National Report of Poland

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Summary

Since 2000 the main geodetic activities on the national level in Poland concentrated on

- re-measuring the EUREF-POL network,
- completing field works related to re-levelling the 1st order vertical control,
- determining geoid model suitable for densification of vertical control with GPS,
- continuing operational work of permanent IGS/EUREF stations,
- conducting GPS data processing on regular basis at Local Analysis Centre at WUT.

The work is summarized in this report. Also the availability of GPS/levelling points in Poland and their quality characteristics is given.

1. Re-measurement of the EUREF-POL network

The first EUREF-POL campaign in Poland was conducted in 1992. The results of the campaign were submitted to the EUREF Technical Working Group and according to the resolution No. 1 of the EUREF Symposium in Warsaw, 8-11 June 1994, they were accepted as a class B standard and endorsed as improvement and extension to EUREF-89 (Report of the EUREF Technical Working Group, 1994). At the XXth Meeting of the EUREF Technical Working Group the need for periodical reoccupation in a class B survey was pointed out and the re-observation at EUREF sites within a period of at least 10 years was recommended (Report of the EUREF Technical Working Group, 1999). Following that recommendation the Head Office for Geodesy and Cartography in Poland confined to the Department of Planetary Geodesy of the Space Research Centre, Polish Academy of Sciences, in 2001, to re-survey the EUREF-POL network. The second EUREF-POL campaign was conducted within the five days 26-30 September 2001. The same set of stations as in the first EUREF-POL campaign was re-surveyed. One EUVN network station was also included in the campaign. The observations collected during the campaign were processed at the Department of Planetary Geodesy of the Space Research Centre, Polish Academy of Sciences, using Bernese v.4.2. The comparison of results of the old and new campaigns shows that the network is stable within the limits of accuracy of the epoch 1992. Estimated average differences in coordinates are ±3 mm (north), ±5 mm (east) and ±10 mm (up). Monumentation of the EUREF-POL stations proved to be robust and reliable. Two permanent stations where antennas were modified show the difference of 20 mm in height. The coordinate differences obtained at the stations are listed in Table1.

A number of other comparisons have been done between this solution and the solutions for POLREF network and the EUVN network. They are reported in (JAWORSKI et al., 2002). The EUREF-POL 2001 campaign demonstrated that the national geodetic system for Poland based on the EUREF-POL 92 solution is good enough for all practical purposes and needs no substantial modifications.

Table 1.

Station	) B [mm]	) L [mm]	) h [mm]
0216 BOROWIEC (BOR1 12205M002)	1.7	-4.0	4.5
0217 BOROWA GORA (BOGI 12207M003)	5.4	-3.6	20.0
0301 ROZEWIE	-1.3	4.7	-6.6
0302 LAMKOWKO (LAMA 12209M001)	-4.8	8.5	19.2
0303 MASZE	5.2	-6.7	14.0
0304 CZARNKOWIE	2.5	3.1	-4.3
0306 JOZEFOSLAW (JOZE 12204M001)	-4.6	-8.6	-10.0
0307 STUDNICA	1.0	3.0	13.6
0308 ROGACZEW	-0.2	3.7	-16.1
0309 ZUBOWICE	-1.8	4.9	1.2
0310 GRYBOW	-2.5	-0.1	3.9

2. Re-levelling the 1st order vertical control

The re-levelling of the 1st order vertical control in Poland has started in 1999. The description and advance of the present campaign that is the 4th vertical control measurement campaign in Poland was reported to EUREF Subcommission in 2001 (PAòUS, 2001). The completion of the fieldwork is expected by the end of June 2002. The map of the levelling lines and node points with computed misclosures and maximum acceptable misclosures in the loops is given in Fig. 1.

