

# Status of the EUREF Permanent Network

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*Presented at the EUREF Symposium, June 1- 4, 2005, Vienna, Austria*

## **Abstract**

*This document introduces the EUREF Permanent Network (EPN) and describes its present status by concentrating on the major changes to the EPN since the EUREF Symposium of June 2-5, 2004 held in Bratislava (Bruyninx et al, in press). These changes comprise the enlargement of the tracking network, the new EPN data flow and the reviewed EPN guidelines.*

## **1. Introduction**

The European Terrestrial Reference System 89 (ETRS89) is used as the standard precise GPS coordinate system throughout Europe. Supported by EuroGeographics, this reference system forms the backbone for all geographic and geodynamic projects on the European territory both on a national as on an international level. The ETRS89 is materialized through the science-driven EUREF Permanent Network, a network of continuously operating GPS reference stations distributed over the European territory and completely based on voluntary contributions.

The EUREF Permanent Network (EPN) was set up in 1995 following the IGS (International GNSS Service) example. EPN operational centres perform data validation, conversion of raw GPS data to the Receiver Independent Exchange Format (RINEX), data compression, and data upload through the Internet (generally on a daily or hourly basis) to EPN data centres, which permanently archive the data and make it freely available to all users. The primary users of the data sets are the EPN analysis centres, which acquire the data for the generation of precise station coordinates.

## **2. Projects and responsibilities**

Major decisions about the EPN are first discussed within the EPN Coordination Group. This group consists of the network coordinator (C. Bruyninx), the data flow coordinator (G. Stangl), the analysis coordinator (H. Habrich), the chairs of the different EPN projects:

- *Time Series monitoring Project (A. Kenyeres)*
  - Geodynamic interpretation of EPN coordinate time series
  - Determination of coordinate jumps and identification of periods that EPN stations have unreliable behaviour
- *Troposphere Project (G. Weber)*
  - Generation of a European reference solution for tropospheric zenith path delays, estimated using post-processed EPN data
- *EUREF-IP Project (G. Weber)*
  - Maintenance of a real-time GNSS infrastructure on the Internet using EPN stations (25 participating EPN stations)
- *European Combined Geodetic Network (J. Ihde)*
  - Connection of long-term space geodetic height (based on the EPN) with repeated gravity and permanent tide gauge measurements in the European coastal regions (46 participating EPN stations)

and the chairman of the EUREF Technical Working Group (Z. Altamimi). The EPN Coordination Group proposes e.g. new EPN guidelines to the EUREF Technical Working Group (TWG) which then makes the final decision.

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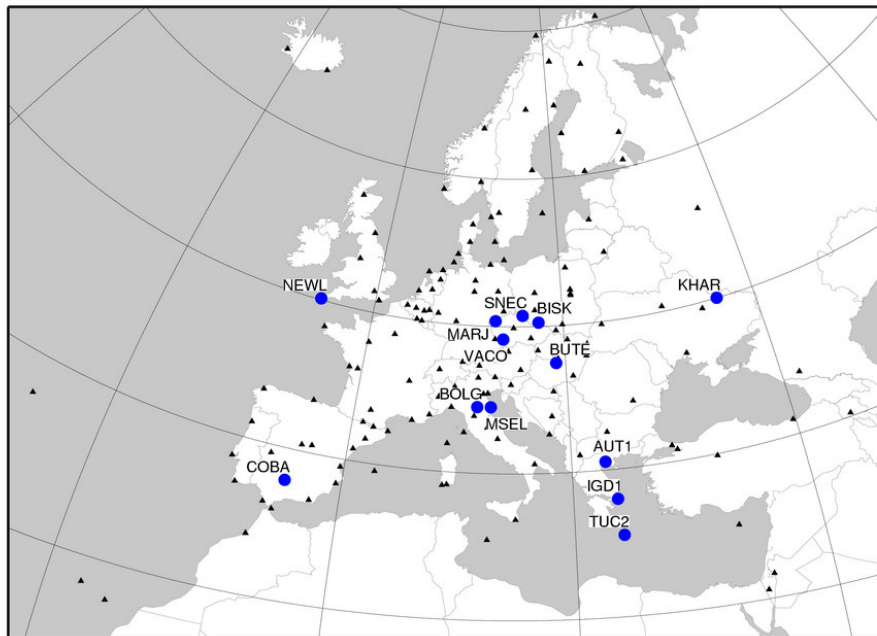
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The EPN Central Bureau (CB), headed by the network coordinator, is responsible for the day-to-day management of the EPN and acts as liaison between station operators and analysis centres, providing the necessary station configuration metadata and ensuring the datasets meet the requirements of the analysis. The EPN CB maintains and verifies the correctness of the station metadata information, monitors the quality of the daily GPS data from all the stations, the hourly data flow and the station coordinates and sends notification emails to station operators when abnormal conditions occur. The EPN CB makes all this information available through its web site <http://www.epncb.oma.be> and maintains the EUREF and EUREF LAC mailing lists.

