ASG-EUPOS DENSIFICATION OF EUREF PERMANENT NETWORK ON THE TERRITORY OF POLAND

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1. INTRODUCTION

The ASG-EUPOS multifunctional system for precise satellite positioning is a part of the EUPOS project involving countries of Central and Eastern Europe. The ASG-EUPOS reference stations will consist of: 68 GPS RTK reference stations and 8 GPS/GLONASS RTK reference stations built within the realized project, 16 existing GPS RTK reference stations situated in Poland, 6 GPS/GLONASS existing RTK reference stations admissioned into the system situated in Poland and not more than 30 foreign reference stations situated in the border zone, working within the EUPOS System. All Polish EPN stations are included in the EUPOS network and give a proper realization of the reference frame in that network.
The ASG-EUPOS network will define the geodetic reference system in Poland. A close connection of the ASG-EUPOS stations and 15 of 17 stations of the EPN that are located in the territory of Poland will control the realization of the ETRS89 system at the Polish territory. In the ASG-EUPOS Processing Centre there is installed a Bernese GNSS Software v.5.0 that will be used for calculation on the day by day basis of the whole ASG-EUPOS network according to the EPN standards. This procedure will be used for a "second level control" of the stability of the ETRS89 for the Polish territory. "Third control level" will be effected by the software Trimble GPSNet. The permanent control will be made to the station Borowiec where the satellite laser and GPS/GLONASS techniques are available.
The ASG-EUPOS multifunctional precise satellite positioning system project is realized utilizing the resources of the European Regional Development Fund within the Sectoral Operational Programme „Improvement of the Competitiveness of Enterprises". The contract for project subsidizing was signed on the 2nd of August 2005. The Ministry of Regional Development is the Managing Authority, while Department of European Funds acting within the Ministry of Science and Higher Education is the Implementing Authority and the General Surveyor of Poland is the Final Beneficiary.
On the 2nd of January 2007 the Head Office of Geodesy and Cartography (GUGiK), the consortium: WASKO S.A., Geotronics Poland S.A. and Trimble Europe BV have signed a contract for building the ASG-EUPOS multifunctional precise satellite positioning system in Poland. The consortium finished the realization of the system in April 2008 and after the tests on the 2nd of June 2008 GUGiK opened ASG-EUPOS for all users.

2. ASG-EUPOS SYSTEM STRUCTURE AND FEATURES

The ASG-EUPOS is a multifunctional satellite positioning system built based on international EUPOS standards. Its structure is divided into four basic segments: satellite, reference, management and user segment. Those segments working together provide the system for precise positioning in real-time and post-processing applications.
The reference stations network (reference segment) consists of 98 Polish (76 established during the project) and up to 30 foreign stations that have been built according to the EUPOS standards. The mean distance between reference stations is below 70 km and the stations are regularly distributed, creating a uniform network that covers whole Polish territory.

Fig. 1a. ASG-EUPOS LOMZ station as an example of a GPS station established during the project.

68 GPS stations established during the project include TRM41249.00 TZGD antennas and Trimble NetRS receivers. An example of LOMZ GPS station is shown on Fig. 1a. On Fig. 1b one can see the example of BPDL station (one of 8 GPS/GLONASS stations established) that consists of TRM55971.00 TZGD antenna and Trimble NetR5 receiver. All stations established during the project have UPS's and communication modules for secure and efficient links with Management Centres.

Fig. 1b. ASG-EUPOS BPDL station as an example of a GPS/GLONASS station established during the project.

Following EUPOS standards, additional reference stations' real-time data streams from Czech Republic (CZEPOS), Germany (SAPOS), Lithuania (LITPOS) and Slovakia (SKPOS) were connected to the system. All reference stations of the ASG-EUPOS system are shown on the presented map (Fig. 2).

