Preliminary results of the GNSS Campaign for integration of the ASG-EUPOS permanent stations with first order national geodetic networks

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Abstract. The active geodetic network - ASG-EUPOS in Poland was established in 2008. The main goal of the GNSS campaigns performed in 2008 and 2010/11 was the integration of the new network with existing national geodetic networks (satellite and "classical", horizontal and vertical). In total 151 field points and 133 permanent stations (EPN/IGS, ASG-EUPOS, SAPOS, CZEPOS, SKPOS, LITPOS) were measured in 2008 and 275 field points of existing network, 113 new ASG-EUPOS eccentric points, 94 direction points and 135 permanent stations were measured in 2010/11.
Both campaigns were processed in Bernese GPS Software ver.5.0 using the same data processing strategy and ITRF2005 reference frame.
There are presented the results obtained for those two independent campaigns and for integration in one common solution.

Keywords: GNSS, ASG-EUPOS, national geodetic networks, networks integration

1. Introduction

The ASG-EUPOS network consists of 99 permanent stations: 81 GPS stations and 18 GPS/GLONASS stations.
The establishing of the new permanent network involved the realisation of the measurement campaign for integration it with the existent geodetic networks in Poland. The Head Office of Geodesy and Cartography managed two campaigns – the first one in 2008 and the second one in 2010/2011. During both of them, the field points of Polish GPS and classical networks were measured together with ASG-EUPOS stations and with selected EUOPOS stations from neighbourhood counties (Germany, Czech Republic, Slovakia, Lithuania). To connect those sub-networks to ITRF the data from IGS and/or EPN stations were used. During the second campaign, new external points for each ASG-EUPOS station were also established and measured.

2. Observation Campaigns

During both campaigns, selected sets of points of Polish geodetic networks were measured. Table 1 presents the number of different type of points measured in 2008 and 2010/2011.

Table 1. Number of different type of points measured in 2008 and 2010/2011 campaigns

Type of point	Number of points measured in 2008 campaign	Number of points measured in 2010/11 campaign
EUREF-POL	8	
POREF	102	242
EUVN	41	4
First order of classical network		31
Direction point		16
Eccentric point of class A		114
Eccentric point of class B		77

In year 2008, the measurements were carried out from 23-rd of April to 11-th of May. In 2010/2011 campaign the measurements were managed in three parts:

- 12.10.2010 – 14.11.2010 (stopped because of requirement that eccentric stations could be measured after 4 months from date of their stabilisation),
- 07.12.2010 – 12.12.2010 (stopped because of weather conditions – hard frost, heavy snowfalls),
- 23.03.2011 – 04.04.2011.

In both campaigns different observation sessions for different type of measured points were setting. They are presented in Table 2.

Table 2. The observation sessions for different type of points measured in both campaigns.

Type of measured point	Observation session
ASG-EUPOS stations	Permanent observations (24 hours from 0:00 UT till 24:00 UT)
EUREF-POL	7 days of permanent observations (24 hours from 0:00 UT till 24:00 UT)
Main field points and eccentric stations class A	Two sessions by 24 hours-observation (start 12:00 UT stop 12:00 UT and (minimum 24 hour of break between sessions)
Direction points and eccentric stations class B	Two sessions by 2 hours-observations (minimum 1 hour of break between sessions)

In order to obtain the high quality of data and good results during processing special conditions for measurements carried out at field points were defined. They are:
– homogenous measurement equipment (Trimble R8 GPS receivers in year 2008 and Trimble R8 GNSS receivers in years 2010/2011),
– continuous observation for 24 hour-sessions (the breaks longer than 60 minutes induce must of re-measurement),– observation interval – 5 seconds– elevation cut off for satellites – 0^o
– accuracy of antenna height measurements not worse than 0.005m – antenna centering accuracy not worse than 0.003m

3. Data processing

The 2008 campaign was processed first time just after the measurements in May/June 2008 and published by (Jaworski et. al., (2008)). New conditions posed by the Head Office of Geodesy and Cartography to processing and integration of both campaigns resulted in the need of re-processing of 2008 campaign.