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Figure 1. Current status of the 4th vertical control campaign in Poland

3. Determining geoid model suitable for densification of vertical control with GPS

Following the resolution No. 3 of the EUREF Symposium in Tromsø, 22-24 June 2000, on the initiative of the Head Office for Geodesy and Cartography in Poland, the works on determining new GPS/levelling geoid model were carried on. The new geoid model completes and extends the EUVN project. It could be recommended for wide range of levelling with GPS all over the country. All available data referred to EUVN'97 from EUVN (6 fiducial stations of EUVN'97 and 4 IGS/EUREF permanent GPS stations in Poland as well as 52 points at the bench marks), EUREF-POL (11 stations), POLREF (348 pairs of points, i.e. main and directional point), WSSG (554 pairs of points, i.e. main and directional point) and TATRA (23 points) networks were used (PAÒUS et al., 2002). As a result of statistical tests a few outliers were eliminated from the data and the weights for each data set were estimated. A model of GPS/levelling geoid 2001 was obtained by estimating parameters of a function that fits the existing quasi97 gravimetric geoid model to the GPS/levelling geoid at the points of EUVN, POLREF, WSSG and TATRA networks. Third order spline function was found to give an optimum fit. The similar model was determined using the deflection of the vertical data, available at 168 points distributed all over the country. The comparison of the deflection of the vertical components derived from both models showed no distinguished bias. The Head Office for Geodesy and Cartography in Poland recommends the geoid model 2001 as a standard for densification of vertical control with GPS.

4. 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. Recently 5 permanent stations, i.e. Borowa Gora (BOGO), Borowiec (BOR1), Jozefoslaw (JOZE), Lamkowko (LAMA) and Wroclaw (WROC) (Fig. 2) are in operation in Poland within the IGS/EUREF program. A brief characteristic of those stations is given in Table 2. Soon a new GPS station in Krakow will start operating at permanent basis. 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.

Figure 2. IGS/EUREF network of permanent stations in Poland

5. 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 Institute of Astronomy, University of Bern. The new strategy is used since 1996 to process the EPN data at Local Analysis Centres (LAC) of EUREF. Recently 15 LAC operates in Europe. Data from 34 permanent GPS stations of EPN (Fig. 3) are processed at the Warsaw University of Technology EUREF Local Analysis Centre (WUT EUREF LAC) on the daily basis (BOGUSZ et al., 2001).

The coordinators of EUREF program recognize the contribution of WUT to both the operating program of Local Analysis Centres and the strategy of GPS data processing in EUREF permanent network. The EUREF Permanent Network 3rd Workshop was organized by the Institute of Geodesy and Geodetic Astronomy of WUT. 28 participants from Europe and Canada took part in the workshop at Warsaw (31 May – 1 June 2001). The proceedings from the workshop were published in the Reports on Geodesy, No.3 (58), 2001 - the journal of the Institute of Geodesy and Geodetic Astronomy of WUT.

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. 4) within consecutive observational campaigns in 1994, 1995, 1996, 1997, 1999 and 2001 and participated in analysis of the results.

WUT EUREF LAC as one of 15 local analysis centres provides parameters for ionosphere model and conducts works on determination of water vapour content in troposphere (KRUCZYK et al., 2001a, 2001b, 2001c) advancing towards becoming a member of IGS ionosphere modelling service.

Table 2. Characteristics of Polish EPN stations

4 char Station ID	Domes Number	Location/ Institution	Receiver/ Antenna	Started operating	Meteo/ Rec. device	Data transfer blocks	Additional obser-vations
BOGO	12207M00 2	Borowa Gora Inst. of Geo-desy & Carto-graphy	Ashtech ZXII3 ASH700936C_M SNOW	08JUN1996	Yes LAB-EL Poland	24 h 1h	Ground water level, Astrometry, Gravity, GPS/ GLONASS
BOR1	12205M00 2	Borowiec Space Research Centre, PAS	Rogue SNR-8000 AOAD/M_T	01JAN1994	Yes NAVI Ltd. Poland	24 h 1h	SLR, GPS/ GLONASS
JOZE	12204M00 1	Jozefoslaw Inst. of Geo-desy & 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/ GLONASS
LAMA	12209M00 1	Lamkowko Inst. of Geo-desy, UWM	Ashtech ZXII3 ASH700936F_C SNOW	01DEC1994	Yes LAB-EL Poland	24 h	Gravity
WROC	12217M00 1	Wroclaw Agriculture Academy	Ashtech Z18 ASH700936D_M	28NOV1996	Yes LAB-EL Poland	24 h 1h	Ground water level, GPS/ GLONASS