The EPN data flow coordinator monitors the EPN data flow to identify critical points and proposes correction steps. The EPN analysis coordinator is responsible for generating the weekly EUREF combined solution and proposes a common data analysis strategy to the EPN analysis centres.

### 3. Status of the EUREF Permanent Network

Today, the EPN network consists of 171 continuously operating GPS reference stations (Figure 1). Four EPN stations are presently inactive: HFLK (Hafelekar, Austria), IAVH (Rabat, Morocco), LINZ (Linz, Austria) and MDVO (Mendeleevo, Russia). The 14 new EPN stations that joined the EUREF network since June 2004 are given in Table 1.



**Figure 1** – EUREF permanent tracking network (status June 2005); the circles show the stations added to the network after June 2004.

44 % of the EPN stations belong also to the IGS network. As can be seen from Table 1, none of the new EPN stations is part of the IGS which has become more restrictive in the acceptance of new stations.

Station	4 char ID	Country	Agency	Date inc.	H	TG	ECGN	IP	GLO	TL	IGS
Newlyn	NEWL	England	IESSG	27-06-2004			TG	ECGN			
Athens	IGD1	Greece	IGD	19-09-2004	H						
Medicina	MSEL	Italy	UNIBO	10-10-2004				ECGN			
Chania	TUC2	Greece	TUC	24-10-2004	H						
Budapest	BUTE	Hungary	DGS BUTE	31-10-2004	H			IP			
Taranto	TARS	Italy	DIASS	19-12-2004	H						
Cordoba	COBA	Spain	IGN-E	27-02-2005	H			IP			
Kharkiv	KHAR	Ukraine	MAO	20-03-2005	H						
Bologna	BOLG	Italy	UNIBO	27-03-2005				ECGN			

Thessaloniki	AUT1	Greece	DGS	24-04-2005	H	
Zlate Hory	BISK	Czech Republic	IRSMASCR	24-04-2005	H	GLO
Jachymov	MARJ	Czech Republic	IRSMASCR	24-04-2005	H	GLO
Pec	SNEC	Czech Republic	IRSMASCR	24-04-2005	H	GLO
Vacov	VACO	Czech Republic	IRSMASCR	24-04-2005	H	GLO

with:

IESSG	:	Institute of Engineering Surveying and Space Geodesy, England
IGD	:	International Geodynamics Group AE, Greece
UNIBO	:	University of Bologna, Department of Physics, Italy
TUC	:	Technical University of Crete, Greece
DGS BUTE	:	Department of Geodesy and Surveying, BUTE, Hungary
DIASS	:	Dipartimento di Ingegneria dell'Ambiente e per lo Sviluppo Sostenibile - Politecnico di Bari, Italy
IGN-E	:	Instituto Geografico Nacional, Spain
MAO	:	Main Astronomical Observatory of the National Academy of Sciences of Ukraine
DGS	:	Department of Geodesy and Surveying, Aristotle University of Thessalonike, Greece
IRSMASCR	:	Institute of Rock Structure and Mechanics, Academy of Science of the Czech Republic

and

H	:	station submitting hourly data
TG	:	TIGA station
ECGN	:	ECGN station
IP	:	EUREF-IP station
GLO	:	GPS/GLONASS station
TL	:	Time laboratory
IGS	:	IGS station

**Table 1-** Tracking stations added to the EPN since June 2004

The list of proposed EPN stations is given in Table 2. In addition 8 more permanent stations in France are planned to be proposed to the EPN.

