National Report of Poland to EUREF 2004

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Summary

Since 2002 the main geodetic activities at the national level in Poland concentrated on

- completing data processing related to re-levelling the 1st order vertical control,
- activity towards a cm geoid model in Poland
- continuing operational work of permanent IGS/EUREF stations,
- conducting GPS data processing on the regular basis at Local Analysis Centre at WUT,
- activity towards setting up an active GPS geodetic control

The work is summarized in this report.

1. Re-levelling the 1st order vertical control

The re-levelling of the 1st order vertical control in Poland with total length of 382 lines of 17 516 km has started in May 1999 was completed in June 2002. Levelling rod comparation corrections as well as thermal and tidal corrections have been implemented to raw levelling. Based on differences between back and fore levelling of a section (about 16 000 sections surveyed) mean square error of levelling equals to ±0.278 mm/km$^{1/2}$. Random and systematic errors of levelling estimated using Lallemand formula are ±0.261 mm/km$^{1/2}$ and ±0.088 mm/km, respectively. Normal heights determined in preliminary adjustment of the network in the mode of free network adjustment fit very well to those from the previous levelling campaign in 1974-1982. Estimated standard error of observation of unit weight equals to ±0.088 mm/km and coincides with the one obtained in previous campaign. Work on the ties of the network with the vertical control of Belarus, Czech Republic, Germany, Lithuania, Russia, Slovakia and Ukraine is in progress.

2. Modelling a cm geoid for Poland

The project on the cm geoid in Poland (Krynski, 2001) that came into operational stage at the beginning of 2003 is in progress. In the first step is a qualitative and quantitative analysis of all available data, i.e. gravity data (terrestrial, sea-borne and air-borne), deflections of the vertical, GPS/levelling, altimetry, tide gauge, topographic data (DTM), crust density was carried out. About one million of terrestrial gravity data acquired within numerous geological prospective projects conducted over last 50 years of 20th century was carefully analysed and transformed to recently adopted geodetic systems and gravity level. Also shipborne, airborne gravity data as well as altimetry data for southern Baltic Sea was collected and transformed to a uniform system. Deflections of the vertical surveyed in the second half of last century were also analysed in terms of their usefulness for precise geiod modelling. Some new astronomical observations were also conducted for densification of the existing data as well as for control. Quite extensive research was done on GPS/levelling data from EUVN network as well as from the networks that densify EUREF stations in Poland, all together consisting of almost 1000 stations. Different algorithms of geoid height interpolation based on GPS/levelling data with and without use of gravity data were discussed. Levelling data from 1st order vertical control network obtained during last levelling campaign (1998-2002) was analysed and compared with data from previous campaign (1974-1982). Countrywide digital terrain model of 30×30 m was found quite useful for precise geoid modelling except in high mountain region where the model is insufficient in terms of accuracy. Upper lithosphere density derived from geological survey in Poland was also analysed. The construction of database consisting of all data used for the project is in progress. Some sections of the dense GPS/levelling control traverse crossing Poland from south-western borders to north-eastern ones were surveyed. Also some supplementary control gravimetric survey was conducted. The project is in progress; its closing is expected by the end of 2005.

3. Operational work of permanent IGS /EUREF stations

Permanent GPS stations of IGS and EUREF network operate in Poland since 1993. The number of GPS stations in Poland was growing within last years.

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Recently 10 permanent GPS stations, i.e. Borowa Gora (BOGO, BOGI), Borowiec (BOR1), Jozefoslaw (JOZE, JOZ2), Lamkowko (LAMA), Katowice (KATO), Krakow (KRAW), Wroclaw (WROC) and Zywiec (ZYWI) (Fig. 1) operate in Poland within the IGS/EUREF program. A brief characteristics of those stations is given in Table 1. Products of the permanent GPS stations in Poland, together with such stations in Europe, were the basis of the networks that are applied for both research and practical use in geodesy, surveying, precise navigation, environmental projects, etc. Data from those stations is transferred via internet to the Local Data Bank for Central Europe at Graz, Austria and to the Regional Data Bank at Frankfurt/Main, Germany. The EPN stations at Borowa Gora, Borowiec, Jozefoslaw and Wroclaw participate in IGS/IGLOS program.

Jozefoslaw and Krakow stations as well as Borowa Gora that is in the test operational phase, take part in the EUREF IP pilot project (Table 2) (*http://www.epncb.oma.be/projects/euref_IP/euref_IP.html*). Some practical tests with RTK and DGPS survey using the IP technology and mobile phone data transfer were conducted at the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology (Rogowski, 2003; Rogowski et al., 2004), at the Institute of Geodesy and Cartography in Warsaw (Cisak et al., 2001; 2004) as well as at the Chair of Satellite Geodesy and Navigation of the University of Warmia and Mazury (Oszczak, 2004).