3.1 Processing strategy

The data processing, for both campaigns, was performed using the Bernese GPS Software, version 5.0. In computation the procedure recommended by (C. Bruyninx et. al (2010)) were used, i.e.:
– use of IGS final precise orbits and IGS Earth Rotation Parameters,
– Antenna Phase Centre from IGS_05.ATX for absolute models and EPN_05.ATX file for individual models,
– reference frame - ITRF2005 rotated to observation epoch,
– minimally constrained solution,
– using the ionosphere–free linear combination L3,
– introducing the fixed L1 and L2 ambiguities resolved from QIF strategy for baseline,
– estimating tropospheric zenith delay parameters for every hour with *„dry Neill”* mapping function and taking NMF for each point with horizontal gradient computed with TILTING option,
– elevation cut–off angle with elevation–dependent weighting (5, 10 and 15 degree for 2008 campaign and 5, 10 degree for 2010/2011 campaign),
– Sun and Moon ephemeris – model DE405,– Precession and Nutation parameters – standard IAU2000,– Tidal model – IERS2000,– Ocean loading effect – model FE2004.

The baseline computations were carried out in different variants:
– computation of all GPS observations for permanent stations and main field points measured for elevation cut-off 5, 10 and 15 degrees – for 2008 campaign.
– computation of all GPS observations for permanent stations and main field points measured for elevation cut-off 5 and 10 degrees for 2010/2011 campaign
– computation of homogenous 24-hour observation data for permanent stations and main field points measured in 2008 campaign
– computation of GPS and GLONASS observations for permanent stations and main field points measured in campaign 2010/2011– computation of all GPS observations for permanent stations and main field points measured in both campaigns
– computation of GPS observations for direction points and eccentric stations class B processed with reference to main points for 2010/2011 campaign

3.2 Baseline configuration

During processing, ASG-EUPOS and Polish EPN stations with full set of data were selected. They built a net of nodes for connection of network to ITRF. The main baselines link external EPN/IGS stations with node stations. Other points were computed using baselines to node stations. The configurations of baselines to reference EPN/IGS stations are presented in Figures 1 and 2, respectively for 2008 and 2010/2011 campaigns.
The processed baselines are presented in Figures 3 and 4, respectively for 2008 and 2010/2011 campaign.

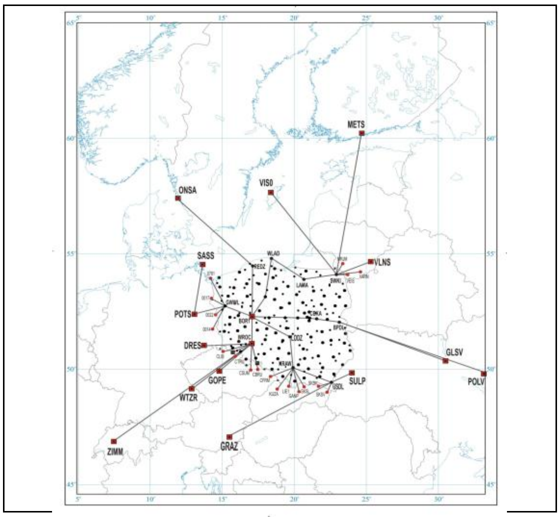

Figure 1. Baselines to reference EPN/IGS stations for 2008 campaign.

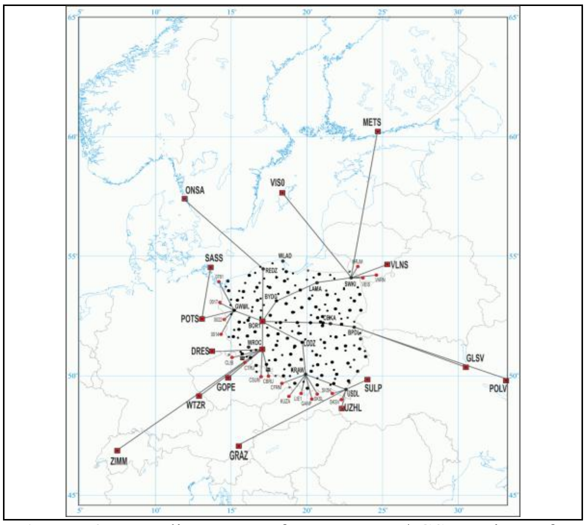

Figure 2. Baselines to reference EPN/IGS stations for 2010/2011 campaign.

4. Results

Preliminary results obtained for described measurement campaigns are presented in form of daily repeatability. Comparison of different variants of baseline computation for 2008 campaign carried out for different elevation cut-off and homogenous 24-hour observations are presented in Figure 5. It shows that for lower angle of cut-off satellite observations we obtain better results in daily repeatability.