Station	4 char ID	Country	Agency	Status
Banska Bystrica	BBYS	Slovak Republic	TOPU	Commitment letter missing.
Diyarbakir	DYR2	Turkey	UNAVCO	No data. Receiver to be replaced.
Evpatoria	EVPA	Ukraine	MAO	Hourly data missing.
Maspalomas	GMAS	Spain	JAXA	Hourly data missing.
Trapani - Milo	MILO	Italy	ASI	Lack of low-elevation tracking data on L2.
Obninsk	MOBN	Russian Federation	RDAAC-JPL-IRIS	Hourly data missing.
Paris	OPMT	France	BNM-SYRTE	Commitment letter missing.
Poustka	POUS	Czech Republic	IRSM AS CR	Receiver to be repaired.
Reggio Calabria	TGRC	Italy	ASI	Lack of low-elevation tracking data on L2.
Pernitz	TRFB	Austria	SRI	Late data availability.
Zwenigorod	ZWE2	Russia	GFZ	Lack of low-elevation tracking data on L2.

with

GFZ	:	GeoForschungsZentrum Potsdam, Germany
SRI	:	Space Research Institute, Austria
IRSM AS CR	:	Academy of Science of the Czech Republic - Institute of Rock Structure and Mechanics, Czech Republic
TOPU	:	Topographic Institute, Slovak republic
UNAVCO	:	University NAVSTAR Consortium, USA
JAXA	:	Japan Aerospace Exploration Agency, Japan
MAO	:	Main Astronomical Observatory, Ukraine
RDAAC-JPL-IRIS	:	RDAAC-JPL-IRIS, Russia
BNM-SYRTE	:	BNM-SYRTE, France
ASI	:	Agenzia Spaziale Italiana, Italy

**Table 2 -** Proposed EPN stations

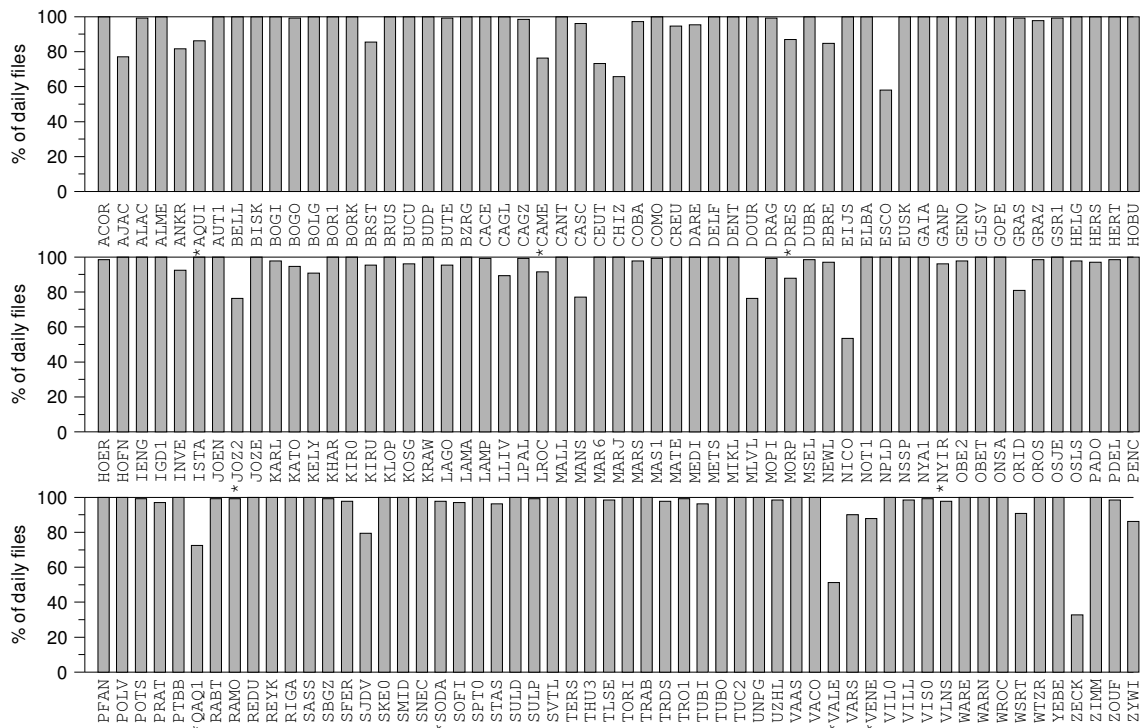
Recently, three stations have been withdrawn from the EPN: AMMN (Amman, Jordan, withdrawn in Oct. 2004), ZWEN (Zwenigorod, Russia, withdrawn in Nov. 2004) and TARS (Taranto, Italy, withdrawn in April 2005).