Fig. 1. IGS/EUREF network of permanent stations in Poland in 2004

Table 1. Characteristics of Polish EPN stations

4 char Station ID	Domes Number	Location/ Institution	Receiver/ Antenna	Started operating	Meteo/ Rec. device	Data transfer blocks	Additional observations
BOGO	12207M002	**Borowa Gora** Inst. of Geodesy and Cartography	**Ashtech ZXII3** ASH700936C_M SNOW	08JUN1996	**Yes** LAB-EL Poland	24 h 1h	Ground water level Astrometry Gravity GPS
BOGI	12207M003	**Borowa Gora** Inst. of Geodesy and Cartography	**Javad JPS Eurocard** ASH700936C_M SNOW	06MAY2003	**Yes** LAB-EL Poland	24 h 1h	Ground water level Astrometry Gravity GPS/GLONASS
BOR1	12205M002	**Borowiec** Space Research Centre, PAS	**Rogue SNR-8000** AOAD/M_T	01JAN1994	**Yes** NAVI Ltd. Poland	24 h 1h	SLR GPS/GLONASS
JOZE	12204M001	**Jozefoslaw** Inst. of Geodesy and Geod. Astr., WUT	**Trimble 4000SSE** TRM14532.00	03AUG1993	**Yes** LAB-EL Poland NAVI Ltd. Poland	24 h 1h	Ground water level Astrometry Gravity tidal GPS
JOZ2	12204M002	**Jozefoslaw** Inst. of Geodesy and Geod. Astr., WUT	**Ashtech Z18** ASH701941.B SNOW	02JAN2002	**Yes** LAB-EL Poland NAVI Ltd. Poland	24 h 1h	Ground water level Astrometry Gravity tidal GPS/GLONASS
KATO	12219S001	**Katowice** Head Office of Geodesy and Cartography	**Ashtech µZ-12** ASH701945C_M SNOW	29JUL2003	**No**	24 h 1h	GPS
KRAW	12218M001	**Krakow** AGH UST	**Ashtech µZ-12** ASH701945C_M SNOW	01JAN2003	**Yes** LAB-EL Poland	24 h 1h	GPS
LAMA	12209M001	**Lamkowko** Inst. of Geodesy, UWM	**Ashtech ZXII3** ASH700936F_C SNOW	01DEC1994	**Yes** LAB-EL Poland	24 h	Gravity GPS
WROC	12217M001	**Wroclaw** Agriculture Academy	**Ashtech Z18** ASH700936D_M	28NOV1996	**Yes** LAB-EL Poland	24 h 1h	Ground water level GPS/GLONASS
ZYWI	12220S001	**Katowice** Head Office of Geodesy and Cartography	**Ashtech µZ-12** ASH701945C_M SNOW	29JUL2003	**No**	24 h 1h	GPS

Table 2. Characteristics of Polish stations participating in the EUREF IP pilot project

Location	Appr. lat. [deg]	Appr. long. [deg]	RTCM message types (update rate [s])	Bitrate [bits/s]	Site log file
Krakow	50.01	19.92	1(1),3(30),16(60),18(1),19(1),22(60)	1900	KRAW
Jozefoslaw	52.10	21.03	1(1),3(60),18(1),19(1),22(60),31(1)	1200	JOZ2
Borowa Gora*)	52.48	21.04	1(1),3(60),18(1),19(1),22(60),31(1)	1200	BOGI

*) Test phase

4. Data processing at Local Analysis Centre at WUT

Works on data processing strategy in the networks of permanent GPS stations are conducted since 1995 at Warsaw University of Technology in close cooperation with the CODE Centre of the Institute of Astronomy, University of Bern. The strategy is used since 1996 to process the EPN data at Local Analysis Centres (LAC) of EUREF. Recently 16 LAC operates in Europe. Data from 45 permanent GPS stations of EPN (Fig. 2) are processed at the Warsaw University of Technology EUREF Local Analysis Centre (WUT EUREF LAC) on the daily basis (Rogowski et al., 2004).

