Part 2.
THE ASG-EUPOS SYSTEM – CURRENT STATUS AND DEVELOPMENT PLANS

Artur Oruba
Wiesław Graszka
Marcin Ryczywolski
Szymon Wajda

Head Office of Geodesy and Cartography, Warsaw

1. INTRODUCTION

Since June 2nd, 2008 the ASG-EUPOS (Aktywna Sieć Geodezyjna – Active Geodetic Network) augmenting system for precise satellite positioning in Poland has been running at full operability. We now approach the moment when a certain resumé can be obtained and therefore future development plans can be stated.

This paper gives the reader an overview of the ASG-EUPOS system in general, describes its structure and functioning services. Also, testing and quality control procedures and some usage statistics are presented. Additionally, current status of integrating of the ASG-EUPOS system with existing control geodetic network in one optimal reference frame, so called calibration campaign, has been presented.

2. SYSTEM DESCRIPTION – STRUCTURE AND FEATURES

2.1. Main system segments

ASG-EUPOS is a multifunctional system augmenting precise satellite positioning based on international EUPOS standards. Its structure is divided into four basic components i.e. satellite, reference, management and user segment. Those elements working together provide an effective augmenting system for precise positioning in real-time and post-processing applications.

The satellite (space) segment consists of Global Navigation Satellite Systems such as NAVSTAR GPS or GLONASS. It is also planned that when GALILEO becomes operable, it will be the main component of the satellite segment, supported by GPS and GLONASS.

The reference segment consists of 98 national reference stations distributed regularly across Polish territory and 22 foreign stations in neighbouring countries. The final distribution of stations, typically the distance between points is ca. 70 km, assures maximized factor of network reliability and precision versus reasonable costs. The locations of the stations depend on local terrain topography, distribution of other existing GNSS stations nearby, etc. Among 98 national stations, 14 of them are equipped with GPS/GLONASS receivers. Although the inclusion of existing reference stations to the ASG-EUPOS enabled cost reduction, it also introduced of different type and manufacturer's hardware (including GNSS antennas and receivers). The use of absolute antenna calibration models diminishes influence of heterogeneous equipment on overall network precision.

Beside national stations, in ASG-EUPOS system there are included 22 foreign reference stations that originate from similar systems in neighbouring countries: Czech Republic (CZEPOS), Germany (SAPOS), Lithuania (LITPOS), Slovakia (SKPOS). According to preliminary discussion with Ukrainian partners also some stations located in vicinity of Polish border are to be included into ASG-EUPOS. The international cross-border data exchange is accomplished according to bilateral agreements as well as EUPOS guidelines and standards. Including foreign stations to network solutions improves system's reliability and precision in border zone. In ASG-EUPOS this data are used in generating network corrections in KODGIS, NAWGIS and NAWGEO services as well as in automated post-processing service POZGEO. Users who wish to get direct access to data from foreign stations are encouraged to contact the owners of the data i.e. institutions responsible for managing a particular foreign system. Table 1 below presents the list of foreign reference stations that are included into ASG-EUPOS system.

Table 1. The list of foreign ASG-EUPOS reference stations.

Country	System	ID	City	Type
Czech Rep..	CZEPOS	CBRU	Bruntal	GPS
		CFRM	Frýdek – Místek	GPS
		CLIB	Liberec	GPS
		CPAR	Pardubice	GPS
		CSUM	Šumperk	GPS
		CSVI	Svitavy	GPS
		CTRU	Trutnov	GPS
Germany	SAPOS	0014	Cottbus	GPS/GLONASS
		0017	Schwedt	GPS/GLONASS
		0022	Frankfurt	GPS/GLONASS
		0139	Rothenburg	GPS
		0147	Zittau	GPS
		0781	Ahlbeck	GPS/GLONASS
Lithuania	LITPOS	MRJM	Marijampole	GPS
		VARN	Varena	GPS
		VEIS	Veisiejai	GPS
Slovakia	SKPOS	GANP	Poprad Ganovce	GPS/GLONASS
		KUZA	Žilina	GPS/GLONASS
		LIE1	Liesek	GPS/GLONASS
		SKSK	Svidnik	GPS/GLONASS
		SKSL	Stará L'ubovňa	GPS/GLONASS
		SKSV	Snina	GPS/GLONASS