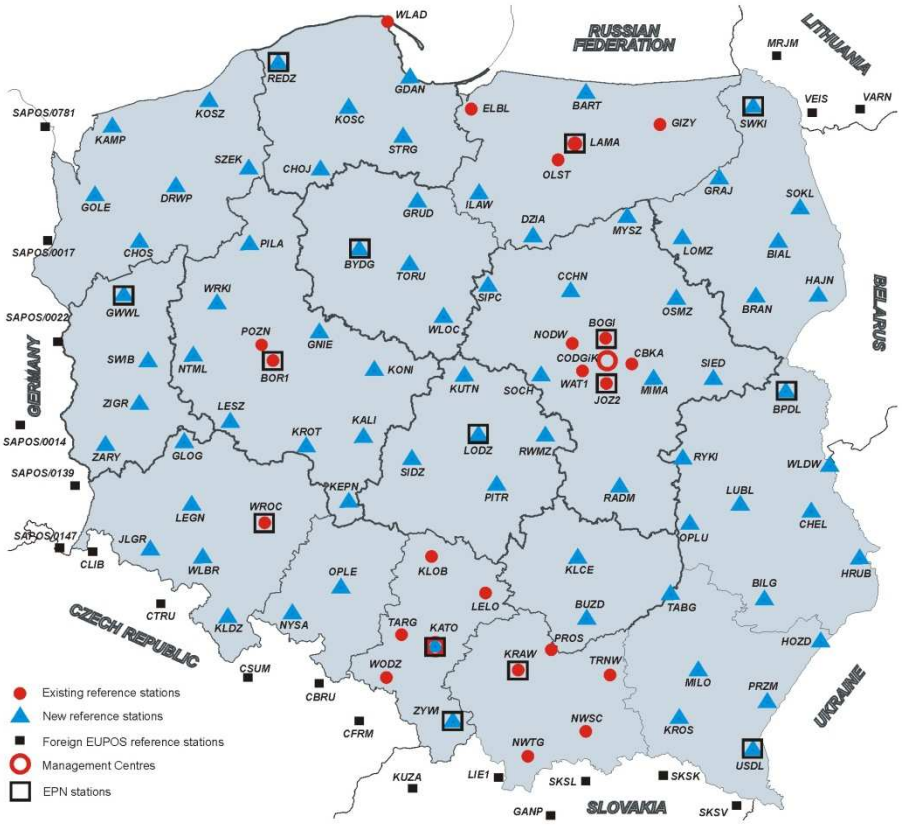

Fig. 2. The map presenting ASG-EUPOS reference stations.

The ASG-EUPOS system consists of two Management Centers: in Katowice and Warsaw. In case of disabling one of the centers the services are switched to the remaining one. The reference network is being managed by Trimble Infrastructure Software™ installed in both MC's.
A calibration campaign is being calculated in order to connect the ASG-EUPOS with existing Polish ground control EUREF-POL, POLREF and EUVN networks and determine the coordinates in one uniform reference frame (one of ETRS'89 realizations).

3. EPN NETWORK DENSIFICATION IN POLAND

During the ASG-EUPOS project, 7 new reference stations were proposed to the EPN network in order to improve uniformity of distribution of EPN stations in Poland. Additionally 2 existing EPN stations (KATO and ZYWI) were completely transformed with new hardware - including new receivers and antennas. All new EPN stations have individual absolute antenna calibrations. Figures on the left show the distribution of the EPN network before (Fig. 3a) and after (Fig. 3b) the ASG-EUPOS project realization. Recently (on June 8, 2008) the proposed stations (BPDL, BYDG, GWWL, LODZ, REDZ, SWKI, USDL) were included in the EPN network as full member stations.