## 4. Reliability of the Data Flow

While one could expect that the daily data submissions are presently running efficiently, it is still surprising to see how many daily data files do not arrive at the data centres and for which no notification from the station operator's side was sent through EUREF mail.

Figure 2 shows the total percentage of daily observation data that were made available by each EPN station since the beginning of 2005 up to mid-May 2005. This percentage was computed by using for each station the data center with the highest amount of data for that station. For EPN stations that were introduced in the EPN during the last months, only the period where the station was officially part of the EPN was considered.

In general, after a communication problem, the data should be resubmitted to the data centres. Consequently, missing data can only occur in case of equipment (GNSS receiver/antenna – station PC) problems in which case the station operator should send a EUREF mail to inform the community about the problem. In Figure 2, we have indicated the stations that reported an equipment failure as the reason for all the missing data with an “\*”.\*



**Figure 2** - Percentage of daily data files for each EPN station that arrived at least at one EPN data centre from January to May 2005.

In the past year, several EPN stations have made a considerable effort to deliver hourly tracking data, bringing the total number to 74 % of the EPN stations (see Figure 3). However, even if the number of stations submitting hourly data is continuously growing, not all of these stations make available their hourly data with a sufficiently small delay. Especially for meteorological applications, the station data should be available with a delay of less than 10 minutes. Looking at the large number of missing hourly data for some stations (see Figure 4), it is clear that some of the operational centres should urgently implement procedures to automatically check if their hourly data did arrive properly at the EPN data centres and resubmit the data if necessary.

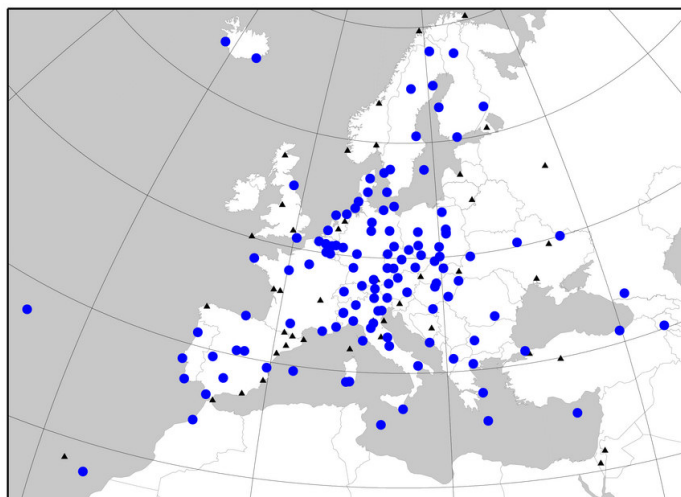


Figure 3 – EPN stations submitting hourly data (big circles), status May 2005.