All reference stations of the ASG-EUPOS system are presented in Fig. 1. In addition to GNSS equipment, 14 reference stations are equipped with automated meteorological sensors, allowing near-real-time monitoring of the state of troposphere, namely temperature, air pressure and relative humidity. Modern Paroscientific MET-4A sensors are installed nearby GNSS antennas of stations: BOGI, BPDL, BYDG, GWWL, JOZ2, KATO, KRAW, LAMA, LODZ, REDZ, SWKI, USDL, WROC and ZYWI, where station BOR1 is equipped with its own, different set of meteorological sensors.

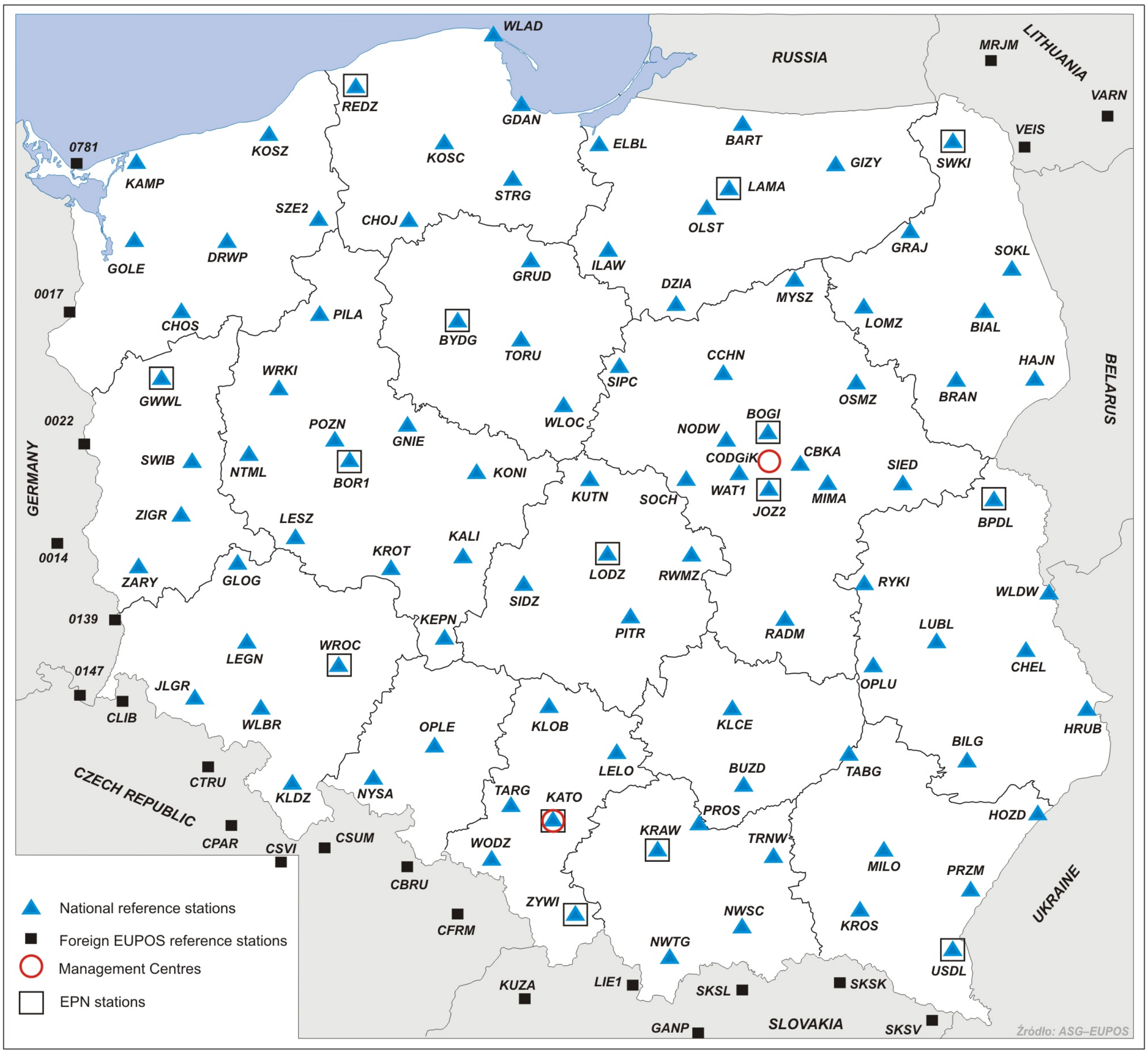


Fig. 1. ASG-EUPOS reference stations distribution

Observation data from reference stations are processed and stored in a management centre which is divided into two locations – Warsaw (the main seat) and Katowice (the spare seat). Data security and real-time service continuity was the reason of development of the emergency centre in Katowice. In case of major malfunction of hardware or software in the main centre, all active services are quickly switched to the spare centre. Both centres work simultaneously so the services can be restored without any visible effect on system's functionality.

The proper work of the management centre is continuously supervised by a team of administrators that are responsible for monitoring the activity of all system modules, as well as technical assistance and support for users. In case of any problems, the administrators try to solve themselves, if this gives no positive outcome – the problem is being forwarded to the system provider and, depending on the severity of the problem, appropriate information is being posted to users on system website.

2.2. System services for positioning

