

**CIVIL GPS SERVICE INTERFACE COMMITTEE  
INTERNATIONAL INFORMATION SUBCOMMITTEE  
(CGSIC/IISC)**

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**NATIONAL REPORT OF POLAND**

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This Report was compiled from contributions reported lately by the correspondents from Polish institutions dealing with different use of satellite navigation systems.

**1. TIME METROLOGY**

(see also: "National Report of Poland 2000" presented to the 9th European Meeting of the CGSIC, Monaco, 30 November - 1 December 2000)

The institutions involved in time metrology report on

- \* development of the national independent atomic time scale, TA(PL), and
- \* development of the high-accuracy multi-channel GPS time transfer receiver.

Several Polish scientific and commercial institutions are equipped with caesium frequency standards, which can be used for the establishment of a National Atomic Time Scale. Among them are:

- Time and Frequency Laboratory of the Central Office of Measures (GUM), four Cs clocks;
- Institute of Communication, two Cs clocks;
- Central Laboratory of the Polish Telecommunication Company (TPSA), one Cs clock;
- Astrogeodynamical Observatory of the Polish Academy of Sciences (AOS), two Cs clocks.

The Polish Atomic Time Scale is computed from the readings of the clocks of the above-listed laboratories according to a special algorithm developed in cooperation with the BIPM.

All participating laboratories are equipped with the TTS-2 GPS time receivers, based on the Motorola VP Oncore module (general diagram of the receiver – see below Fig. 1)

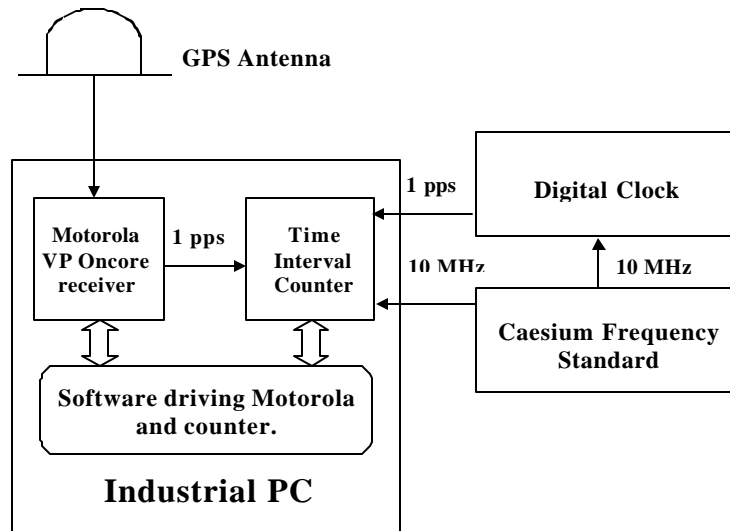


Fig. 1. Diagram of the TTS-2 multi-channel GPS time transfer receiver

Some technical specifications related to the adopted time transfer system TTS-2 are summarised below:

#### UNCERTAINTY:

- ❖ For 1-channel observations: rms ~3 ns.
- ❖ According to new schedule: 96 observations at up to 8 channels.
- ❖ Average at Borowiec is about 650 passes per day.
- ❖ Uncertainty obtained for multichannel observations AOS Borowiec – BIPM Sevres: rms: 1-2 ns.

#### ADVANTAGES:

- ❖ Independent raw satellite observation data.
- ❖ Compatibility with previous versions of data exchange format.
- ❖ Low cost, high accuracy.

TTS-2 receivers are currently working at:

- Astrogodynamical Observatory (AOS), Borowiec Poland, 2 rcvs.
- United States Naval Observatory (USNO), 2 rcvs.
- Bureau International des Poids et Mesures (BIPM), 2 rcvs.
- Metrology Department of Semiconductor Physics Institute (SPI), Lithuania, 1 rcv.
- National Institute of Standards (NIS), Egypt, 1 rcv.
- Observatorio Naval Buenos Aires (ONBA), Argentina, 1 rcv.
- Swiss Office of Metrology, (SOM), Bern, 1 rcv.
- Observatoire des Cote d'Azur (OCA), France, 1 rcv.
- Main Office for Measurements (GUM), Warsaw, 2 rcvs.
- Institute of Communication (IL), Warsaw, Poland, 2 rcvs.