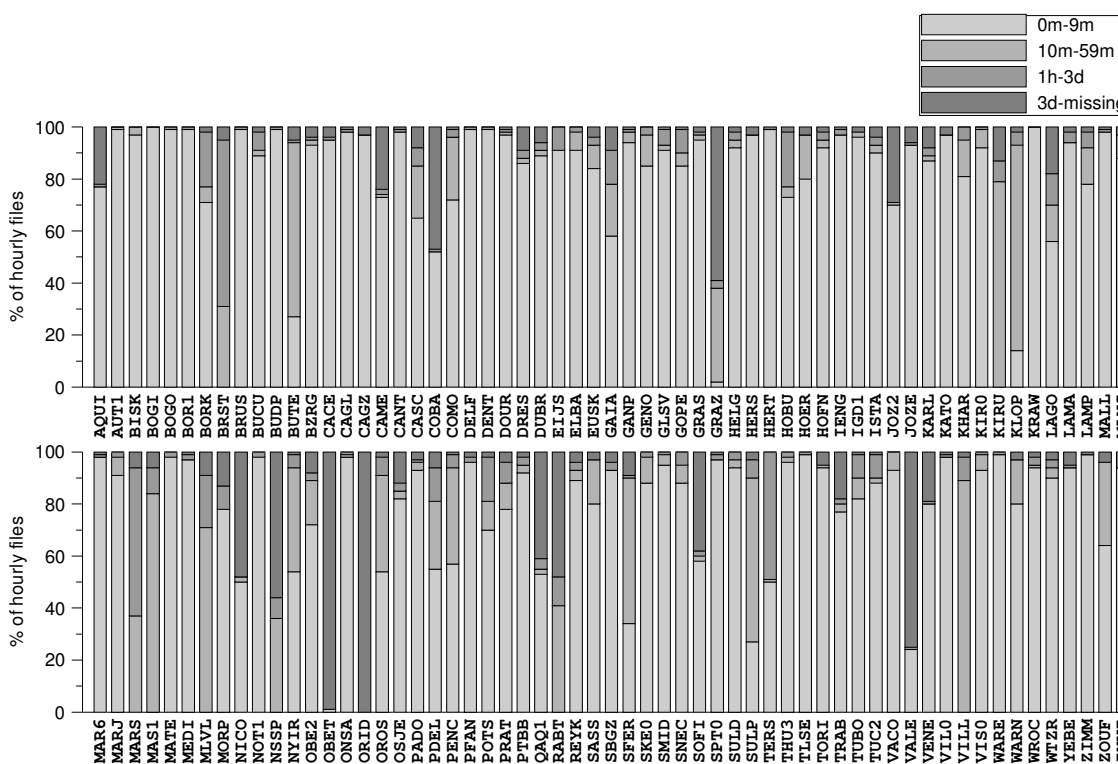


Figure 4 – Mean latencies of the hourly EPN data over the period 01/01/2005 – 30/04/2005

## 5. New guidelines for EPN stations and Operational Centres

The IGS (International GNSS Service) issued in 2004 new guidelines for its stations and also within the EPN the introduction of new guidelines for EPN stations and operational centres became necessary. After a first iteration within the EPN Coordination Group, the updated guidelines have been discussed at the EUREF TWG meeting in Prague, Nov. 2004. Following this discussion, a final version of the guidelines was approved by the TWG on Nov. 30, 2004 and distributed through EUREF mail to the EPN network components on 14 Dec. 2004.

The new guidelines list the requirements that all EPN stations and operational centres (OC) must follow, as well as some additional desirable characteristics, which are not mandatory, but enhance a station's or OC's value to the EPN.