The ASG-EUPOS system has been established to provide the users with set of corrections (services) assisting them in various applications that require precise and reliable positioning or navigation. In order to fulfil the user needs, concerning precision, usage costs, availability, reliability etc, finally five standard positioning services have been developed (see Table 2).

Table 2. Positioning services of the ASG-EUPOS system.

General division	Service	Surveying method	Data transmission method	Estimated accuracy	Minimum hardware requirements
Real-time services	**NAWGEO***	Kinematic RTKN	GSM/ GPRS Internet	0,03 m (horizontal) 0,05 m (vertical)	L1/L2 receiver communication modem
	KODGIS	Kinematic/ DGNSS	GSM/ GPRS Internet FM/ VFM**	0,3 m	L1 (P) receiver communication modem
	NAWGIS/			3,0 m	L1 (CA) receiver communication modem
Postprocessing services	**POZGEO**	Static	Internet/ hardcopy	0,01 m	L1/L2 receivers
	POZGEO D	Static/ kinematic	Internet/ hardcopy	0,1 m	L1 receivers

* All abbreviations given in Polish
** An optional solution, not used yet.

Real-time services are based on the principle of differential observations using DGNSS (Differential GNSS) or RTK (Real-Time Kinematics) utilizing a reference stations network. The whole process of data exchange is being made in real time with the use of GPRS transmission via Internet, therefore the users receive their precise position in the field, in real time.

Depending on the surveying method being used and hardware capabilities the accuracy of real-time services in ASG-EUPOS vary from 3 m to 0,03 mm. KODGIS and NAWGIS DGPS services are being used generally in GIS applications. The NAWGEO service is most commonly used in geodetic applications of all kinds. In NAWGEO service the user has the possibility to choose among various types of RTK corrections, starting with traditional corrections from a single base station, but mainly network corrections like MAC (*Master and Auxiliary Concept*), VRS (*Virtual Reference Station*), FKP (germ. *Flächenkorrekturparameter*) are used. The details are presented in the Table 3.

