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# Development Process of EPN Analysis

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## Abstract

The development process of the EUREF Permanent Network (EPN) analysis will be summarized for the period between the two EUREF symposia 2005 and 2006. The EPN Local Analysis Centres (LACs) convened for a splinter meeting during the EUREF symposium 2005 in Vienna and clarified all-important questions to change from Bernese GPS software version 4.2 to 5.0 in the EPN analysis. LACs are now in the position to switch over to 5.0 within its own responsibility.
The LAC Workshop in Padua, Italy in 2006 was an important happening to develop new EPN analysis strategies. The LACs agreed on a schedule how to introduce the absolute phase centre variations (APCVs) and will thus follow the activities of the International GNSS service (IGS). It is furthermore appreciated that station operators of EPN stations setup combined GPS/GLONASS receivers and that LACs add GLONASS observations into the analysis process. Those LACs who could provide near real-time station coordinates are asked to deposit it at a central place and open thus the possibility for a station monitoring.
A new ITRF realization ITRF2005 is currently in preparation and as consequence a new EPN multi-year solution yields in a regional densification of the new ITRF within the scope of IAG sub-commission 1.3. Helmert parameters between weekly solutions and the multi-year solution show a yearly signal. This phenomenon is under investigation.
Conclusions from the IGS Workshop 2006 in Darmstadt, Germany will be considered in the EPN analysis as far as reasonably.

## 1 Introduction

EPN Analysis is a continuous effort of Local Analysis Centres (LACs) in European countries to realize a European Reference Frame in the most accurate manner and thus requires questioning the applied methods and strategies all the time. There are LAC workshops mostly every two years beside the yearly EUREF symposia to consider recent analysis aspects. Innovations from other organisations, e.g., conclusions of IGS workshops, are implemented in the EPN as far as meaningful.

## 2 The 5th Local Analysis Centre Workshop

The most recent LAC workshop took place at the University of Padua, Italy, March 15 – 16, 2006. There registered 37 participants from 15 European Nations. The workshop was organized in 5 Working Sessions:

- Session 1: Reports from the EPN Coordination Group
- Session 2: Local Analysis Centres reports
- Session 3: Experiences with new processing strategies
- Session 4: Site, receiver and antenna issues

- Session 5: Wrap-up and closing session

The results of the discussions are summarized in seven conclusions:

**LAC Workshop Conclusions (1/7)**

***- Absolute Phase Centre Variations –***

Absolute phase centre variations (APCV) will be introduced simultaneously with the IGS. At the same time the EPN will switch to ITRF2005.

**LAC Workshop Conclusions (2/7)**

***- Tropospheric Gradients –***

Estimation of tropospheric gradients will be introduced simultaneously with the introduction of APCV. The gradients will be pre-eliminationatd before submission of troposphere SINEX files, because the gradients are currently no supported by the SINEX format.

**LAC Workshop Conclusions (3/7)**

***- GLONASS –***

LACs are authorised to add GLONASS observations to their GPS analysis, provided the results are not degraded. The LACs recommend replacing obsolete GPS equipment with GPS/GLONASS/GALILEO equipment and proposing to assess the recommendation with a EUREF symposium resolution.

**LAC Workshop Conclusions (4/7)**

***- Re-Processing –***

There is the general agreement between LACs on EPN re-processing of all observations since the beginning of the EPN. This action is postponed until re-processed final IGS orbits are available.

**LAC Workshop Conclusions (5/7)**

***- Real-Time Strategies –***

The discussion about strategies for real-time (RT) data analysis has been postponed until RT software becomes available.

**LAC Workshop Conclusions (6/7)**

***- Near Real-Time Processing –***

Near real-time (NRT) processing is useful for monitoring of station coordinates. The LACs already doing NRT processing are asked to submit hourly SINEX files. It is planned to establish a coordinate check and alert generation. The LACs are asked to cooperate with National Mapping Agencies (NMAs) and to contribute with dense national networks to meteorological applications (e.g., TOUGH/E-GVAP).

**LAC Workshop Conclusions (7/7)**

***- Divers –***

It was agreed upon to switch from GOT002 to FES2004 ocean loading model simultaneously with APCV and ITRF2005. It is proposed to generate a „rapid EPN combination product“. It provides coordinates with significant reduced delay, and the corresponding analysis follows a strict timetable without waiting for missing LAC contributions.

