the ASHTECH Z-XIIT receiver that was installed in Brussels in March 2001, we have replaced the receivers in Dourbes, Dentergem, Meeuwen and Bree by ASHTECH receivers. We expect to change the Rogue receiver in Waremme by an ASHTECH one and to change the old ROGUE SNR-8000 in Membach by a ROGUE AOA SNR-12 ACT in a very near future.

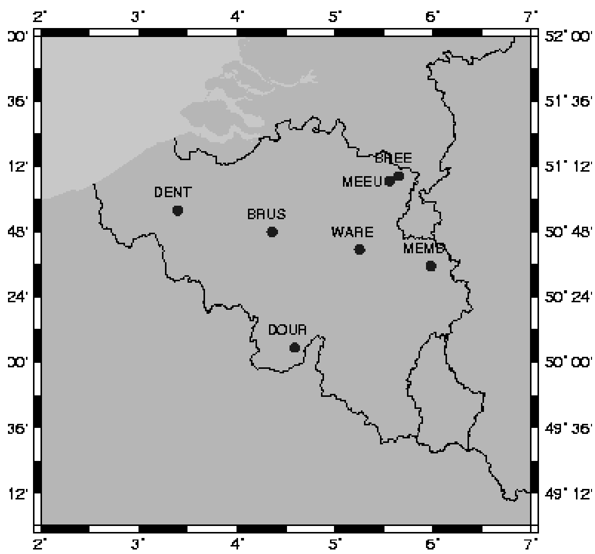

Figure 4: Permanent GPS network operated by the ROB in Belgium

4. Contribution to the EUREF Permanent Network (ROB)

4.1 Tracking Network

Four of the ROB stations: Brussels (BRUS), Dentergem (DENT), Dourbes (DOUR) and Waremme (WARE) belong to the permanent EUREF network (EPN) since 1996. One of them belongs also to the IGS network (Brussels since 1993) and submits hourly data. Dentergem and Dourbes submit also hourly data to EUREF and, in a near future, Waremme will start to submit hourly data to EUREF too.

In addition to this, the ROB continues to operate, since 1996, the "ROB"EUREF Local Data Centre, the "ROB" EUREF Local Analysis Centre and it is responsible for the coordination of the activities related to the EUREF permanent network (BRUYNINX C. and ROOSBEEK F. 2002[1]).

4.2 Local Data Centre

The ROB's EUREF local data centre receives each day the data from its 7 permanent GPS tracking stations. Both daily and hourly observation files are made available. Data with a sampling rate of 30 sec. are available for all our stations through the EUREF and IGS network. We have also 10 sec. data available for all stations except Membach and 1 sec. data available upon request for all stations except Membach and Waremme.

The goal is to run all procedures fully automatically:

- The ROB compresses the received data using the Hatanaka compression scheme, which was especially developed for the efficient compression of RINEX data;
- Data holding files are generated. These ASCII files give a quick overview to the users which data files are available to the users. In addition to this, these data holding files allow checking quickly if a data file has been properly transferred to the Data Centre.

4.3 Local Analysis Centre

Within its function as EUREF local analysis centre, the ROB analyses daily the GPS data of a network of about 28 EUREF tracking stations. The results of the daily ROB data analysis flow each week to the EUREF Combination Centre where they are combined with the solutions of the other EUREF Local Analysis Centres. It should be mentioned that the ROB has initiated a new "rapid" data analysis method using the rapid IGS products. It typically runs at 19h00 UTC the day after observation. In addition to the coordinate information, the daily GPS data analysis gives long-term information about the behaviour of the permanent tracking stations, which is essential for the monitoring of their stability.

4.4 EPN Central Bureau

As the Central Bureau of the EUREF Permanent Network, the ROB coordinates the activities of the tracking stations, data centres and analysis centres. It distributes standards and guidelines. The web site containing all the information related to the permanent network can be found at the following address: http://www.epncb.oma.be/. More informations can be found in BRUYNINX et al. 2002[2].

5. Ionospheric refraction (ROB)

The Royal Observatory of Belgium is performing a long-term study of the ionospheric refraction effect on GPS measurements. In particular, the ionospheric Total Electron Content behaviour is monitored since April 1993 using GPS measurements. Since the end of 1998, the ionospheric activity has increased and has reached two maxima at the beginning of 2000 and at the end of 2001. As a consequence several strong geomagnetic storms have been observed during the period 2000-2002. The effect of these geomagnetic events on GPS data processing has been studied. First results show that these events have not much influence on mid-latitude station data preprocessing with the BERNESE 4.2 software: in most of the cases, the MAUPRP program is able to handle such "disturbed" measurements in a satisfactory way (WARNANT et al. 2002[7]).

In addition, a first experiment (15-day trial) has been performed in March 2002 at Dourbes in order to reconstruct the electron density profile from GPS and ionosonde measurements in real-time (STANKOV et al. 2002). The long-term goal of this experiment is to make forecasts of the ionospheric activity for real-time applications of GPS.