Table 3. RTK corrections distributed by ASG-EUPOS

Port No	Correction type	Data stream	Correction format
8080	Networking	NAWGEO_RTCM_3_1_VRS	RTCM 3.1
		NAWGEO_RTCM_3_1_MAC	RTCM 3.1
		NAWGEO_RTCM_2_3_FKP	RTCM 2.3
		NAWGEO_RTCM_2_3_VRS	RTCM 2.3
8080	Single stations	NAWGEO_RTCM_3_1_POJ	RTCM 3.1
8082-8083		xxxx_RTCM_3_1*	RTCM 3.1
8084- 8085		xxxx_RTCM_2_3*	RTCM 2.3

* - xxxx – four digit station's code

The post-processing services are provided mostly for users that conduct static surveys in the field and demand most precise results. POZGEO service enables the user to send the observation file in RINEX format in order to receive automatically calculated coordinates of the measured point along with estimated precision of the solution. The last stage of calculation is transformation to the state coordinate system. The result is generated in the form of a report available for downloading via ASG-EUPOS website. In case some errors are discovered whole process is analysed by operators and an message is sent to the user.

The POZGEO D service is meant for more advanced users that are able to utilize their own software to process GNSS observations or want to adjust GNSS networks. These users download observation files from ASG-EUPOS reference stations for their own processing. The user determines for whole period and from which stations data are to be processed.
All services are available cost free by the webpage www.asgeupos.pl.

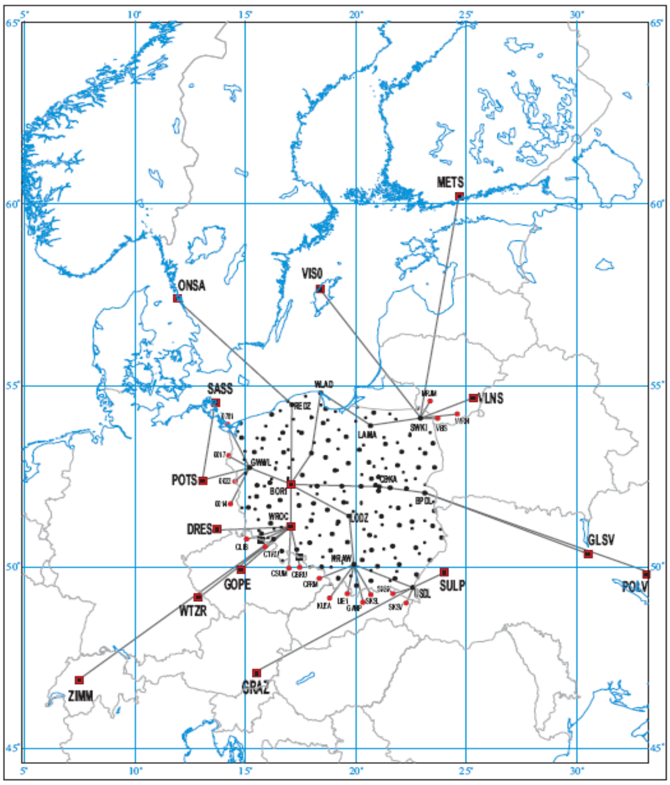
3. ASG-EUPOS CALIBRATION CAMPAIGN. ASSESSMENT OF COORDINATES.

3.1. A campaign general description.

During the period of April 23 May 10, 2008 (DOY-s 114-131/2008) a field campaign was conducted aiming at determining the coordinates of ASG-EUPOS reference stations along with EUREF-POL, POLREF and EUVN ground control networks in one uniform reference frame of ETRF89. The whole ground control network was previously measured at least once each, but the main campaigns were performed in early 1990's when the precision of GPS measurements was significantly lower and processing algorithms were not optimized such as nowadays.

Establishing a uniformly distributed network of permanent reference stations gave the opportunity and as well the need to once again process observations for the whole 1st order geodetic control network in one adjustment. The total of 284 points including: 97 ASG-EUPOS, 5 CZEPOS, 3 LITPOS, 4 SAPOS, 6 SKPOS, 8 EUREF-POL, 41 EUVN, 18 IGS/EPN (outside ASG-EUPOS), 102 POLREF, took part in the campaign. Except from EUREF-POL, EUVN and POLREF other points were observed permanently. All ground control was measured utilizing Trimble R8 GPS receivers in at least two independent 24h sessions (EUREF-POL points were measured in 7-day sessions).

