National Report of Poland to EUREF 2005

J. KRYNSKI[1], J.B. ROGOWSKI[2], J.B. ZIELINSKI[3]

1. Introduction

Since 2003 the main geodetic activities at the national level in Poland concentrated on continuing operational work of permanent IGS/EUREF stations, activity in the framework of the EUREF IP pilot project, conducting GPS data processing on the regular basis at Local Analysis Centre at WUT, activity towards setting up an active GPS geodetic control, activity towards implementing the EUPOS project in Poland, research and computational work on a centimetre geoid model in Poland, establishing of new absolute gravity stations, new adjustment of gravity national control and extension of national gravity calibration baseline, activity within the European ESEAS-RI project and within the Galileo project, in particular establishing the EGNOS RIMS station in Warsaw.

2. Modelling a centimetre 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. Some new astronomical observations were conducted for densification as well as for control of the existing deflections of the vertical. Also some supplementary control gravimetric and GPS surveys were conducted.

An extensive analysis of the existing geological data from Poland was performed by at the Polish Geological Institute. The map in the scale of 1:1 000 000 corresponding with the resolution of geological prospecting that illustrates spatial density distribution in the upper lithosphere level was elaborated. Density data is also available in a digital form on 2.5 km × 2.5 km grid. Mean densities for geological regions were also estimated. Geological database fulfilling project requirements was completed at the Polish Geological Institute.

Pre-processing and unification of the data have been completed. The algorithms for transforming point gravity data to an official gravity system POGK-99 (Sas, 2004) and to the reference system ETRF89 (Cisak and Sas, 2005a, 2005b) were developed and verified at the Institute of Geodesy and Cartography. They were implemented to the gravity database. The transformations were also applied to the existing mean anomalies and the improved quasigeoid model *quasi04a* was derived and checked against the existing GPS/levelling data (Krynski and Lyszkowicz, 2004a, 2004b). The terrain corrections to point gravity data were calculated at the Institute of Geodesy and Cartography using high-resolution 1"×1" digital terrain model DTED2 for the area of Poland, and the SRTM3 as well as the SRTM30 of the resolutions 3"×3" and 30"×30", respectively. Also an algorithm for determination of mean gravity anomalies by using point gravity data and digital terrain models was developed at the Institute of Geodesy and Cartography.

Data records from numerous tide gauges in the Baltic Sea basin were analysed in the framework of the project (Krynski and Zanimonskiy, 2004). In particular, an attempt to construct an empirical numerical model of variations of the Baltic Sea level was taken. The representativeness of the model was investigated. The model was also used for studying local and regional features of tide gauge records as well as for estimation of land uplift in the Baltic region. Also the existence of polar motion component in Baltic Sea level variations was investigated using correlation analysis.

A new astro-geodetic quasigeoid based on almost 200 astro-geodetic and 370 astro-gravimetric deflections of the vertical was computed and checked against the existing solutions of gravimetric quasigeoid models.

Quite extensive research was done on the usefulness of newly developed geopotential models for determination of gravimetric quasigeoid models. The geopotential models were verified against corresponding height anomalies at GPS/levelling sites in Poland. A number of new quasigeoid models for Poland were developed with use of six different global geopotential models: EGM96, EIGEN-CH03S, GGM01S, GGM02S, GGM02C and GGM02S/EGM96. Data quality was discussed and global geopotential model best fitting in Poland to GPS/levelling height anomalies at the POLREF and densified EUVN network stations was specified. It was shown that the quality of the present solutions of the POLREF and EUVN networks does not allow for quantifying the improvement of quasigeoid models due to the use of newly developed geopotential models. Also the quality of the POLREF and EUVN networks was independently estimated (Krynski and Lyszkowicz, 2005a, 2005b, 2005c).

The construction of database consisting of all data used for the project is in progress.