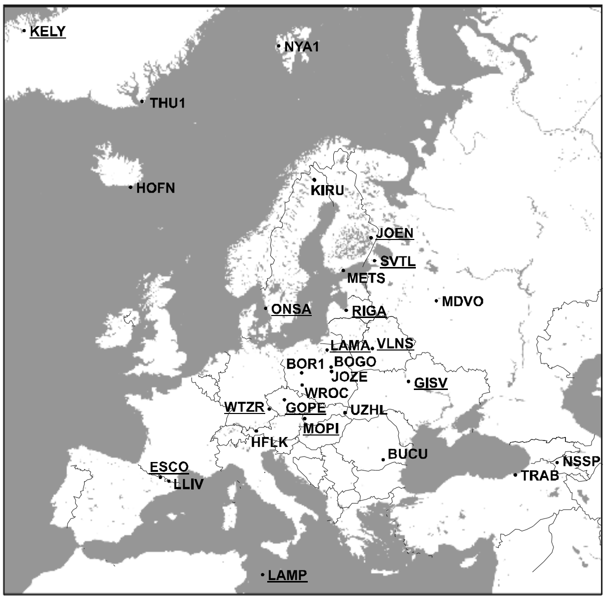

Figure 3. Network of EPN stations providing data for processing at WUT EUREF LAC

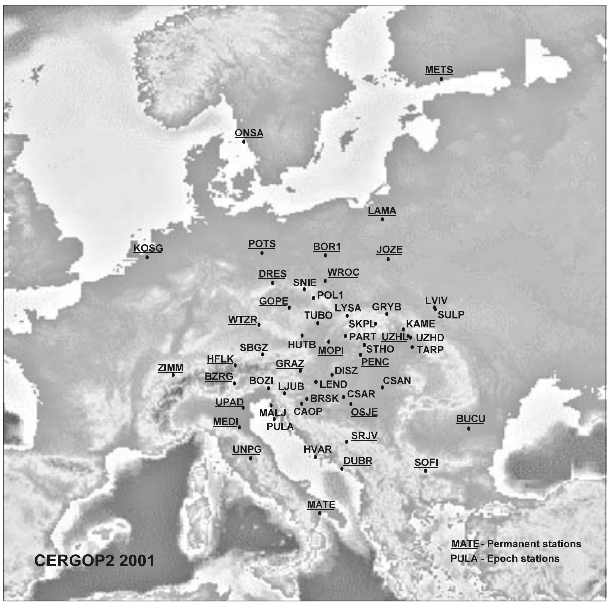

Figure 4. CERGOP-2 2001 network

6. Availability of GPS/levelling points in Poland

Besides 5 EPN stations there are almost 2000 GPS/levelling points in Poland (Fig. 5). The general information on the GPS/levelling points is given in Table 3.

Summary of quality and availability of heights of GPS/ levelling points in Poland obtained from spirit levelling is given in Table 4.

Table 3. Summary of quality and availability of heights of GPS/levelling points in Poland from GPS observations

Campaign	Number of points	Mean point separation [km]	Length of sessions	Software used	Reference frame	Expected accuracy	Availability
EUREF-POL (1992)	11	170	4.5days x 10h	Bernese	ETRF'89	3cm	Yes
POLREF (1994-95)	348 + 348	30	2 x 3.5h	Bernese	ETRF'89	3cm	Yes
TATRA (2000)	20	7	3h	Bernese	ETRF'89	2cm	Yes
EUVN (1997)	6+1	250	7.2days	Bernese	EUVN'97/ ETRF96	1.5 – 2cm	Yes
EUVN densification (1999)	52	70	2 x 1day	Bernese	EUVN'97/ ETRF96	2cm	Yes
WSSG (1993 - 1996)	554 + 554	24	2 x 5h	Bernese	EUREF89	3cm	No

Table 4. Summary of quality and availability of heights of GPS/levelling points in Poland from spirit levelling