6. Tropospheric refraction (ROB)

Since 1998, the Royal Observatory of Belgium (ROB) is performing a long-term study on the wet component of the tropospheric error that remains the major error source in high accuracy GPS positioning. This research program uses GPS receivers, Radiosonde (RS) and Water Vapor Radiometers (WVR) in order to get a better understanding of the atmospheric Water Vapour effect on GPS position time series. The promising results given by the first comparison between the water vapour content derived from GPS and radiosonding observations collected at Brussels has been confirmed. At the end of 2001, after collecting nearly one year of observations, the WVR data of Brussels were processed and the tropospheric delay estimations obtained were compared to the GPS estimations of Water Vapor. Estimations given by both techniques show an agreement at a level of 3.2 millimeter of Zenith Wet Delay and the more recent results concerning the comparison of the three techniques are promising for the future investigations.

7. Time transfer applications with geodetic receivers (ROB)

7.1 Contribution to TAI with geodetic receivers

The International Atomic Time scale (TAI) is computed by the Bureau International des Poids et Mesures (BIPM) from a set of atomic clocks distributed in about 40 time laboratories over the world. The time transfer between these remote clocks is mostly performed by the so-called GPS common view method using C/A code receivers. We developed a new approach (DEFRAIGNE and BRUYNINX 2002[3]), which uses the geodetic receivers and takes advantage of the availability of the P codes and in particular the ionosphere free combination. For transatlantic time links, the improvement with respect to the procedure presently used for the TAI computation, i.e. using the IONEX maps, reaches a factor of 2 (see Figure 5).

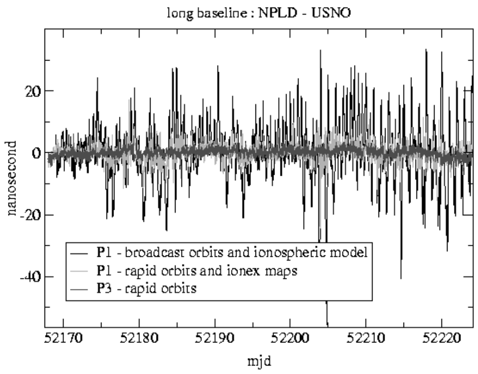

Figure 5: Time transfer between the Hydrogen masers located in NPL (Teddington, UK) and USNO

7.2 Contribution to the IGS time scale

In the last year, the IGS developed new “time products”, including receiver and satellite clock offsets, and performed the realization of a new time scale, the IGS time scale, based on a weighted ensemble algorithm using all the available clocks at the IGS sites and in the GPS satellites. The ROB uses a Hydrogen maser to drive the GPS receiver Ashtech ZXII3-T used for the IGS station; the behaviour of our clock with respect to the IGS time scale is shown in Figure 6 for the GPS week 1152. This Hydrogen maser is also the clock used to generate the local realization of UTC at the ROB, and the same receiver is used for the IGS contribution as for the TAI contribution, as explained in Section \ref{sectai}; by the way, the ROB is a fiducial station for the link between the IGS time scale and UTC.

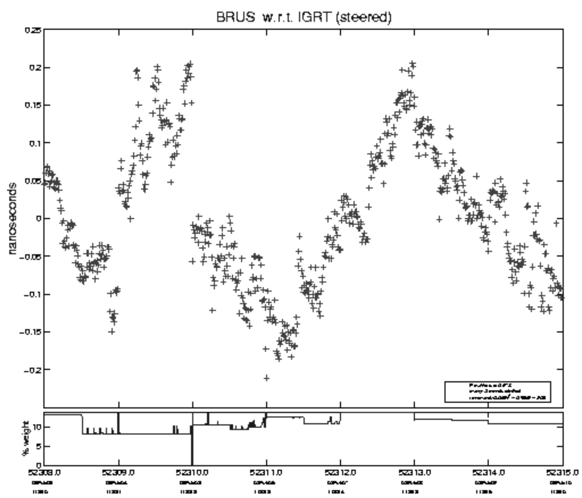

Figure 6:(top) IGS combined clock estimate of the hydrogen Maser of the ROB referenced against the IGS time scale IGRT, for the GPS week 1152 (feb 3 to feb 9, 2002); (bottom) relative weight of BRUS in the IGR clock combination

8. Outlook

- For the Belgian geoid model based on GPS/levelling data, the first results are promising but several steps still have to be taken to come to a reliable model:
  - Not all outliers have been filtered out yet;
  - The existing ETRS89 coordinates are temporary, as they are a result of network compensations carried out in several blocks. A new compensation of a network containing all ground markers and all independent baselines between them, will be carried out soon;
  - In cooperation with the ROB the available gravity data will be integrated too.
- The active engagement of the ROB in the permanent EUREF network will be continued.
- The ROB will set up a 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 goal is to have in place a reliable, robust and manageable system of data and products exchange coming from our future network of real-time tracking stations.
- The Royal Observatory of Belgium will continue its research program on the ionospheric and tropospheric errors: on the one hand, the possibility to make forecasts of the ionospheric activity will be further investigated and on the other hand, the calibration of the Brussels radiometer will be studied in more details.

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