[1] Jan Krynski, Institute of Geodesy and Cartography, 27 Modzelewskiego St, PL 02-679 Warsaw, Fax: +48 22 3291950, Tel.: +48 22 3291904, E-mail: krynski@igik.edu.pl

[2] Jerzy B. Rogowski, Institute of Geodesy and Geodetic Astronomy, Warsaw University of Technology, 1 Pl. Politechniki, PL 00-661 Warsaw, Fax: +48 22 6210052, Tel.: +48 22 6607754/5, E-mail: jbr@gik.pw.edu.pl

[3] Janusz B. Zielinski, Space Research Centre, Polish Academy of Sciences, 18a Bartycka St., PL 00-716 Warsaw, Fax: +48 22 8403131, Tel.: +48 22 8403766/278, E-mail: jbz@cbk.waw.pl

The survey of high-density GPS/levelling control traverse crossing Poland from south-western borders to north-eastern ones was completed. Also numerous GPS/levelling control stations of POLREF network were re-surveyed. The traverse consisting of almost 200 stations will be used for control of geoid models developed. The project's closing is expected by the end of 2005.

3. New absolute gravity stations and the extension of national gravity calibration baseline

In October 2004, the Polish gravity control network, containing 378 gravity field stations and 12 absolute gravity stations, was extended by one more absolute gravity station in Zakopane, at the foothills of the Tatra Mountains. Another absolute gravity station was established in high mountains at the Tatra Meteorological Observatory on Kasprowy Wierch. Both new stations will constitute the vertical gravity calibration base line of the range of ~250 mGal, which is indispensable for research of mountain dynamics. The absolute measurements have been performed together with Finnish Geodetic Institute using the ballistic gravimeter FG5 No 221. At both stations the standard deviations of measured gravity have not exceeded 3 μGal (Sas et al., 2005). Establishing the new station in Zakopane has made possible to extend the Central Gravity Calibration Baseline [Gdansk-Borowa Gora-Ojcow] to the southern border of the country and thereby to cover the whole area of Poland with its range (Fig. 1). The absolute gravity station in Zakopane has been tied to three neighbouring field station of the gravity control network.

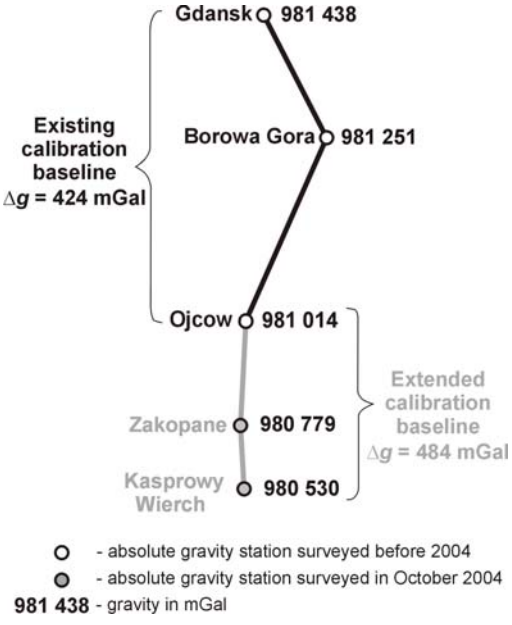

Fig. 1. Central Gravity Calibration Baseline in Poland

Besides, two more stations of national gravity control, one in Kuznice and the other one in Warsaw were established. They were tied to the existing gravity control with relative gravity measurements.
The new adjustment (2004) of the Polish gravity control network, with use new absolute and relative gravity survey on the sites at Zakopane, Kuznice and Warsaw has been performed (Sas et al., 2005).

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 10 permanent GPS stations, i.e. Borowa Gora (BOGO, BOGI), Borowiec (BOR1), Jozefoslaw (JOZE, JOZ2), Lamkowko (LAMA), Katowice (KATO), Cracow (KRAW), Wroclaw (WROC) and Zywiec (ZYWI) (Fig. 2) operate in Poland within the IGS/EUREF program (Krynski et al., 2004, 2005). 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 the International GLONASS Service Pilot Project (IGLOS-PP) (*http://igscb.jpl.nasa.gov/projects/iglos/index.html*).