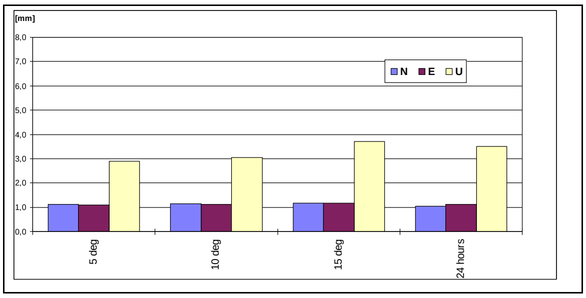

Figure 5. Daily repeatability of co-ordinates for different type of processing determined for 2008 campaign

Analyses of results obtained for different parts of 2010/2011 campaign are presented in Figure 6.
It is clearly seen that weather conditions during the measurements are still visible in results of the processing. The results for wintertime are worse than for other seasons. We can suppose that it is caused by applied models in data computation, that are still not good enough or by very bad weather conditions during wintertime when hard frost, heavy snowfalls could disturb the measurements.

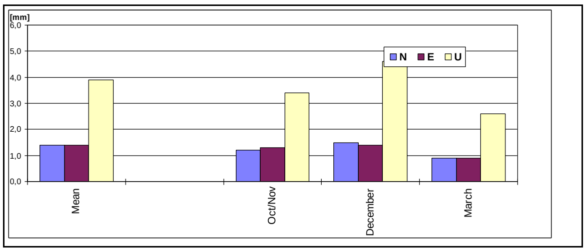

Figure 6. Daily repeatability of co-ordinates determined for consecutive part of 2010/2011 campaign.

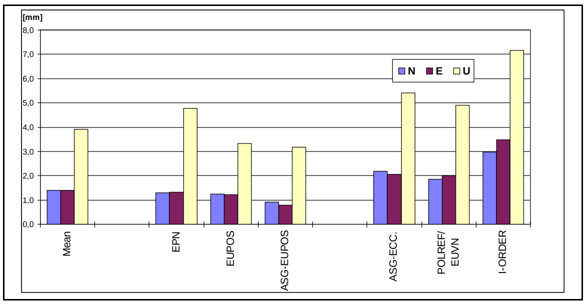

Figure 7. Daily repeatability of co-ordinates determined for different type of measured stations for 2010/2011 campaign.

Figure 8. Picture of horizon prepared for point I324. Those conditions are unsuitable for GNSS measurements.

Different types of measured points give us the possibility of comparison the daily repeatability of obtained coordinates. The results are presented in Figure 7. The best results were obtained for permanent stations because they have better observation conditions (open horizon) and bigger set of data. Analysing the field points we observe that POLREF/EUVN points coordinates obtained better accuracy than ASG-EUPOS eccentric points and points of First Order Classical network. It is caused by the observation conditions on the points. The eccentric points are located in cities, near the main ASG-EUPOS stations and in many cases there was not possible to find location with open horizon. The same reason concerns the points of classical network. The rules for point location were very different for classical measurement. Some of selected by the Head Office of Geodesy and Cartography points were unsuitable for GNSS observations (see Figure 8 as the example of bad point selection), but for analyses, all of them were used.

During 2010/2011 campaign few cases of changes the measurement equipment on the ASG-EUPOS stations were occurred. It gave the opportunity to prepare analyses of changes in station coordinates for different receiver/antenna pairs.

The first example is station KATO. On that station, 17.12.2010 Trimble NETRS with TRM41249.00 TZGD antenna was replaced by Trimble NETR5 with TRM57971.00 TZGD antenna. The diurnal changes of coordinates for that station are presented in Figure 9. In that case, both antennas have the individual model of phase centre variations. The observed changes in coordinates are neglected.

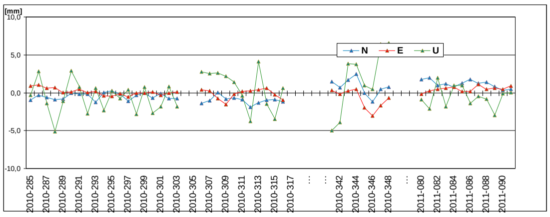

Figure 9. Station KATO - equipment exchange (17-12-2010). Trimble NETRS with TRM41249.00 TZGD antenna replaced by Trimble NETR5 with TRM57971.00 TZGD antenna

The second example is station WODZ. On that station, 9.02.2011 Ashtech UZ-12 with ASH701945C_M SNOW antenna was replaced by Trimble NETR5 with TRM57971.00 TZGD antenna. The diurnal changes of coordinates for that station are presented in Figure 10. In that case, only Trimble antenna has the individual model of phase centre variations. Observed changes are significant, especially in Up component, in which the changes reach 2cm.