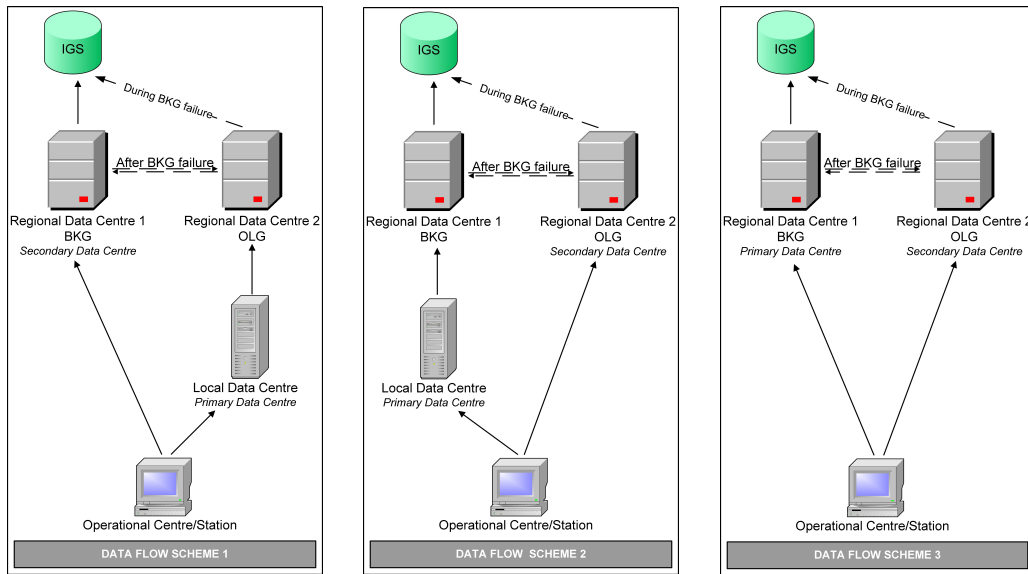


Figure 5 – Recommended EPN data flow.

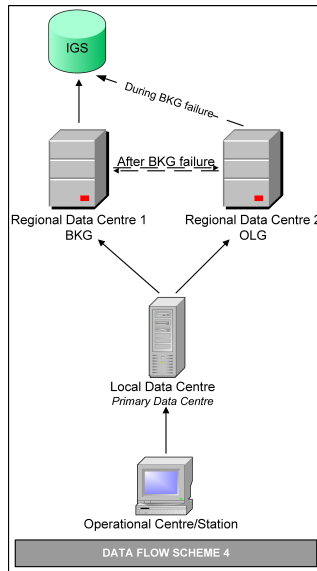


Figure 6 – Alternative EPN data flow scheme.

The most important change in the new guidelines with respect to the old ones is related to the data flow. In order to improve the reliability of the availability of the EPN data at the regional level (especially important for EPN stations also contributing to the IGS), the EUREF TWG decided that all stations should from now on make available their data in two regional data centres (RDC). These two RDCs are BKG (Federal Office of Cartography and Geodesy, Germany) and OLG (Space Research Institute, Department of Satellite Geodesy, Austrian Academy of Sciences), who gracefully proposed to act as the second EPN RDC. Each RDC will contain the data from all the EPN stations. Under normal conditions, BKG will continue to routinely upload the relevant EPN data to the IGS. However, in case of a failure at BKG, OLG will now be able to take over this upload so that there will be no

interruption in the data flow to the IGS and all EPN data can temporarily be downloaded from OLG instead of BKG.

In order to ensure the highest reliability, it is imperative that the EPN data should arrive at the two RDCs using two independent data flow paths. This requires that all EPN stations upload their data routinely to two data centres. The names of these data centres are indicated in the station site log as "Primary Data Center" and "Secondary Data Center". Based on this principle, each station/OC should distribute its data following one of the three standard data flow schemes given in Figure 5. Exceptionally, if none of the schemes in Figure 5 can be applied, the scheme given in Figure 6 can be used. In this scheme, the station/OC submits its data only to one data center, noted as the "Primary Data Center" in the site log. The primary data centre will have the responsibility to upload the station data to the two RDCs. In case of a failure of this primary data centre, the data flow will be interrupted. For this reason, the scheme in Figure 6 is not considered as optimal.