Fig. 2. IGS/EUREF network of permanent stations in Poland in 2005

5. Activity within the EUREF-IP Project

Jozefoslaw and Krakow stations as well as Borowa Gora that is in the test operational phase (Krynski et al., 2004, 2005), take part in the EUREF IP pilot project (*http://www.epncb.oma.be/projects/euref_IP/euref_IP.html*). In the AGH University of Science and Technology in Cracow the broadcaster

(*http:\\gps1.geod.agh.edu.pl:2100*) was established in January 2005.
Some practical test 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 et al., 2004), at the Institute of Geodesy and Cartography in Warsaw (Cisak et al., 2004) as well as at the Chair of Satellite Geodesy and Navigation of the University of Warmia and Mazury.
The system of GPRS Tele-transmission for DGPS/RTK Station Network in Warmia and Mazury region, developed at the Chair of Satellite Geodesy and Navigation of the University of Warmia and Mazury consists of a network of GPS reference stations connected to the system's main server using IPSEC tunnels. The system's server collects data from all existing GPS reference stations, manages data and distributes data to mobile users in real time. Distribution of corrections is possible using different GSM operators in Poland, which makes the system fully independent. Each mobile receiver is connected to the main system server via GSM network and has pre-defined primary GPS reference station. In case of failure of primary reference station the server detects emergency and automatically switches the user to another nearest GPS station. Each GPS reference station in the network can be remotely controlled from arbitrary place all over the world. The system is fully compatible with all GPS receivers having RTCM option. The only need for a user is the GPRS modem with an active SIM card dedicated to server application (Oszczak, 2005).
The RTCM Client software has been developed in the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology. The software provides a stable work and is easy to operate for the client. It operates at the moment in MS Windows (Rogowski et al., 2004).
The location of two EPN stations BOGI and JOZ2 taking part in the EUREF-IP pilot project is extremely suitable to provide the RTK corrections at any place of the capital of Poland with sub-decimetre accuracy. Studies on precise point positioning in the urban area using two NTRIP servers of EPN stations BOGI and JOZ2 were performed in the Institute of Geodesy and Cartography (Cisak et al., 2005).

6. 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 the 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 operate in Europe. Data from 45 permanent GPS stations of EPN (Fig. 3) is processed at the Warsaw University of Technology EUREF Local Analysis Centre (WUT EUREF LAC) on the daily basis (Rogowski et al., 2004).

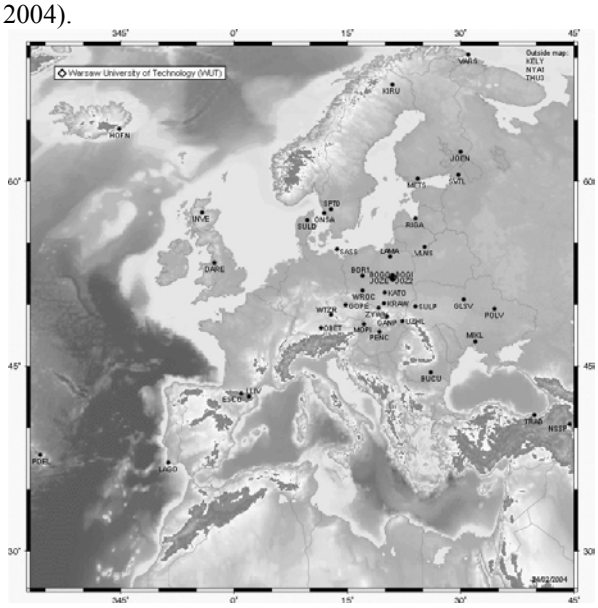

Fig. 3. Network of EPN stations providing data for processing at WUT EUREF LAC

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*) (Figurski. and Rogowski, 2004) and conducts works on determination of water vapour content in troposphere (Kruczyk et al., 2004).