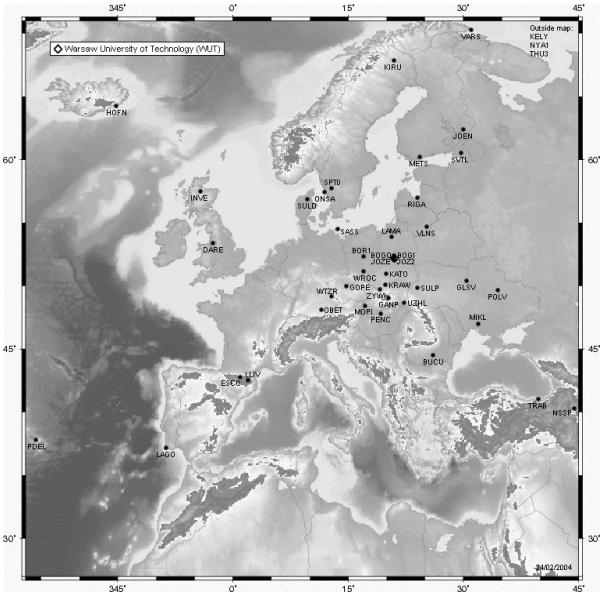

Figure 2. Network of EPN stations providing data for processing at WUT EUREF LAC

WUT EUREF LAC is also one of the main analysis centres within Central Europe Regional Geodynamics Project (CERGOP) that is coordinated by section C "Geodesy" of the Central European Initiative (CEI) (Becker et al., 2001). WUT EUREF LAC processed the data collected at CERGOP network (Fig. 3) within consecutive observational campaigns in 1994, 1995, 1996, 1997, 1999, 2001 and 2003 and participated in analysis of the results. Data from CERGOP and CERGOP2 campaigns were reprocessed in 2003 according to recent EPN standards. The results obtained were combined with those of all CERGOP Data Processing Centres.

WUT EUREF LAC as one of 16 local analysis centres provides parameters for ionosphere model (*http://www.gik.pw.edu.pl/stara/joze/jozefoslaw.html*) and conducts works on determination of water vapour content in troposphere (Kruczyk et al., 2004).

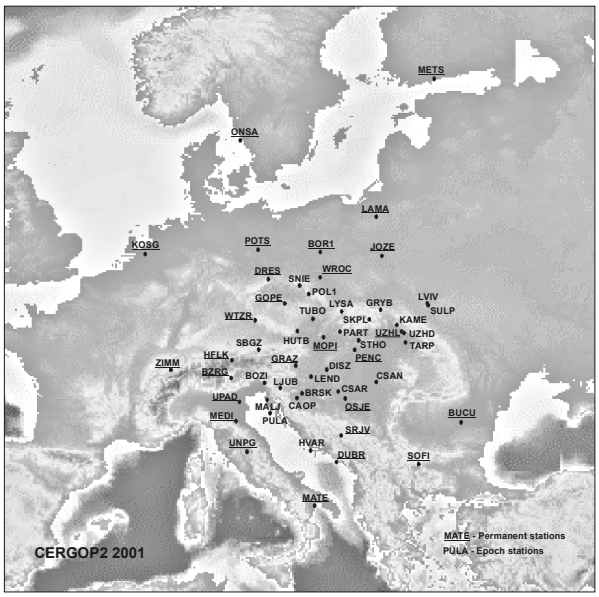

Figure 3. CERGOP-2' 2003 network

5 ASG-PL Polish Active Geodetic Control

A sub-network of the ASG-PL, Polish Active Control, with a processing centre was established by the end of 2002 in Upper Silesia as a pilot project of governmental and local (regional Silesian) authorities (Krynski et al., 2003). In February 2003 it has reached a preliminary operational stage. It became fully operational in December 2003. The map of this network is given in Fig. 4. The network consists of 6 permanent stations (two of them: KATO i ZYWI have been accepted in 2003 as EPN stations) and is recently linked to EPN (BOGI, BOGO, BOR1, JOZ3, JOZE, KRAW, LAMA, LAM6, WROC) stations and four other permanently operating GPS stations (CBKA, GDAN, INS1, POZN) that provide GPS data at 5 s sampling rate (Fig. 4). The ASG-PL network stations are equipped with multifunctional Ashtech μZ-12-CGRS receivers with ASH701945C_M SNOW

antennas. Observations are acquired at 1 sec sampling rate and stored in the RINEX2 format. Data of each station thinned down to 5 s sampling rate is transferred in hourly blocks via Frame Relay transmission using POLPAK network to the ASG-PL Processing Centre at Katowice. The receivers at ASG-PL stations can also generate the RTK corrections in the RTCM v.2.1 format.