Campaign	Height quality of main points	Height quality of eccentric points	Expected accuracy	Availability of geop. numbers
EUREF-POL (1992)	1st, 2nd & 3rd order vert. control	-	1-2 cm	Yes
POLREF (1994-95)	3rd order vert. control	3rd order vert. control	4 cm	Yes
TATRA (2000)	1st&2nd order vert. control	-	2 cm	Yes
EUVN (1997)	1st order vert. control	-	1-1.5 cm	Yes
EUVN densification (1999)	1st order vert. control	-	1.5 cm	Yes
WSSG (1993-1996)	3rd&5th order vert. control	3rd&5th order vert. control	4-6 cm	No

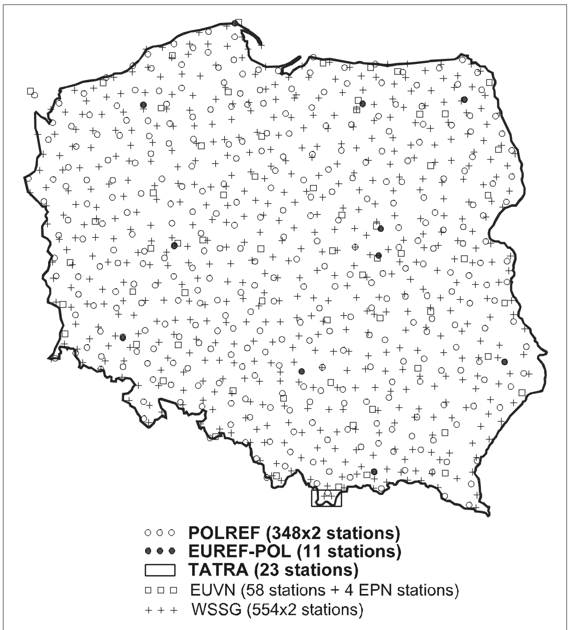

Figure 5. GPS/levelling points in Poland

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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.

BOGUSZ J., FIGURSKI M., KRUCZYK M., KUJAWA L., KURKA W., LIWOSZ T., PFEIL M., ROGOWSKI J.B., (2001): *WUT LAC Status Report*, Presented at the 3rd EPN Workshop, Warsaw, 31 May-1 June 2001, Reports on Geodesy No. 3 (58), 2001.

JAWORSKI L., ĐWI TEK A., ZDUNEK, R., ZIELI¼SKI J.B., PAòUS R., (2001): *Results of the EUREF-POL 2001 Campaign*, Presented at the Symposium of the IAG Subcommission for Europe (EUREF), Ponta Delgada, 5-8 June 2002.

KRUCZYK M., LIWOSZ T., ROGOWSKI J.B., (2001a): *Analysis of Integrated Water Vapour Derived Using GPS*, Presented at the XXVI EGS General Assembly. Nice, France, 24-30 March 2001, Reports on Geodesy No 2 (57) 2001.

KRUCZYK M., LIWOSZ T., ROGOWSKI J.B., (2001b): *Comparison of IPWV Determination from GPS Observations and Radiosounding Results,* Presented on the Symposium of the IAG Subcommission for Europe (EUREF) in Dubrovnik, Croatia, 16–18 May 2001.

KRUCZYK M., LIWOSZ T., ROGOWSKI J.B., (2001c): *On Accuracy of IWV Determinations,* Presented at the 3rd EPN Workshop, Warsaw, 31 May-1 June 2001, Reports on Geodesy No. 3 (58), 2001.

PAòUS R., (2001): *National Report of Poland to EUREF 2001*, Report on the Symposium of the IAG Subcommission for Europe (EUREF), Dubrovnik, 16-18 May, 2001.

PAòUS R., OSADA E., OLEJNIK S., (2002): *Levelling geoid* (in Polish), Geodeta, Nr. 5 (84), May 2002.

Report on the Symposium of the IAG Subcommission for Europe (EUREF), Warsaw, 8-11 June 1994.

Report on the Symposium of the IAG Subcommission for Europe (EUREF), Prague, 2-5 June 1999.