7. 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, 2004, 2005). 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. 3. 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 six other permanently operating GPS stations (CBKA, GDAN, INS1, POZN, WLAD, KWBB) 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 rate is transferred in hourly blocks via Frame Relay transmission using POLPAK network to the ASG-PL Processing Centre in Katowice. The receivers at ASG-PL stations can also generate the RTK corrections in the RTCM v.2.1 format. The works on implementing operational RTK option in the network are in progress.
Some improvements of the processing module used by the ASG-PL Processing Centre in Katowice, worked out by the SRC PAS were implemented. They concern

modification of the method for evaluation of ionospheric and tropospheric corrections using close EPN stations beyond the Polish territory, improvement in checking procedure by comparison with the independent calculation using different set of reference points, changes in the algorithm for selection of reference points taking into account the geometry of the solution and the quality of observations, and developing the procedure for control compatibility of the observations with the requirements of the ASG-PL.
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 for 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.

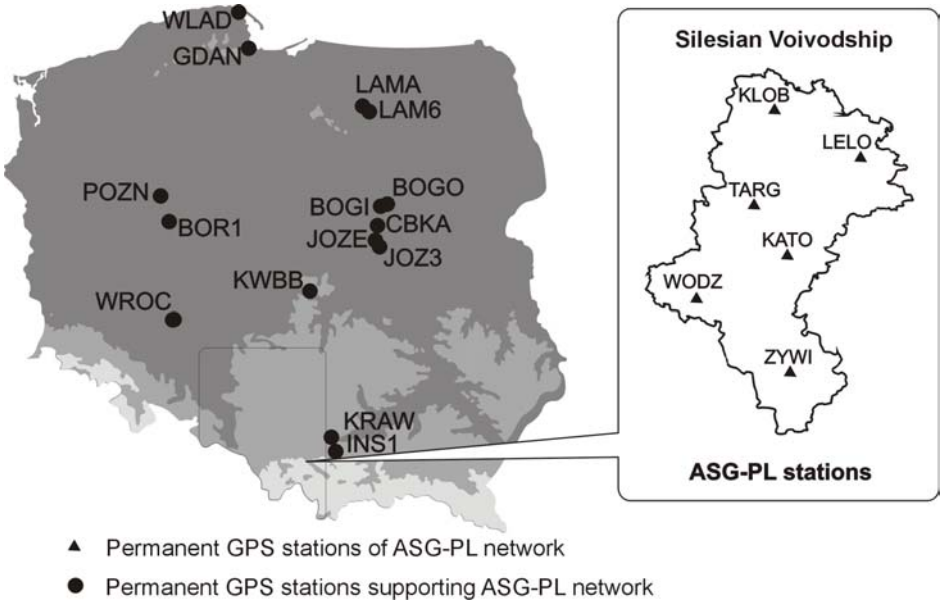

Fig. 4. Map of the operating in 2005 part of the Polish Active Control Network

Another local network that may become a part of ASG-PL has been established in three seacoast cities: Gdansk, 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.