- Central Laboratory of the Polish Telecommunication Company (CBR), Warsaw, Poland, 1 rev.
- Centre for Metrology, Zielonka, Poland, 1 rev.

More details on the activities related to the time transfer in Poland – please contact: Jerzy Nawrocki, Astrogeodynamical Observatory, Space Research Centre, Polish Academy of Sciences, Borowiec, Poland (e-mail address see below).

## 2. ACTIVITIES OF THE POLISH MARITIME INSTITUTIONS

The following maritime institutions are involved in realisation of the GPS and GPS/GLONASS projects for maritime applications:

- Polish Naval Academy Gdynia (military)
- Gdynia Maritime Academy (civil)
- Maritime University Szczecin (civil),
- Maritime Office Gdynia,
- Maritime Office Szczecin,

Two Polish permanent GPS reference stations in Dziwnów and Rozewie are routinely operating at the Polish Baltic Sea coast and are used for maritime navigation, sounding operations, dredging works and partially for improving buoys positioning when they are removed for winter and installed again for summer season. They are cooperating with Swedish maritime reference stations at the Baltic Sea coast. Some technical characteristics of these stations are given in Table 1.

Table 1  
POLISH MARITIME DGPS REFERENCE STATIONS

Station	Position Latitude Longitude	Nominal range at 34 dBuV	Frequency	Availability	Accuracy 2s
Dziwnów	54 <sup>0</sup> 01'18"N 14 <sup>0</sup> 43'51"E	90 km	288.0 kHz	99.7 % at 38 dB	2-5 m
Rozewie	54 <sup>0</sup> 49'50"N 18 <sup>0</sup> 20'07"E	90 km	311.0 kHz	99.7 % at 38 dB	2-5 m

Basic maritime surveys, which are made using the positioning RTK/ DGPS systems with the aim to estimate shipping conditions of the waterways, are:

1. Surveys of the relief of sea bottom, by executing the bathymetrical surveys using one or multi-beam hydro-sounding systems and RTK/DGPS;
2. Hydro-sounding (sonar) surveys of the sea bottom for purpose of detection of the underwater objects and obstructions to navigation;

3. Magnetometric surveys of the sea bottom for purpose of detection of the steel
4. objects;
5. TV inspection of the sea bottom recording underwater obstructions to navigation;
6. Execution of the geological surveys;
7. Defining of the navigational marks position;
8. Executing the hydrological surveys, as well as making inspections and calibration procedures of hydro-sounding equipment, including:
9. defining the sound speed in sea water;
10. recording the vertical oscillation of thesea level;
11. Geodetic and/or hydrographical measurements to evaluate WGS-84 positions of lighthouses, floating and permanent objects (buoys, leading lines), lights and other aids to navigation.

The activities of two administrative maritime offices in Gdynia and Szczecin and three above mentioned universities are focused on the following projects and other actions:

- Upgrading the permanent DGPS maritime reference stations Rozewie and Dziwnow (increasing of range and availability of service, stability of emission, remote continuous monitoring of the DGPS service) ;
- Application of satellite positioning systems for the determination of capabilities of ship manoeuvres; several experiments were successively performed;
- Studies of the ship hull deformations during the process of launching using RTK technique.
- Application of satellite GPS positioning for establishment of a baseline for the determination of the state border line on the Baltic Sea;
- Application of DGPS techniques for testing the radar Vessel Traffic System on Bay of Gdansk, for bottom setting the VTS optic fibre cable in Zalew Szczecinski and for locating ship wrecks in Zatoka Pomorska;
- At the Polish Naval Academy Gdynia the installed GPS simulator Welnav 720 is used for the research works as well as for teaching;
- Working contacts of Polish staff members of Maritime Office Gdynia with administrative personnel of Sweden and UK aimed at upgrade of Polish stations to the standard of IALA. There are also worth mentioning the Polish contributions to (1) IALA proposal of standards for DGPS station in the frame of Radionavigation Committee "Guidelines for the Performance and Monitoring of DGNSS Service" – RNAV11/11/6 Annex 2 of 15 March 1999 and to (2) EUMATONA (European Marine Aids to Navigation Authorities) – works dealing with systems EGNOS, GALILEO, EUROFIX;
- Programme of hydrographic works including hydrographic 3D surveys in the lower River Odra and bathymetric surveys by joint use of GPS and GPS/GLONASS satellite positioning and echo -sounding.