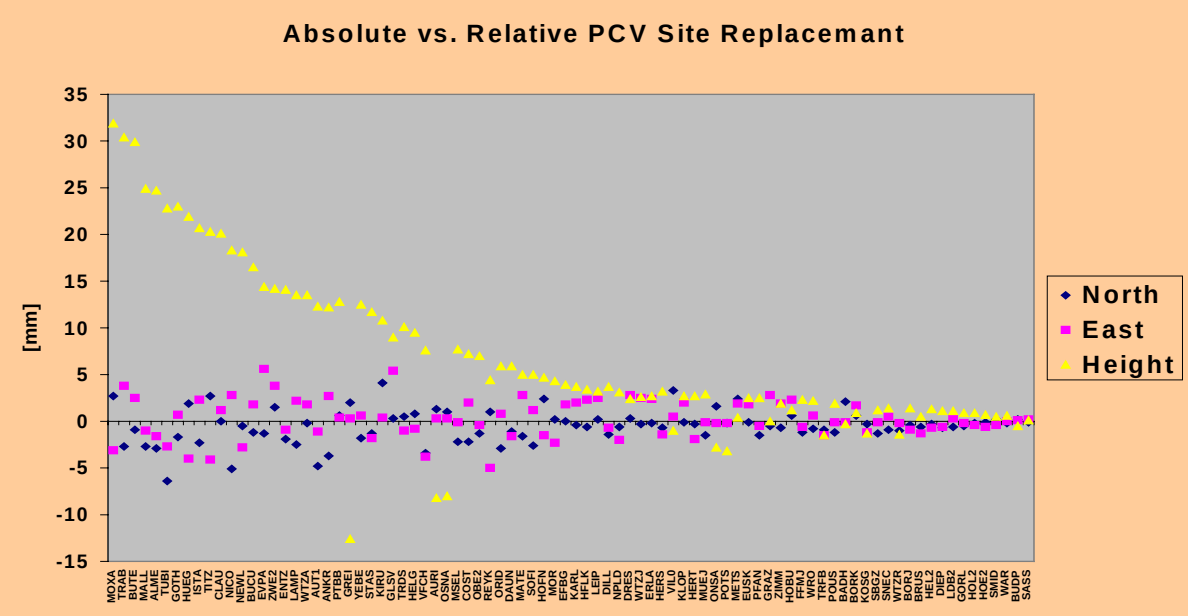


**Figure 1: BKG sub-network of week 1374 site displacements**

# 3 Planned Changes in the EPN Analysis

The conclusions of the 5th LAC Workshop appoint a certain number of planned changes in the EPN analysis options. These are beside others the simultaneously introduction of APCVs, switch to ITRF2005 and estimation of tropospheric gradients. It needs obviously more specifications for the practical implementation, e.g., the definition of the applied ANTEX file for APCVs as well as book keeping aspects of antenna radome types and individual antenna serial numbers. The BKG sub-network was analysed with relative and absolute PCV numbers in order to get some idea about the coordinate changes of the planned actions. Figure 1 shows the station coordinate differences between both solutions ordered by the corresponding quantity. Nearly 50 % of the stations experience height changes of larger than 5 mm. It should be considered that minimum constraints have been applied to selected reference sites. This will restrict changes for the reference site coordinates.

