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EPN Analysis Coordinator Report

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Abstract

This report includes the activities related to EPN analysis since the past EUREF symposium in 2009. The personal responsibility for the Local Analysis Centre (LAC) at the Warsaw University of Technology (WUT) changed at week 1560 (December 2009) coupled with technical changes for that LAC. Since the same week a new LAC at the Military University of Technology (MUT) has been accepted responding to specific redundancy needs. New guidelines for EPN Analysis Centres have been published at the EPN Central Bureau (EPN-CB) website and provide up-to-date information about analysis components and processing/submission instructions. All LACs have been asked to change the SINEX format for the weekly solutions in a way that the normal equation vector and matrix will be included instead of the co-variances of the solutions. It is expected that the new format, that is called NEQ-SINEX, will avoid numerically instable format conversion as occasionally appeared in the past. The GNSS Data Centre at the Federal Agency for Cartography and Geodesy (BKG) is the primary source for LAC solutions and EPN combined product files. Structure and design of its website has recently been re-newed, where a separate account for the EPN re-processing initiative has already been added. The 7th LAC Analysis Workshop has already been announced to take place on November 18 and 19, 2010 hosted by the Military University of Technology in Warsaw, Poland. The re-processing of the complete EPN network since its creation in 1996 will be a major topic of this workshop.

1 Introduction

The main task of the EPN Analysis Coordinator (AC) is to manage all items related to the analysis of the EPN GNSS data and to combine EPN sub-network solutions as calculated by currently 17 LACs. The combined solutions become official EPN products. This paper will not report on the complete series of products, but will highlight a few recently happened events and actions that are related to EPN analysis.

2 The Military University of Technology, Warsaw LAC

Since week 1560 (December 2009) the personal responsibility for the Warsaw University of Technology (WUT) LAC changed and was coupled with some operational changes. The WUT LAC has been operated in cooperation with the Military University of Technology, Warsaw (MUT) until December 2009, and MUT requested now to continue EPN activity as new LAC. The new LAC at MUT was accepted by the EUREF Technical Working Group (TWG) and the EPN Coordination Group responding to specific redundancy needs in the EPN analysis and it started operation with week 1560. A separate sub-network of 114 EPN stations was assigned to MUT analysis by following the criterion to increase the redundancy from 3 to 4 LACs for all EPN sites. The formal improvement of redundancy as derived from the assignment of stations to the LAC's sub-networks has

been confirmed in the weekly EPN solutions. Figure 1 sows the redundancy for week 1575 (MUT included). This validation of the formal changes is important because in practise for many reasons the assigned stations are not always included in the solutions completely. The redundancy factor, which is equivalent to the number of stations analysing a particular station, was calculated as a mean considering all stations of one particular weekly solution and is given in Figure 2 for the period of week 1300 to week 1576. It improved from approximately 3.5 to 4.1 since the inclusion of MUT solutions. If we focus of such stations, which hold the minimal redundancy factor of a single week, we observe an increase of almost the factor of one since MUT is contributing. It confirms the intended improvement, where the MUT solution does not change the maximal redundancy factor. A higher redundancy increases the reliability for detection of outlier and inconsistencies in the combination of the LAC solutions.