### **3. PERMANENT GPS STATIONS IN POLAND**

Eleven permanent geodetic GPS stations are operating in Poland. They are:

- Borowiec (managed by the Space Research Centre, Polish Academy of Sciences),
- Borowa Gora (managed by the Institute of Geodesy and Cartography),

- Gdansk, Gdynia, Sopot (complex consisting of three stations established by the Chair of Satellite Geodesy and Navigation of the Warmia and Masury University Olsztyn for the agglomeration of three cities used for land and maritime navigation,
- Jozefoslaw (managed by the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology),
- Krakow (managed by the University of Mining and Metallurgy, Faculty of Mining Surveying and Environmental Engineering, Krakow),
- Lamkowko-Olsztyn (managed by the Institute of Geodesy of the Warmia and Masury University Olsztyn),
- Wroclaw (managed by the Department of Geodesy and Photogrammetry of the Agriculture University Wroclaw).
- Rozewie and Dziwnow - two stations at the Baltic Sea coast operating permanently as maritime navigation stations.

Three Polish permanent stations are incorporated to the International GPS Service IGS (Borowiec, Jozefoslaw, Lamkowko-Olsztyn). Five stations are included to the EUREF Permanent Network EPN (Borowa Gora, Borowiec, Jozefoslaw, Lamkowko-Olsztyn, Wroclaw).

Some stations maintain also other permanent services:

Borowiec	- SLR (Satellite Laser Ranging) and time service,
Borowa Gora	- time service
Jozefoslaw	- gravimetric tidal monitoring, astrometric observations, TEC ionosphere variation,
Lamkowko-Olsztyn	- TEC ionosphere variation.

At the station Borowa Góra an there have been installed an Ashtech Z-12 receiver (operating since 1996) and a JPS Eurocard GPS-GLONASS receiver (operating since June 2001). This station can act upon request since April 1998 as DGPS station. The station took also part in international programmes HIRAC/SolarMax Campaign and IGS/IGLOS.

Station Józefoslaw, managed by the Warsaw University of Technology, has been operating permanently since 1994. At the moment four GPS receivers are operating at the station: Trimble 4000SSE, Trimble CORS, Turbo Rogue 8000 and Ashtech Z18 GPS-GLONASS. Besides the permanent services listed above the studies on vapour content and tropospheric delay are conducted at the station. The station may generate upon request the real time differential corrections that can be available via cellular telephones. Another station, that can work upon request, was established by the WUT in the city centre on the top of the main building of the University.

The Processing Centre of the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology acts for years as:

- EUREF Local Analysis Centre (EUREF LOC) with everyday processing of GPS data from over 30 European permanent stations,
- IGS Regional Network Associate Analysis Centre (IGS RNAAC),
- CERGOP (Central European Regional Geodynamics Programme) Processing Centre, working for the organisation CEI (Central European Initiative).

**Table 2**  
**PERMANENT GPS STATIONS IN POLAND**

No.	Station	Institution	Activities
1.	Borowiec	Space Research Centre, Polish Academy of Sciences	IGS, EUREF, SLR, Time service
2.	Borowa Góra	Institute of Geodesy and Cartography, Warsaw	EUREF Time service
3.	Gdansk	Warmia-Mazury University, Olsztyn	Stations for the agglomeration of three cities used for land and maritime navigation
4.	Gdynia		
5.	Sopot		
6.	Józefosław	Institute of Geodesy and Geodetic Astronomy, Warsaw University of Technology	IGS, EUREF, gravimetric tidal service, ionospheric service, astrometric service
7.	Lamkówko-Olsztyn	Warmia-Mazury University, Olsztyn	IGS, EUREF ionospheric service
8.	Wrocław	Agriculture University Wrocław	EUREF
9.	Kraków	University of Mining and Metallurgy Kraków	geodetic positioning
10.	Dziwnów	Maritime Office	stations used for maritime navigation
11.	Rozewie		