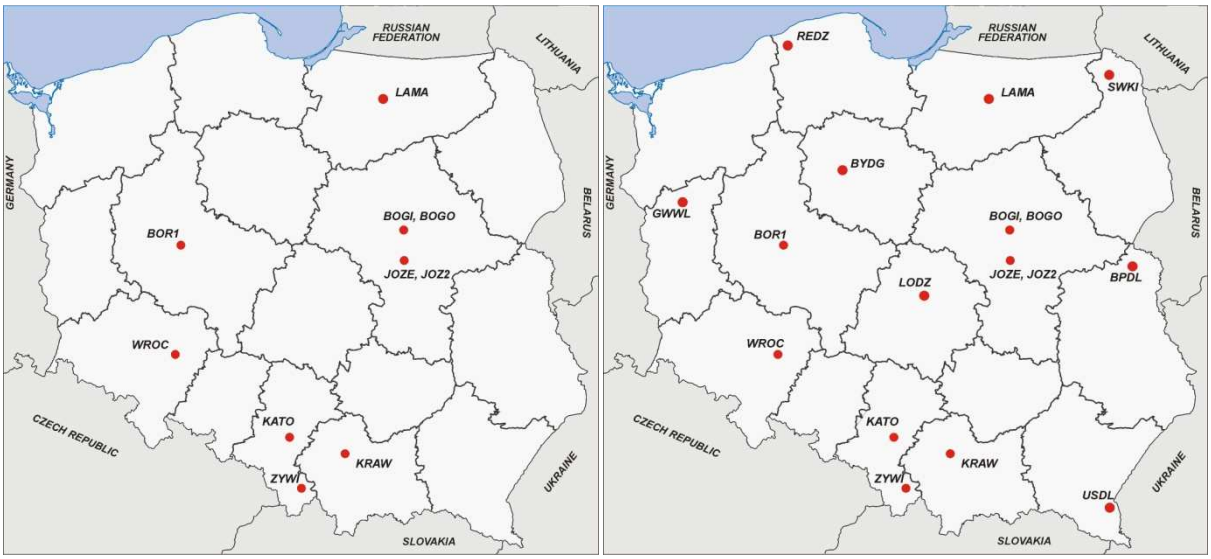

Fig. 3. Former (a – left) and current (after June 8, 2008; b – right)
Polish EPN reference stations.

Currently an order for 14 meteorological stations Paroscientific MET4A is being realized. In the end of June 2008 all Polish EPN stations should be supported with adequate meteorological observations for tropospheric modeling.

4. ETRS'89 REALIZATION IN POLAND

The implementation of the ASG-EUPOS system created the possibility to rearrange the Polish realization of ETRS'89 (the official reference system in Poland) and mechanisms for its control.
The first-level control is being realized by the EPN Analysis Centres that each week calculate the coordinates of regularly distributed GNSS stations on Polish territory.

In order to check the stability of the reference stations' coordinates and the proper realization of ETRS'89 an autonomous calculating system based on the Bernese GNSS Software v. 5.0 is launched.

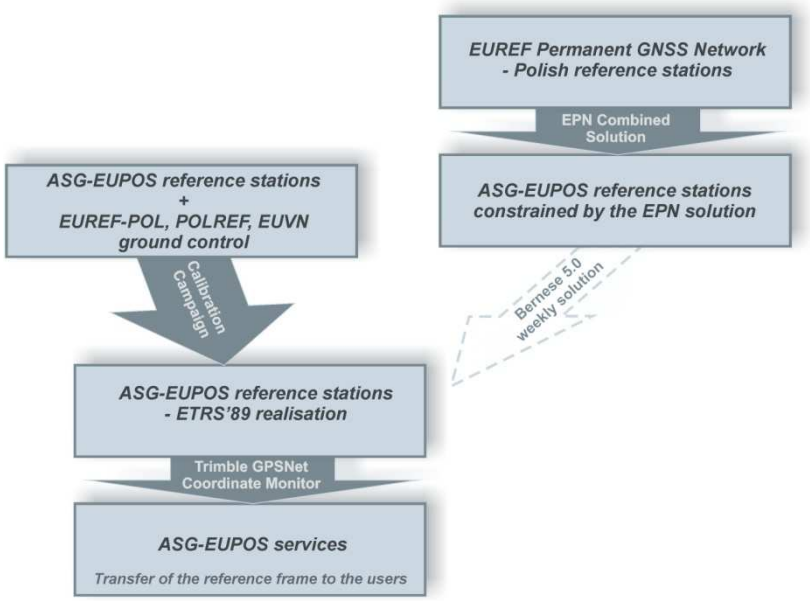

Fig. 4. ETRS'89 realization and control via ASG-EUPOS system.