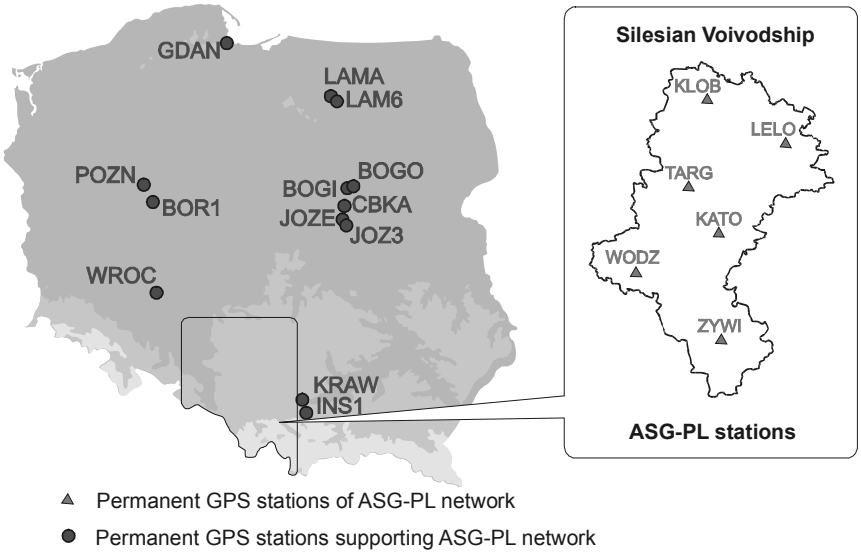

Figure 4. Map of the operating in 2004 part of the Polish Active Control Network

Data acquired at the ASG-PL stations are available free of charge at the web page: *www.asg-pl.pl*. GPS data is processed at the Processing Centre at Katowice with use of the software based on Bernese v.4.2. The Processing Centre provides GPS solutions for the network stations on daily basis. It also provides a continuous service the users via internet. The reports with the results of calculations are provided to the users from Silesian Voivodship within 24 hours while the users from other regions receive the reports within 48 hours. In the last quarter of 2003 the ASG-PL system was validated using test GPS surveys conducted by the team of the Space Research Centre of the Polish Academy of Sciences. At the same time the user service was successfully tested.

Another local network that may become a part of ASG-PL has been established in three seacoast cities: Gdańsk, Sopot and Gdynia. The system consists of 3 reference stations, located in the three towns. Each reference station is equipped with a GPS receiver, radio system for transmission of correction data, and modems for providing mutual link between stations and vehicles.

References

Becker M., Caporali A., Figurski M., Grenerczy C., Kenyeres A., Hefty J., Marjanovic M., Stangl G., (2001): *Regional ITRF densification by blending permanent an campaign date- The CERGOP Campaigns and Central European Velocity Field*, IAG Scientific Assembly, Budapest 2001.

Cisak J., Krynski J., Mank M., (2001): *RTK w terenie zurbanizowanym na przykładzie Warszawy*, Zeszyty Naukowe, WSOSP, Dęblin, 2001, Dod. nr 2/2001, pp. 63-78.

Cisak J., Zak L., Mank M., (2004): *First results obtained with the EUREF-IP system in Warsaw Metropolis using BOGI and JOZ2 EPN stations*, Presented at the EUREF Symposium, Bratislava, Slovakia, 2-5 June 2004.

Kruczyk M., Liwosz T., Rogowski J.B. (2004): *Some aspects of GPS tropospheric delay behaviour, usefulness and* estimation, 1st EGU General Assembly, Nice, France, 25-30 April 2004.

Krynski, J., (2001): *Polish Geoid Project*, The NKG Working Group Meeting on Geoid, Satellite Geodesy and Geodynamics, 8-10 October, 2001, Hønefoss, Norway.

Krynski, J., Rogowski, J.B., Zieliński, J.B., (2003): *National Report of Poland to EUREF 2003*, EUREF Symposium, Toledo, Spain, 4-7 June 2003, Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Frankfurt am Main (in print).

Oszczak S., (2004): *Involvement of Poland in Galileo Applications and development*, Presented at the Munich Navigation Summit 2004, Munich 23-25 March 2004.

Rogowski J.B., (2003): *RTK and DGPS measurements using INTERNET and GSM Mobile-phone*, Slovenska technicka univerzita v Bratislave, Bratislava, 2003.

Rogowski J.B., Bogusz J., Figurski M., Kłęk M., Kruczyk M., Kujawa L., Kurka W., Liwosz T., (2004): *Research Programme of the Astrogeodetic Observatory in Jozefoslaw*, 1st EGU General Assembly, Nice, France, 25-30 April 2004.

Rogowski J.B., Kujawa L., Leszczyński M., Rogowski A., (2004): *Some experiences in RTK and DGPS measurements using internet and GPS mobile phone*, 1st EGU General Assembly, Nice, France, 25-30 April 2004.