#### **4. PROJECT OF THE NETWORK OF MULTI-FUNCTIONAL REFERENCE STATIONS FOR CENTRAL AND EASTERN EUROPE**

The European Academy of the Urban Environment (EA.U.E), Berlin, Germany suggested in March 2002 to organise in Berlin an international conference devoted to the discussion of possibilities and reality of establishment of the "multi-functional GNSS system of reference stations for Europe" that could be used for both geodetic point positioning and also for land, air and marine navigation. The conference was held in Berlin on 4-5 March 2002 and was attended by representatives of 15 European countries: Bulgaria, Croatia, Czech Republic, Estonia, Germany, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Russia, Slovakia, Slovenia and Yugoslavia.

The participants of the conference stated that the existing and already operating German positioning system SAPOS gained in the German regional surveying authorities and also in neighbouring countries extremely positive experience as far as its capacity,

effective procedures as a multi-functional DGNSS reference station system and fundamental infrastructure components is concerned. The participants decided to form a founding committee with the goal of drawing up in the near future the basic principles concerning setting up multi-functional DGNSS reference station systems compatible with the German system SAPOS in countries expressing an interest.

The first conference of the Founding Committee was held in Warsaw, Poland on 2-3 July 2002 and was organised by the Institute of Geodesy and Geodetic Astronomy of the Warsaw University. The conference was devoted to practical aspects of realisation of establishment of a multi-functional network of GNSS reference stations in Central and Eastern European countries. It was decided that the Founding Committee would be renamed the "Steering-Committee" of the unified project called "European Position Determination System (EUPOS)". Since many of countries participating in the project are EU pre-accession countries, it was also agreed that the attempt would be made to realise the Project EUPOS as a EU Programme "Instrument for Structural Policies for Pre-Accession" (ISPA). For this reason one general project description will be developed which will be supplemented by regional details for particular countries. For countries which are not the EU pre-accession ones other possibilities of founding will be searched. All countries submitted in July the general proposals concerning location of their reference GNSS stations. The distance between stations could not be greater than 70-100 km at maximum. The next meeting of the EUPOS Steering Committee will be held in November 2002 in Sofia, Bulgaria.

Fig. 2 shows an example of a distribution of proposed EUPOS stations for Poland. The expertise and a general programme of establishment of the network of multi-functional permanent GNSS reference stations in Poland for the aims of geodesy and navigation was worked out in Poland on request of the Head Office for Geodesy and Cartography by joint effort of two scientific bodies: the Commission of the Satellite Geodesy of the Committee for Space Research of the Polish Academy of Sciences and the Section for Geodetic Networks of the Committee for Geodesy of the Polish Academy of Sciences. The location of Polish reference stations, given below, was analysed and described in the mentioned expertise. As EUPOS stations there will be incorporated all existing permanent stations and about 45-50 further stations.

The location of two stations (Katowice and Warszawa) will be finally fixed as soon as the establishment of the local systems in Upper Silesia Region and the agglomeration of Warsaw, now being constructed, are completed.

On request of the General Surveyor of Poland and the authorities of the Silesia Province (voivodeship) a pilot project is being realised aimed at establishment of the Active Geodetic Network covering the area of the Silesia Voivodeship. The system is based on 6 reference fully automated stations and a System Processing Centre and is designed for establishing the geodetic control networks of different types. The System Processing Centre will consist of a control, data base, processing and www-service modules. Potential clients will receive the results via Internet service. Another local GNSS multifunctional reference network based on four stations will be covered the agglomeration of Warsaw and its surroundings.