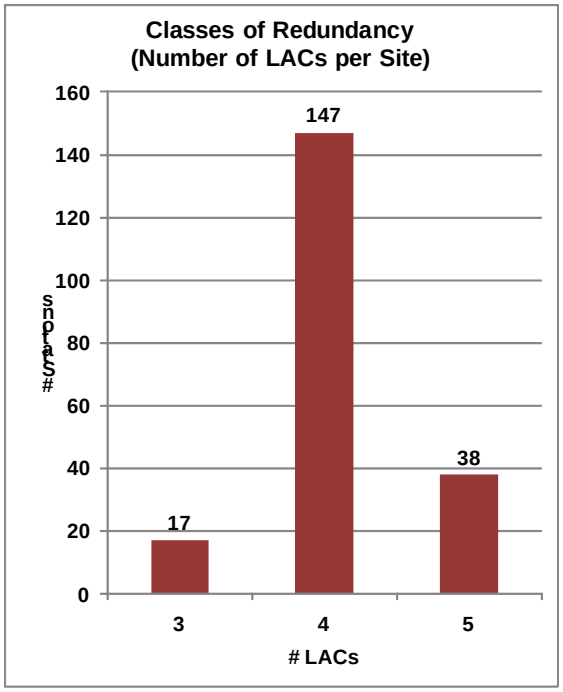

Figure 1: Redundany Week 1575

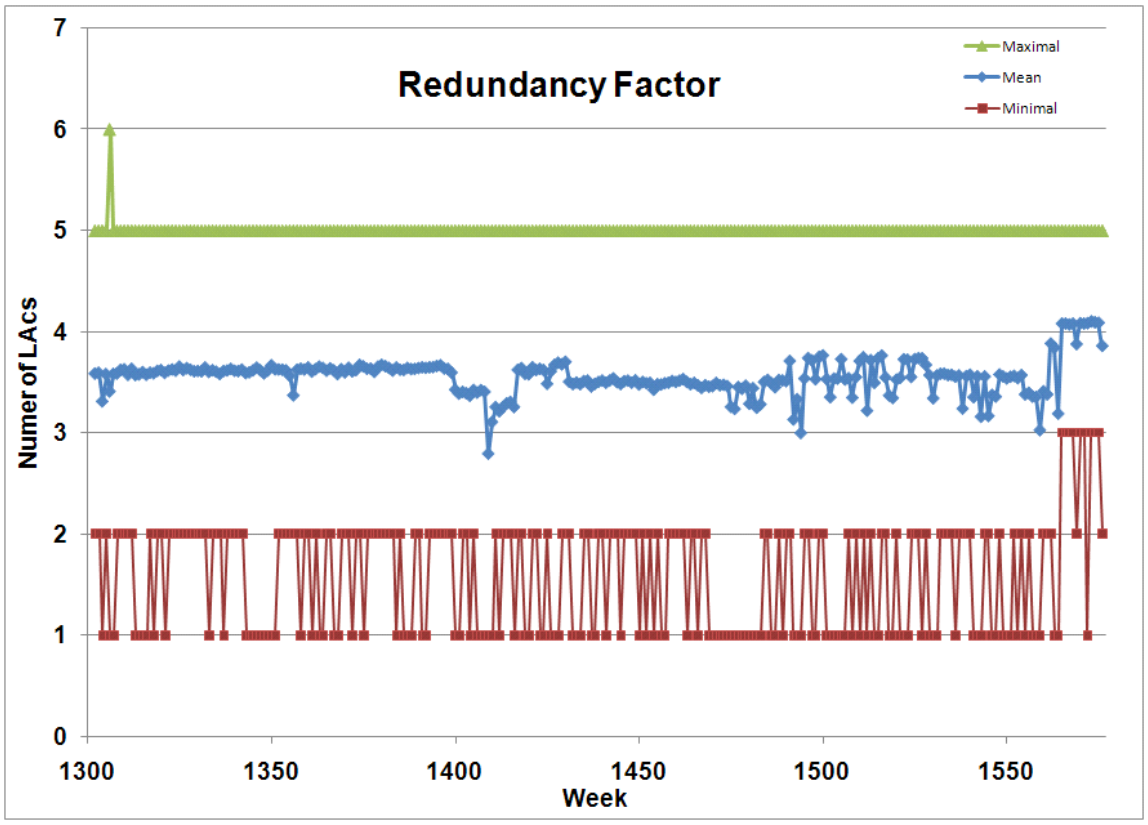

Figure 2: Development of Redundancy

3 Guidelines for EPN Analysis Centres

A complete revision of the Guidelines for Analysis Centres has been put online at the EPN-CB on 12 February 2010 [EPN Central Bureau, 2010]. The document contains now 5 sections and an addendum, which replaces the former document "EPN Processing Option Table". Figure 3 summarizes the analysis components. The LACs submit 5 series of solutions that a classified by the mandatory, recommended or optional attribute. The combined products are available for all types of products, but for the recommended and optional solutions they may not consider all EPN sites.