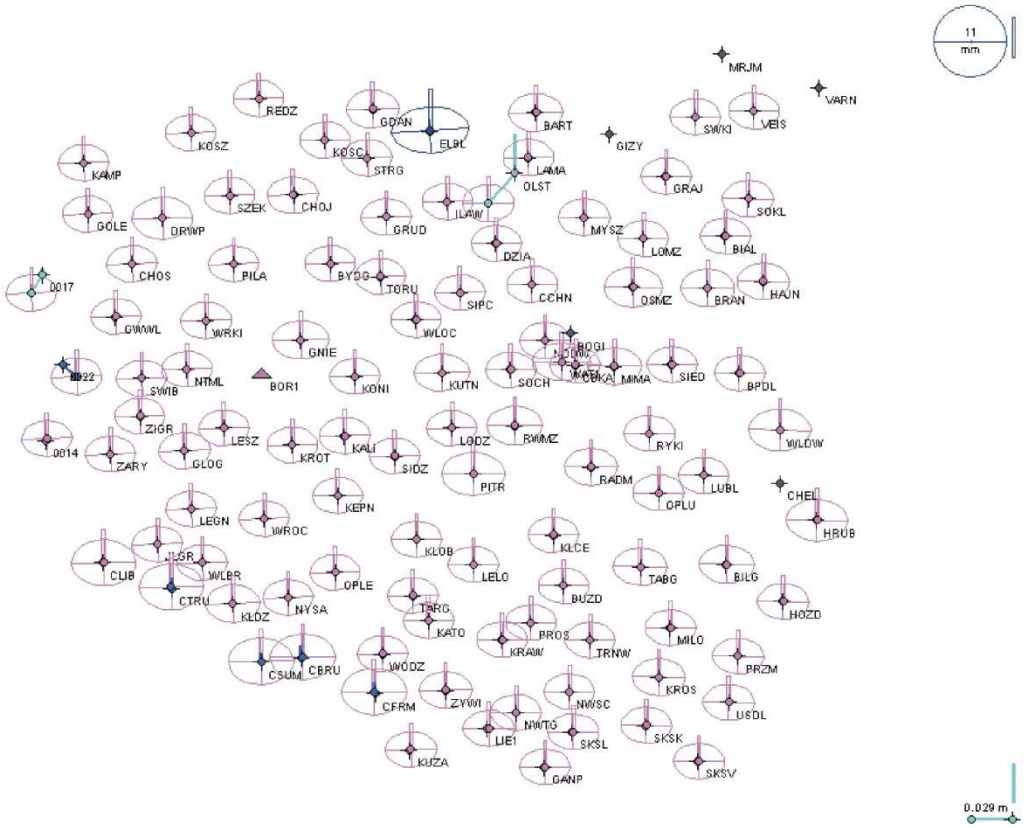

Fig. 5. Coordinate Monitor module in GPSNet software
for stations' stability control in real time.

EPN combined solutions which include the ASG-EUPOS reference stations, are used to calculate whole ASG-EUPOS network. In fact the network is checked in reference to EPN realization of ETRS'89. The calculation procedure is based on the standards applied by the EPN network's Analysis Centres. Processing machine where system is installed is an IBM XSeries 366 with 4 x Intel Xeon 3,16 GHz, 4 x 1024 MB and 4 x IBM SAS 73.4 GB that work in RAID 5 mode.
Additionally the Trimble GPSNet software, which manages and controls the whole ASG-EUPOS network integrity and storage, has additional modules for station stability control. The Coordinate Monitor module (Fig. 5) constantly and in real-time calculates the vectors between the reference stations and by controlling their length, creates alarms when a reference station movement exceeds the given limit.
As mentioned above, the Calibration Campaign, which aim is to connect the existing Polish ground control EUREF-POL, POLREF and EUVN with the ASG-EUPOS stations, is currently being finished. In the first stage static GNSS measurements were taken on 150 ground control points and the results are being calculated in one adjustment process along with the reference stations.
The ASG-EUPOS services enable the transfer of reference frame into real applications in the field. The availability of services assures a uniform distribution of the reference frame over the whole territory of Poland. Table 1 shows real-time and post-processing services available in the ASG-EUPOS system.

Table 1. ASG-EUPOS services provided to the users.

SERVICE GROUP	SERVICE NAME	SURVEY METHOD	DATA ACCESS	ESTIMATED PRECISION	MINIMUM HARDWARE REQUIREMENTS
Real-time services	NAWGEO	Kinematic (RTK/RTN)	GSM / Internet	0.03 m (horiz.) 0.05 m (vert.)	L1/L2 GPS RTK receiver; communication module
	NAWGIS KODGIS	Kinematic (DGNSS)		1.0 - 3.0 m 0.2 - 0.5 m	L1 DGPS receiver; communication module
Postprocessing services	POZGEO POZGEO D	Static/ kinematic	Internet / CD-ROM	0.01 - 0.1 m	L1 GPS receiver

5. CONCLUSIONS

The ASG-EUPOS system will ensure a stable and uniform reference system ETRS89 realization in Poland. The ASG-EUPOS system include three independent levels for the control of the stability of the ETRS89 realization. The system accessibility and the realisation of precise positioning service will be carried out in real time and homogeneous reference frame in the territory of Poland.

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