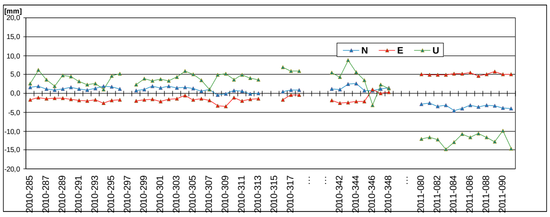

Figure 10. Station WODZ - equipment exchange (09-02-2011). Ashtech UZ-12 with ASH701945C_M SNOW antenna replaced by Trimble NETR5 with TRM57971.00 TZGD antenna

5. Conclusions

Presented results are preliminary, but obtained accuracy is very good and gives us hope that final solution and integration of solutions from both campaigns (2008 and 2010/2011) will give the satisfying results.

Unfortunately, the First Order Classical network points – were selected without making reconnaissance in terrain, so in consequence some of them have not clear horizon, but still have e.g. concrete tripods over them or other obstructions, which increase the noise of repeatability of co-ordinates and means errors of solution.

References

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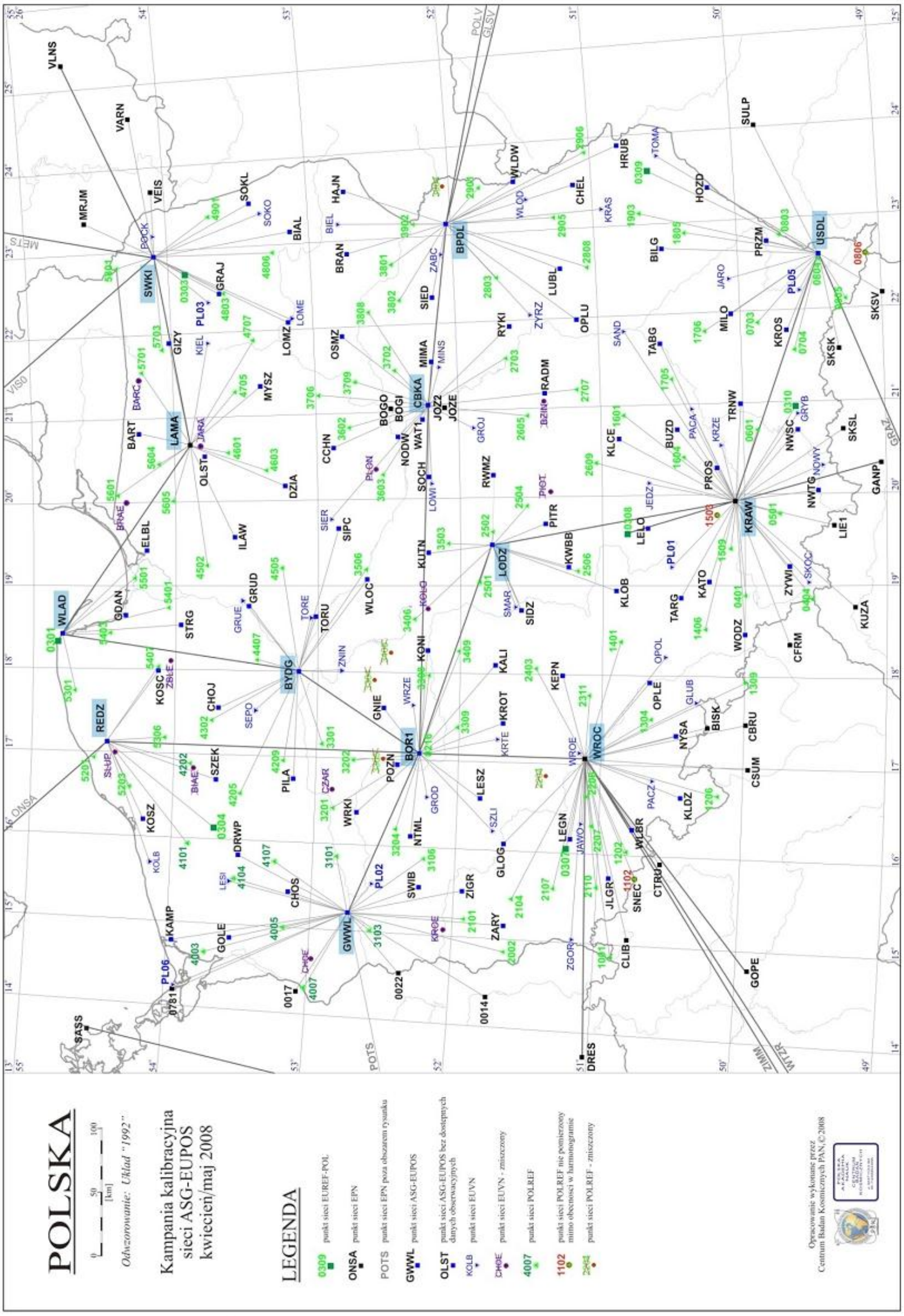

Figure 3. Baselines processed for 2008 campaign. Stations with blue background are the nodes stations.