8. The satellite reference network EUPOS

The European Project EUPOS (European Position Determination System) consists in establishment of about 430 multifunctional satellite reference stations in Central and Eastern Europe. Fourteen European countries intend to participate in the project. The project will include the existing or developed infrastructure in participating countries. The system will use standard signal of the European system Galileo as the basis as soon as it is available and is optional for GPS and GLONASS. The network of reference stations will provide a signal for both positioning of geodetic control points and for land, air and marine navigation. Several levels of positioning accuracy will be offered. The project was consulted with the representatives of European Commission, Brussels, at the EU INTERREG IIIC East Joint Technical Secretariat, Vienna, Austria, and at the UN Office of Outer Space Affairs (OOSA), Vienna and got positive assessments and supports. According to the Project the establishment of about 75 reference stations in average distances of about 70 km are foreseen for Poland (Fig. 5) (Śledziński, 2005). The technical draft project and a final cost estimation will be completed by the end of April 2005.
In December 2004 there was submitted to the Ministry of Scientific Research and Information Technology a proposal with the request for financial support from the programme ERDF (European Regional Development Found). The formal assessment of the proposal is under examination by the Found Council. In case of positive results the establishment of the Polish reference network ASG - EUPOS will start in 2005 and will be completed by July 2007. The Surveyor General has been authorised by the Minister of Infrastructure to coordinate all actions concerning establishment of the ASG - EUPOS system in Poland and to cooperate with

other countries on integration of the system with the European positioning system EUPOS.

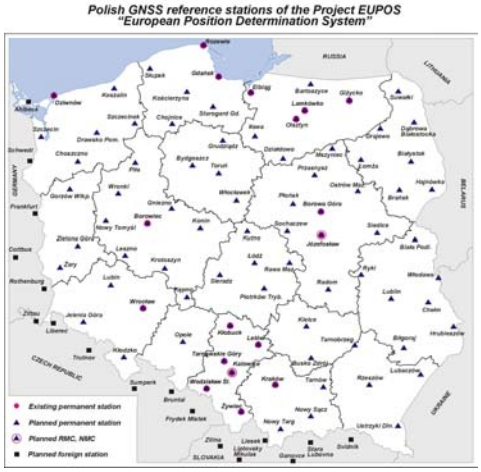

Figure 5. Map of the planned stations of EUPOS network in Poland

9. Activity within the ESEAS-RI Project

The ESEAS-RI Project was assembled within a framework of 5th Frame Program of UE by the European Service for Mean Sea Level (ESEAS) on the initiative of Action COST-40 (EOSS). The project that gathers 21 institutions from the whole Europe was accepted and signed in 18 October 2002 as a 3-years Pilot Project of ESEAS Service. It was established for studying of sea level changes in different time scales from seasonal to secular, and determination of possible in the future level of these changes (in absolute and relative sense). Among the expected results the improvement of ESEAS Service infrastructure, availability of homogenous and quality controlled observation data bases (certificated) with all necessary metadata, new and/or improved empirical models of sea level changes for further studies of climate processes in different time scales, and impact to reports of environment evaluation are listed.

More than 150 of the European tide gauges have been committed to the ESEAS as Observing Sites; some of them with continuous GPS (CGPS) service.

In the ESEAS-RI Project, GPS data from more than 30 CGPS stations near TG are processed, 14 of them were established as new such stations within a framework of the ESEAS-RI.

As a partner of the Project the SRC PAS established a CGPS station collocated with 'old' floating and new pressure tide-gauge sensors in Wladyslawowo. The CGPS station near tide gauge in Wladyslawowo operates since April 2003. It is equipped with Ashtech uZ-CGRS receiver with Ashtech Dorne-Magolin Choke Ring antenna type (ASH701945E_M SNOW) and with RTK option. GPS data is acquired with 30 s sampling rate and with 5º elevation cut-off angle. To connect tide-gauge readings with CGPS and express them in a unified geocentric global terrestrial reference frame, precise levelling measurements connecting GPS marker with Contact Points of both tide-gauge sensors (CP), Tide-Gauge Bench-Mark (TGBM) and other benchmarks of the 1 Order National Levelling Control located near Wladyslawowo were performed every year. Such survey is also made before or after absolute gravity measurement to determine and investigate vertical crustal movements on a selected ESEAS CGPS and tide-gauge stations. The absolute gravity was first time determined at the station in 2004 with FG5 by the Finnish Geodetic Institute – as subcontractor.

The SRC PAS runs one of the ESEAS Analysis Centres (ESEAS–AC). Its task focuses on the analysis of all ESEAS CGPS data, creation and analysis of GPS coordinate time series, determination of vertical crustal movements, and finally - absolute and relative sea level changes.