LAC Solutions		**Coordinate Combination**	
Final Weekly Coordinate Solution	mandatory	Final Weekly Coordinate Solution	
Final Daily Coordinate Solution	recommended	Final Daily Coordinate Solution	
Rapid Daily Coordinate Solution	recommended	Rapid Daily Coordinate Solution	
Hourly Coordinate Solution	optional	Hourly Coordinate Solution	
Final Daily Tropospheric Zenith Path Delays	mandatory	**Troposphere Combination**	
		Accumulated Coordinate Solution	
		EPN Projects	Re-Processing, Real-Time Analysis, GGOS

Figure 3: Analysis Components

4 Re-Construction of Normal Equation

For combination of the sub-networks as submitted in SINEX format by the LACs the Bernese GPS Software (BSW) re-constructs normal equations (NEQs). The NEQs will be stacked and solved to obtain the final combination. Figure 4 shows 4 options of BSW to re-construct the NEQs for the example of the NKG LAC solution of week 1560. This conversion is performed through the SNX2NQ0 program of BSW. The first line refers to a SINEX file, which contains the solution matrix estimate and a-priori (typically provided as covariance, but also correlation may be used). It does not re-construct the original NEQ and thus the number of parameters in the NEQ will be set to the number of coordinates in case of the EPN combination approach. This option was applied since many years in the EPN weekly coordinate combination. It was the only option that could be used for all contributing LACs, because re-construction of original NEQs failed for some (non-BSW) solutions. Under certain circumstances it happened in the past that obviously due to numerical exceptions the term v^tpv was reported to be negative and the variance factor was set to the default by the used program. This situation is given in the first line of Figure 4. The second line of the table refers to the same SINEX file

as the first line, but the original NEQs have now been re-constructed. Resolution of the NEQs results now in reasonable numbers for the a-posteriori RMS of unit weight and variance factor. Es mentioned before this option might be problematic for non-BSW solutions. Since 2009 it became possible to write the normal equation vector and matrix into the SINEX files with BSW version 5.0. We call this format NEQ-SINEX. This option was applied to obtain the results in line three of the table, where the original NEQs has not been re-constructed. The resulting a-posteriori RMS and variance factor are too big after the initial computation, but after applying an empirically determined re-scaling factor in the repeated computation the a-posteriori RMS results to 1 mm as expected. The requirement to determine a re-scaling factor empirically is an disadvantage of this approach. The last line of the table refers again to a NEQ-SINEX file, but the original NEQs have been re-constructed. The resulting a-posteriori RMS is 1.33 mm without further re-scaling. This option is considered to be the best one and is now applied in the combination of the weekly LAC solutions. For non-BSW solutions the old option will be used, until the difficulty of handling NEQ-SINEX will be resolved. It has to be mentioned here, that for the time being the combined EPN product will still be published in the COV-SINEX format. Weekly combined solutions in NEQ-SINEX format are available on request.

Type of SINEX	Re-Construction Original NEQ	A-Posteriori RMS of Unit Weight	Variance Factor
COVA	NO	0.00100 m set to default (v'Pv < 0 reported)	1.00 set to default
COVA	YES	0.00133 m	1.28
NEQ	NO	0.03647 m	1329.89
		0.00100 m after re-scaling	1.00 after re-scaling
NEQ	YES	0.00133 m	1.28

Figure 4: NKG Sub-Network Solution Week 1560

5 Outlook

It is planned to complete the analysis solutions (daily, rapid daily and hourly) for as many EPN stations as possible. Today only the weekly solutions are provided for all EPN stations.

The re-processing of the complete EPN tracking data has been launched as EPN project in 2009. The EPN AC will be involved in this project by combining daily and weekly re-processed LAC solutions and evaluating the results.

During the 7th EPN LAC Workshop on November 18 and 19, 2010 in Warsaw at MUT all aspects relevant for EPN analysis will be discussed and updated. The second day of the workshop has been reserved to cover re-processing issues.

6 References

EPN Central Bureal [2010]: http://www.epncb.oma.be/_organisation/guidelines/guidelines_analysis_centres.pdf