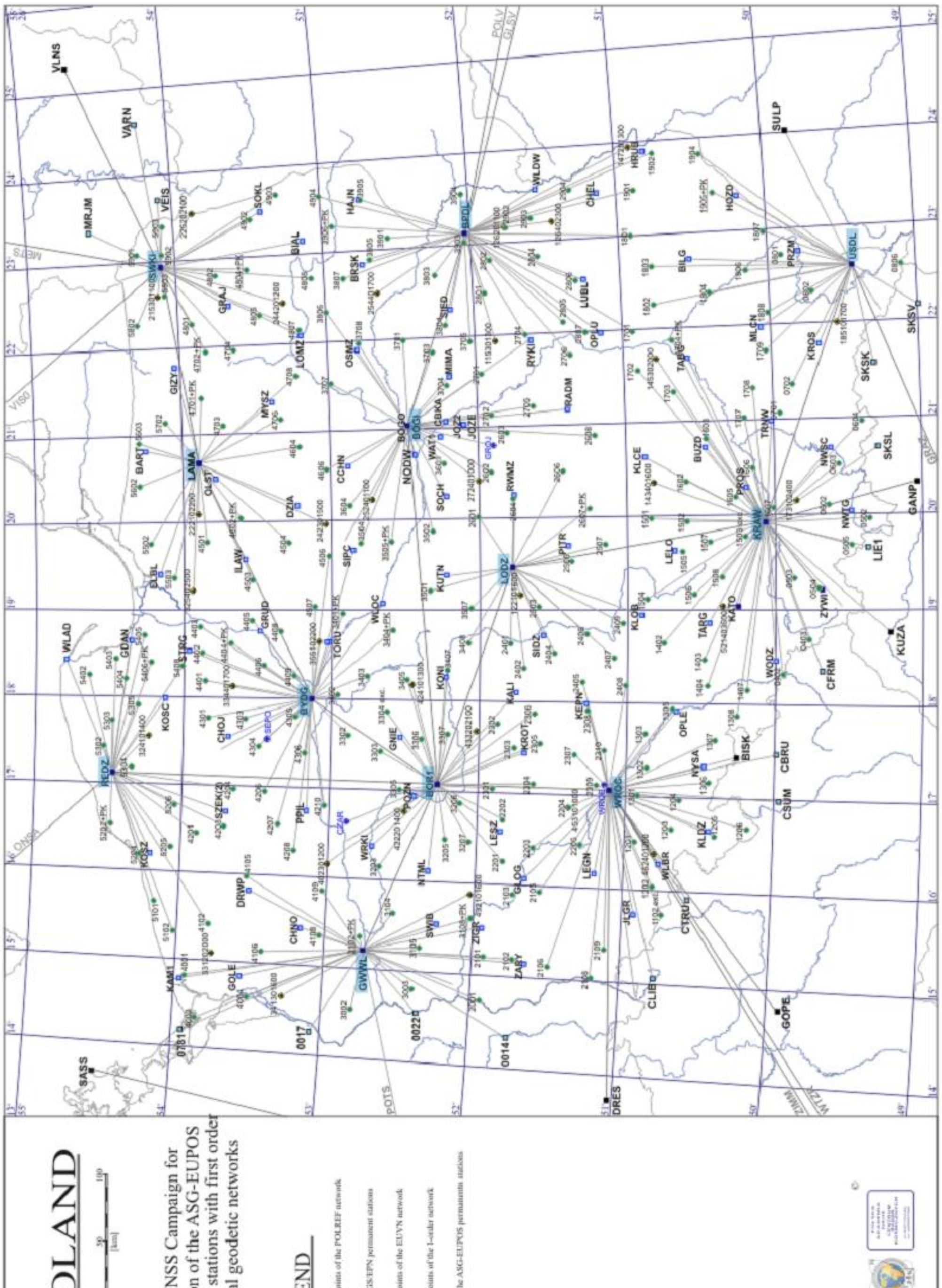

Figure 4. Baselines processed for 2010/2011 campaign. Stations with blue background are the nodes stations.