10. EGNOS RIMS in Warsaw

The GALILEO satellite navigation system is supposed to become operational in 2008. However, the European Commission, ESA and the European Organisation for the Safety of Air Navigation (Eurocontrol) recently decided to install the European regional augmentation to the American GPS and Russian GLONASS – European Geostationary Navigation Overlay Service EGNOS. It is a kind of improvement of the existing systems, by disseminating correction data that enhance the accuracy of the current services from about 10 m to better than 2 m. The second important feature of EGNOS consists in sending the information on the quality of signals, so-called integrity flag. These improvements enable the application of GNSS to the aerial navigation, one of the most important users of the satellite navigation. EGNOS is one of the three inter-regional, interoperable satellite-based augmentation services (the other two are the US WAAS and the Japanese MSAS). Full operation of EGNOS is planned from July 2005. EGNOS will be the first stimulus for European-led navigation services and will as such pave the way for the GALILEO services. It is considered as a fore-runner of GALILEO and it is included in the GALILEO operational structure.

The technical base for EGNOS consists of three geostationary satellites disseminating EGNOS signals and the network of ground stations collecting data necessary for calculation of corrections and integrity warning. The network of so-called Ranging and Integrity Monitoring Stations – RIMS – covers the region with 34 points. One of those stations is located in Warsaw, in the building of the Space Research Centre, PAS.

The location of the station in Warsaw was motivated by several factors. It is on the eastern edge of the region covered by EGNOS, it is in the large city with good communication and transportation links but in the part of Warsaw not affected strongly by the radio pollution. The roof of the building of the SRC is flat and strong enough to place antennas there; no major radio emission source is in the vicinity. The team of specialists in the SRC was trained to work on EGNOS and to analyse data collected. The instrumentation was provided by the ESA, integration and tuning of the system was done jointly.

The ceremonial opening of the station took place in 27 September 2004. The station is already operational and fulfils the requirements of the system. It consists of the two receiving antennas, separated by 60 m, the receivers and data transmission block, rubidium frequency standard and the UPS power supply unit. The direct transmission link is established to the data centre in Amsterdam. The next receiver for monitoring and control of the EGNOS performance will be installed soon. Then the station will be ready to support the Full Operational Capability Phase of EGNOS.

References

CISAK J., ZAK L., MANK M., (2004): *First results obtained with the EUREF-IP system in Warsaw Metropolis using BOGI and JOZ2 EPN stations*, Symposium of the IAG Subcommission for Europe (EUREF) held in Bratislava, Slovak Republic, 2–5 June 2004, EUREF Publication No 14, Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Frankfurt am Main (in print).

CISAK J., MANK M., ZAK L., (2005): *Preliminary results of test surveys in Warsaw area using RTK corrections generated at BOGI and JOZ2 base stations participating in EUREF-IP Pilot Project*, The 6th International Conference on "Environmental Engineering", 26–27 May 2005, Vilnius, Lithuania.

CISAK M., SAS A., (2005a): *Transformation of coordinates from „Borowa Gora" to „1942" system* (in Polish), Proceedings of the Institute of geodesy and Cartography, Warsaw, T. L, z. 108 (in print).

CISAK M., SAS A., (2005b): *Accuracy analysis of transformation of coordinates of gravity points from gravity database from „Borowa Gora" to „1942" system* (in Polish), Proceedings of the Institute of geodesy and Cartography, Warsaw, T. L, z. 108 (in print).

FIGURSKI M., ROGOWSKI J.B., (2004): *Accuracy of Regional TEC Modelling Using Near Real Time GPS Data Processing*, Symposium of the IAG Subcommission for Europe (EUREF) held in Bratislava, Slovak Republic, 2–5 June 2004, EUREF Publication No 14, Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Frankfurt am Main (in print).