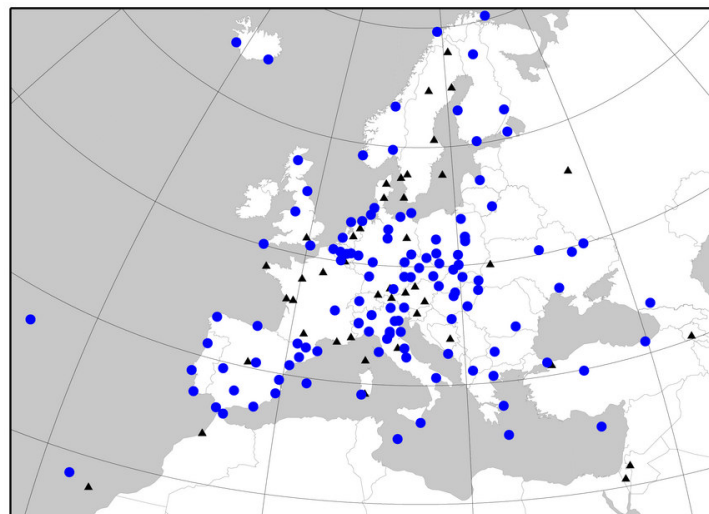
The other changes in the guidelines mostly formalize requirements that were not explicitly mentioned in the previous guidelines but were considered as 'good practices'. Examples are:

- For standard operations, the data delivery to the data centres must be done as quickly as possible which means within 10 minutes after closing time of the file. For remote sites, or sites with difficult communications, the daily data should at least be available within the same delay as the satellite orbits become available (currently 12 days).
- After a communication outage between the station and the OC, or between the OC and the data centres, all recovered data files must be submitted to the data centres.
- If an upload fails, then a retry should be made as quickly as possible. At least a second retry should be done within the hour.
- Hourly files, which could not be sent, or have to be updated, must arrive within three days. After that date, updates must be done through the upload of the appropriate daily file.

In addition:

- Avoid using radomes unless required operationally, for instance due to weather conditions, antenna security, wildlife concerns, etc.
- The receiver must be set to record down to a cut off of 5 degrees or less.
- Additional monuments are desirable for surveys and testing, but it is preferable to maintain one antenna + receiver pair as the best site for the EPN, rather than to submit more than one "site" to the EPN (additionally desired characteristic).

The guidelines are on-line available at: [http://www.epncb.oma.be/\\_organisation/guidelines/](http://www.epncb.oma.be/_organisation/guidelines/).



**Figure 7** – EPN stations that make available their data at both BKG and OLG using independent data flow paths, status June 2005

The implementation of the new guidelines needs realism in both approach and schedule. Only a few of the station

operators spontaneously adapted their data flow to be in accordance with the new guidelines. Therefore, the network and data flow coordinators contacted in March-April 2005 each station operator individually to:

- Draw its attention to the new guidelines and inquire about the actions he/she will take to have the station data flow in accordance with the new guidelines ;
- Map the present data flow of the station and propose a new optimal data flow scheme in accordance with the guidelines ;
- Assist the station operator with the implementation of this scheme.

The stations that have switched to the new data flow and use two independent data flow paths to upload their data to the 2 RDCs are shown in Figure 7.

**Acknowledgements:** *The EPN Central Bureau is funded by the Royal Observatory of Belgium. The author wishes to thank G. Carpentier, D. Mesmaker, A. Moyaert, R. Laurent and F. Roosbeek for their help in maintaining the EPN Central Bureau.*

### ***References***

C. Bruyninx, Carpentier G, and F. Roosbeek (in press), *Day-to-day Monitoring of the EPN*, Proc. of the EUREF symposium held in Bratislava, Slovakia, June 2-5, 2004