In view of full compatibility of the systems EUPOS and SAPOS and the dense existing network of SAPOS stations in Germany the necessity of establishment of some Polish stations at the German-Polish border should be carefully considered. By comparison of the EUPOS networks for Poland, Czech Republic and Slovakia further decreasing of number of Polish stations may be possible.





Fig. 2. Location of the GNSS stations of the Polish part of EUPOS network

## 5. CONCISE INFORMATION ON APPLICATION OF SATELLITE SYSTEMS FOR GEODESY AND GEODYNAMICS

Polish institutions participate in many international geodetic and geodynamic campaigns and projects:

- Campaigns CEGRN (Central Europe GPS Reference Network) realised in the frame of the CEI (Central European Initiative) Project CERGOP (Central Europe Regional Geodynamics Project). Four Polish institutions take part in the Project. Last five-day campaign was organised from 18 June to 23 June 2001. Six

Polish stations (Borowiec, Grybów, Józefoslaw, Lamkówko (Olsztyn), Sniezka and Wroclaw) are incorporated to the CEGRN. More than 60 stations from 14 countries participate in the Project CERGOP.

- **Re-measurement campaign of the EUREF-POL network was organised in 2001 by the Space Research Centre, Polish Academy of Sciences on the request of the Polish Head Office for Geodesy and Cartography. The campaign lasted for five days from 26 to 30 September 2001. The processing was made by the Space Research Centre PAS using Bernese v.4.2. The result was compared with that of the first campaign from 1992. The average differences in coordinates  $\pm 3\text{mm}$  (north),  $\pm 5\text{mm}$  (east) and  $\pm 10\text{mm}$  (up) show that the network is stable within the limits of accuracy of the epoch 1992.**
- **The geodynamic GPS network SUDETES, that is established in close cooperation of Polish and Czech geodesists, covers the area of Middle - and East-Sudety Mts. and Sudety Foreland and joins all existing Czech and Polish local GPS networks in this area. The Polish part of this network includes selected points of network GEOSUD, established in 1996 by the Department of Geodesy and Photogrammetry of Agriculture University of Wroclaw. The Czech part (network SILESIA) was designed and monumented in 1997 by the team of Institute of Rock Structure and Mechanics of the Czech Academy of Science in Prague. The whole SUDETES network is being measured during GPS campaign every year by Polish and Czech GPS teams.**
- **Polish-Slovak Project "Tatra Mts. without border". Project was launched in 1997. GPS monitoring campaigns are organised every year by teams from Slovak and Polish institutions to measure the Tatra Mts. reference satellite network. The general objectives of the project are: investigation of geodynamics of the Tatra Mts. and determination of the local quasigeoid in the region. As by-result there will be determination of heights of some Tatra's picks. The seminar on geodynamic of Tatra Mts is organised every year by Slovak colleagues at fall time.**
- **Czech-Polish-Slovak Cross-Border Studies of Regional Geodynamics (Sudetes, Beskydy, Tatra, Pieniny Mts). There are organised every year coordinated GPS campaigns comprising in total about 40 GPS stations. Long border line between Poland, Czech Republic and Slovakia coincides generally with very interesting geotectonic formations of different age that give an excellent opportunity to undertake a comparative studies that have a significant scientific and practical value. The main general objectives of the Project have been defined as follows:**
  - **Long-term investigation of variations of the recent crustal movements and periodic monitoring of the horizontal and vertical displacements in the structural active tectonic zones of the Polish and Czech parts of the Sudetes Mts. and the Western Carpathians as well as in the regions located close to the existing and planned investments and technical constructions (water reservoirs and dams, power stations, communication lines, etc.).**
  - **In the Tatra Mts., that represent the youngest tectonic formation of the area of Central Europe, a study of tectonic movements and relatively significant velocity vectors as well as determination of the location of the geoid (the quasi-geoid) related to the geocentric reference ellipsoid;**

- Geodynamic research and investigation of the whole area will be directed to both scientific and practical outputs. The geodynamic hazard map of the area will be considered to assess regional mobility characteristics. The obtained data will be used for regional and urban planning;
- Establishment of the test control networks in Sudetes Region and in Tatra Mts. that can be used by Polish, Czech and Slovak geodesists and surveyors for testing new technologies and upgrading the practical quick methods of satellite and geodetic positioning procedures applicable for geodesy and navigation, in particular in hilly and mountainous areas. The established geodetic test fields will also be used by geodetic departments of Czech, Polish and Slovak technical universities for student training in surveying and geodesy.