The processing was made utilizing Bernese GNSS Software 5.0. The observations were processed in ITRF2005, ep. 2008,33 (observation epoch); after processing they were transformed to the ITRF2000, ETRF2005 and ETRF2000 (ep. 2008,33) using transformation parameters of Boucher and Altamimi (2006); the ETRF89 (ep. 1989) was realized by 7-parameter transformation on POLREF points.



.**Fig 2. Points and vectors taking part in the processing of the calibration campaign**.

Figures 2 and 3 show the main vectors on which the network processing was based. One can see that all Polish EPN stations are the root of the network and by them, all other minor points were connected to the network. The fix of the network was realized by all nearby IGS/EPN reference stations that have high long term stability and precise coordinates derived from long observations' time series (Fig. 3)

Although the results show very good internal conformity on the level of 2-3 mm, the comparison with available sets of ground control points' coordinates gives different results.

3.2. Result analysis and assessment of coordinates.

One of the main goals of the calibration surveying campaign was to tie existing ground control in the reference frame used so far (EUREF'89 which is Polish realization of ETRF'89 ep. 1989) with new reference stations of ASG-EUPOS. It was essential to check whether, after realization of a region-wide adjustment, current coordinates of ground control are accurate enough to be bound with reference stations' new coordinates. As a result of multiple analyses, following conclusions have been reached:

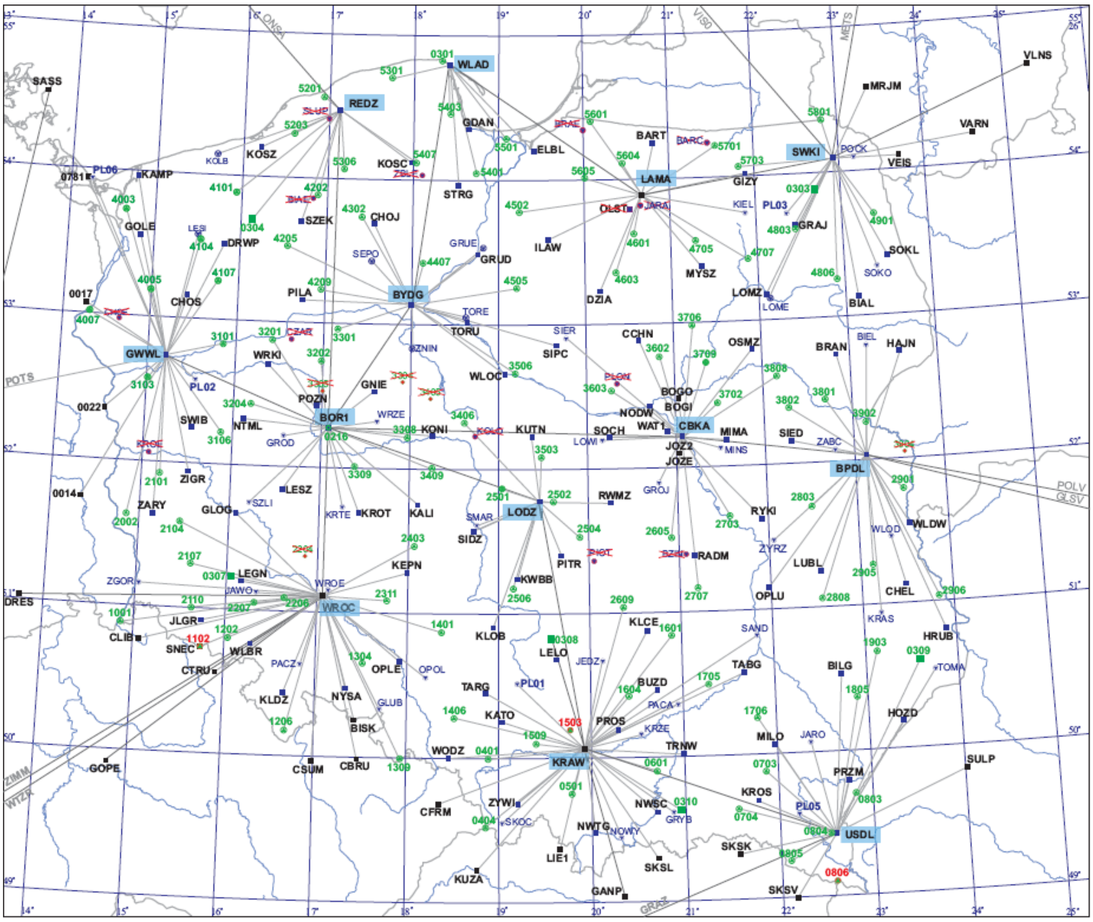


Fig. 3. The fixed points and defined vectors

- EUREF-POL, POLREF and EUVN ground control networks had been processed separately which only once so there are significant differences between them when compared with one common solution,

- the transformation of the campaign outcome using 7-parameter transformation to the datum realized by POLREF control network is not acceptable due to significant scale and rotation value. In Fig. 4 is given the result of testing of a such solution on Trimble GPSNet Coordinate Monitor in relation to the coordinates of BOR1 station. It seems that this solution cannot be used directly in RTK network processing software due to significant at the Northwest and Southeast parts of Poland,

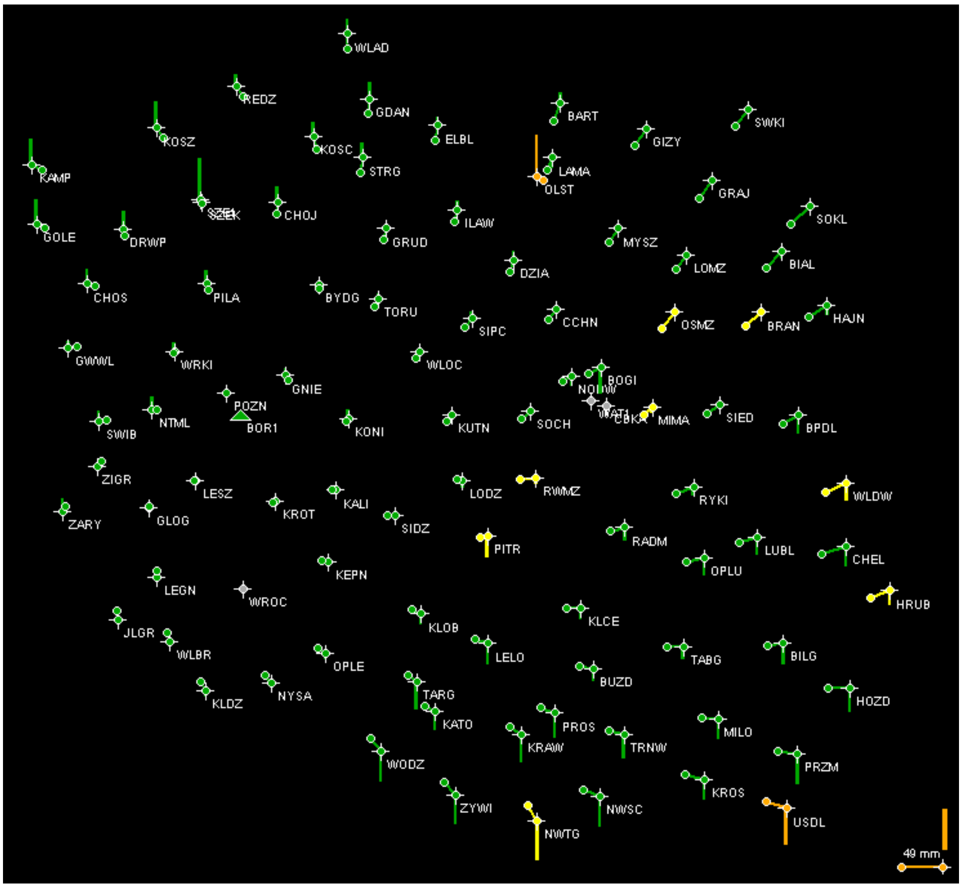


Fig. 4. The result of testing the reference stations' coordinates transformed on POLREF control points. Testing was conducted using Trimble GPSNet software, Coordinate Monitor module.