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*, Report on the Symposium of the IAG Subcommission for Europe (EUREF) held in Ponta Delgada, Portugal, 5–7 June 2002, EUREF Publication No 12, Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Band 29, Frankfurt am Main, pp. 284–288.

KRYNSKI J., ROGOWSKI J.B., ZIELIŃSKI J.B., (2004): *National Report of Poland to EUREF 2003*, Report on the Symposium of the IAG Subcommission for Europe (EUREF) held in Toledo, Spain, 4–7 June 2003, EUREF Publication No 13, Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Band 33, Frankfurt am Main, pp. 264–268.

KRYNSKI J., ROGOWSKI J.B., ZIELIŃSKI J.B., (2005): *National Report of Poland to EUREF 2004*, Report on the Symposium of the IAG Subcommission for Europe (EUREF) held in Bratislava, Slovak Republic, 2–5 June 2004, EUREF Publication No 14, Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Frankfurt am Main (in print).

KRYNSKI J., ZANIMONSKIY Y., (2004): *Tide Gauge Records-Derived Variations of Baltic Sea Level in Terms of Geodynamics*, Geodezja i Kartografia, Vol. 53, No 2, pp. 85–98.

KRYNSKI J., LYSZKOWICZ A., (2004a): *New Results in Precise Geoid Modelling in Poland*, Proceedings of the IAG Symposium „Gravity, Geoid and Space Missions – GGSM2004", 30 August – 3 September 2004, Porto, Portugal (on a CD).

KRYNSKI J., LYSZKOWICZ A., (2004b): *Recent Status of Precise Geoid Modelling in Poland*, Presented at the NKG Geoid Determination Working Group Meeting, KMS, Copenhagen, 11–12 November, 2004.

KRYNSKI J., LYSZKOWICZ A., (2005a): *Study on choice of global geopotential model for quasigeoid determination in Poland*, Geodezja i Kartografia, Vol. 54, No 1, pp. 17–36.

KRYNSKI J., LYSZKOWICZ A., (2005b): *Towards the precise geoid in Poland*, The 6th International Conference on "Environmental Engineering", 26–27 May 2005, Vilnius, Lithuania.

KRYNSKI J., LYSZKOWICZ A., (2005c): *Do the new geopotential models improved the fit of gravimetric quasigeoid in Poland to GPS/leveling data?*, Symposium of the IAG Subcommission for Europe (EUREF) held in Vienna, Austria, 1–4 June 2005..

OSZCZAK B., (2005): *Concept and Technical Development of GPRS Teletransmission for DGPS/RTK Station Network in Warmia and Mazury Region*, 6th International Navigational Symposium on Marine Navigation and Safety of Sea Transportation, 30 June – 1 July 2005,Gdynia, Poland.

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.

ROGOWSKI J.B., BOGUSZ J., FIGURSKI M., KRUCZYK M., KUJAWA L., KURKA W., LIWOSZ T., (2005): *Geodynamic programmes conducted at Józefosław Observatory*, Poster presented at the EGU Symposium G9 Geodetic and Geodynamic Programmes of the CEI, Vienna, 24–29 April 2005.

SAS A., (2004): *Problem of unification of the existing Polish gravity data with European standards* (in Polish), Seminarium "Satelitarne metody wyznaczania pozycji we współczesnej geodezji i nawigacji", Kraków 23–24 September 2004.

SAS A., CISAK M., MÄKINEN J., (2005): *Towards establishing vertical gravity calibration baseline in Tatra Mountains; New adjustment of Polish gravity control*, Symposium of the IAG Subcommission for Europe (EUREF) held in Vienna, Austria, 1–4 June 2005.

ŚLEDZIŃSKI J., (2005): *Establishment of Polish part of the European network of satellite reference stations EUPOS*, Poster presented at the EGU Symposium G9 Geodetic and Geodynamic Programmes of the CEI, Vienna, 24–29 April 2005.