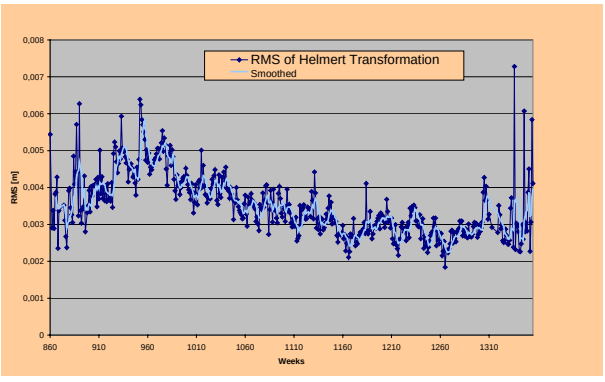


**Figure 2: RMS of weekly networks vs. combined solution**

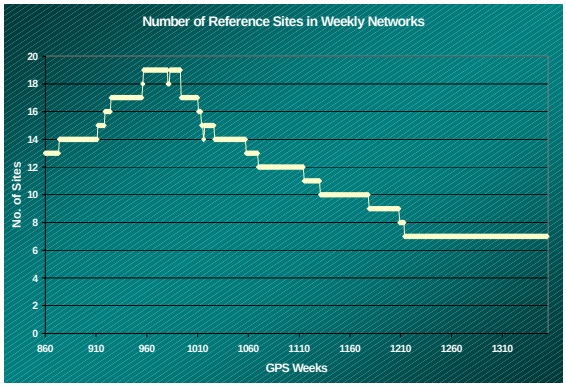


**Figure 3: Number of reference stations in combined solution**

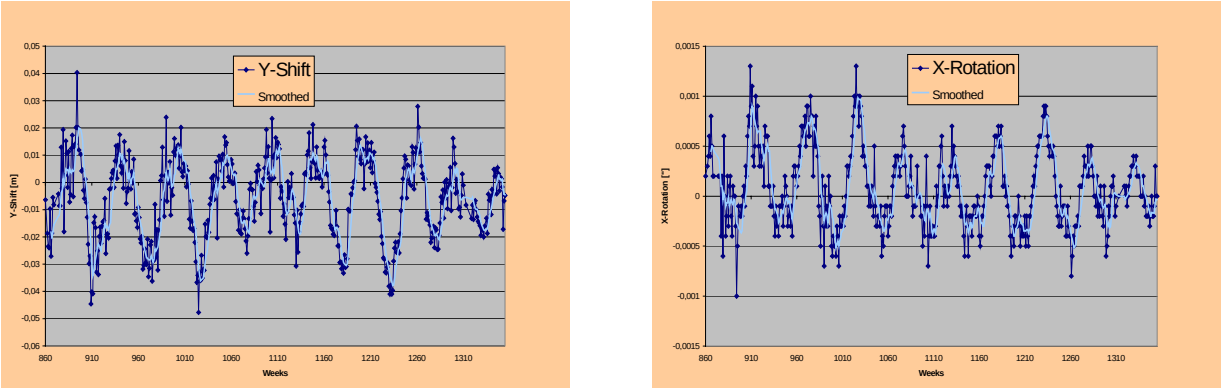


**Figure 4: Helmert parameter of weekly networks vs. combined solution**

# 4 Densification of ITRF2005

The densification of the ITRF2005 realisation of the terrestrial reference frame is an initiative within IAG sub-commission 1.3 „Regional Reference Frames“. Time integrated solutions (positions and velocities) of 6 regional sub-commissions have been inquired. EPN contributes within this scope to the regional European network with the computation of a corresponding multi-year solution. All EPN weekly SINEX files of weeks 860 (30 Jun 1996) – 1355 (31 Dec 2005) have been converted into normal equations (NEQs) and combined into a draft multi-year solution. The variation of the RMS for the Helmert transformations between each weekly solutions and the combined solution is given in Figure 2. It may lead to the assumption of changing analysis accuracy over the given period. But the RMS is highly correlated with the number of reference sites, which are used for datum definitions, as given in Figure 3, and it may explain the variation in Figure 2. The setup of new “solution numbers” for reference stations after a coordinate change leads to a loss of reference sites over the years. This problem will be solved with the availability of ITRF2005, where reference coordinates of all solution numbers will be present. Therefore the current solution has the “draft” status. Seven Helmert parameters have been computed for the transformation between the weekly solutions and the multi-year solution. The time series of the resulting y-shift and x-rotation are given in Figure 4. These parameters show an annual variation, which is not yet explained. Comparable variations are also present for the remaining 5 Helmert parameters.

# 5 Outlook

Changes of the EPN analysis as described in chapter 3 will be implemented with the beginning of GPS week 1400 and thus follow the time schedule of the IGS. Discontinuities in the weekly coordinates of a multitude of stations are expected. The EPN multi-year solution will be re-calculated with the new set of reference coordinates that becomes available with the ITRF2005 terrestrial reference frame realisation.

# References:

EPN Central Bureau (2006): *Minutes of EUREF Analysis Workshop, Padua, Italy, March 15 – 16, 2006*, http://www.epncb.oma.be