In 2001 and in 2002 coordinated three-day GPS satellite observation campaigns were organised in September. About 40 GPS receivers from the Czech Republic, Poland and Slovakia will be involved in the action.

## **6..APPLICATION OF GPS TECHNIQUES IN AVIATION**

Polish Air Force Academy in Deblin continues tests and experiments with the GPS receivers installed on board of helicopters and aircraft. Such experiments were made with GG24 GPS/GLONASS receivers. Another field trials on-board of SU-22 and ISKRA aircrafts for automatic approach and landing system using DGPS and DGLONASS techniques were carried out in Warmia and Masury University Olsztyn.

## **7. RELEVANT CONFERENCES**

In the last time there were organised in Poland several international conferences, seminars and workshop related to the different use of satellite navigation systems. Below we would like to mention the following events:

- International Information Seminar on Space organised for the EU Accession Countries by the European Commission (EC) and European Space Agency (ESA). The Seminar was held in Warsaw, Poland on 20 June 2002. Papers on European space strategy, GALILEO System (technical information, management, schedule, actors), programme objectives and and planning of GMES (Global Monitoring for Environment and Security) and Space within the EC 6<sup>th</sup> Framework Programme were presented at the Seminar. Seminar was attended by about 50 participants from EU accession countries.
- 3<sup>rd</sup> Workshop of Local Analysis Centres of EUREF Permanent Network, Warsaw, Poland, 31 May - 1 June 2001. Workshop was organised by the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology and was attended by representatives of European EUREF Processing and Analysis Centres from Austria, Belgium, the Czech Republic, France, Germany, Hungary, Italy, the Netherlands, Poland, Sweden and Switzerland. The workshop gave a good platform to discuss the standards, organisation further strategies of processing and analysis procedures of permanent GPS data collected by European stations for the aims of EUREF.

- **Three scientific bodies: the Commission of the Satellite Geodesy of the Committee for Space Research of the Polish Academy of Sciences and two Sections of the Committee for Geodesy of the Polish Academy of Sciences - Section for Geodetic Networks and Section for Geodynamics organise every year joint seminars on the use of satellite navigation systems to geodetic and geodynamic purposes. The seminars are attended by participants from many Polish institutions dealing with practical use of GPS for geodetic and geodynamic projects.**

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The following acronyms and abbreviations of names of Polish institutions involved in realisation of GPS projects are usually used in the National Reports:

AUW	Agriculture University of Wroclaw
DG	Department of Geodesy
DGP	Department of Geodesy and Photogrammetry
FMSEE	Faculty of Mining Surveying and Environmental Engineering
GMA	Gdynia Maritime Academy
GSP	General Surveyor of Poland
HOGC	Head Office of Geodesy and Cartography
IG	Institute of Geodesy
IGC	Institute of Geodesy and Cartography
IGGA	Institute of Geodesy and Geodetic Astronomy
MOG	Maritime Office Gdynia
MUS	Maritime University Szczecin
PAFA	Polish Air Force Academy Deblin
PAS	Polish Academy of Sciences
PNAG	Polish Naval Academy Gdynia
SGN	Chair of Satellite Geodesy and Navigation WMUO
SRC	Space Research Centre
UMMC	University of Mining and Metallurgy Cracow
WMUO	Warmia and Masury University Olsztyn
WUT	Warsaw University of Technology

In order to organise a quick transmission of information necessary for preparation of this and all subsequent National Reports for CGSIC there was established a network of correspondents of Polish institutions involved in realisation of GPS scientific and practical projects. Below you can find the names of the correspondents and their contact e-mail addresses. For further detailed information please contact directly the correspondents of particular institutions.

The author of this Report would like to express his sincere thanks to all correspondents for their help in prompt providing all necessary data.

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