- various transformation models were tested concerning search for the best possible match between ground control coordinates used so far and the new calculation resulting from the calibration campaign. The comparison leads to a general conclusion

- that although some of the tested transformations models give better match than the other ones, the result is still not acceptable. Table 4 below presents the outcome of the test;
- the ETRF2000 coordinates of reference stations should be used on the epoch close to the epoch of the campaign. This assumption was made due to insufficient accuracy and distribution of velocity vectors. Only after a few years (at least 3 or 4) of observation one could determine quite well established velocities of the stations. Additionally the currently known velocities cannot be used because of:
    - differences between velocities in various ITRS and ETRS realizations,
    - problems with choosing proper stations for estimation of the velocity fields.

Table 4. Differences between official EUREF89 coordinates of Polish ground control points and various solutions tested for the best match with the ground control.

		EUREF-POL XYH [cm]	POLREF XYH [cm]	EUVN XYH [cm]
ETRF00 (2008.3)	mean	-0,3 1,7 3,8	-0,2 2,1 7,0	-0,5 2,2 3,8
	std. dev.	0,7 1,1 1,2	1,1 1,2 2,0	1,1 3,5 2,8
EUREF89 (POLREF)	mean	0,2 0,5 3,3	0,0 0,0 0,0	0,1 0,1 3,7
	std. dev.	0,4 0,5 1,5	0,6 0,7 1,4	1,1 3,6 3,3
ETRF00 (1989.0) (V_{ITRF05})	mean	-0,1 1,0 4,4	0,0 1,4 7,7	-0,3 1,6 4,6
	std. dev.	0,8 1,3 2,4	1,1 1,4 3,0	1,1 3,5 2,9
ETRF00 (1989.0) (V_{ITRF00})	mean	-0,2 1,5 1,8	-0,1 1,2 5,1	-0,4 2,1 1,9
	std. dev.	0,9 1,6 1,9	1,2 1,6 2,2	1,1 3,6 2,7

An independent adjustment of the whole ASG-EUPOS network constrained by 5 EPN stations was conducted by MUT (Military University of Technology) utilizing Bernese SINEX files for CATREF processing (Figurski et al. 2009). This was compared with earlier campaign results and did not show significant differences in coordinates. Its outcome in ETRF2000 ep. 2005.0 was officially accepted as the reference frame for ASG-EUPOS reference stations. Additionally it was agreed that official parameters for transformation to ETRF89 realized by Polish ground control will be issued in the future.

The comparison of various solutions for choosing optimal reference frame led to a conclusion that the best defined and relatively best fitting - according to the ground control networks - would be ETRF2000. The 2005.0 epoch of reference was chosen so that station velocity uncertainties are relatively small across the period of 3.3 years from the epoch of calibration campaign to the epoch of reference. In table 5 below one can find the list of coordinates of national ASG-EUPOS reference stations in ETRF00 (2005.0).

Table 5. Coordinates of ASG-EUPOS reference stations located in Poland in ETRF00 (2005.0).

	Station ID	X [m]	Y [m]	Z [m]
01	BART	3490896,970	1327143,738	5153172,103
02	BIAL	3526538,164	1507014,553	5079529,914
03	BILG	3747351,671	1568978,071	4900768,665
04	BOGI	3633815,680	1397453,920	5035280,800
05	BOR1	3738358,775	1148173,501	5021815,579
06	BPDL	3615990,141	1544390,857	5005373,519
07	BRAN	3566372,780	1501993,381	5053284,970
08	BUZD	3805091,361	1439261,286	4896192,370
09	BYDG	3647217,195	1184604,086	5079624,975
10	CBKA	3654410,033	1407752,479	5017576,918
11	CCHN	3610611,196	1356983,393	5062816,507
12	CHEL	3678820,534	1598100,900	4942832,630
13	CHOJ	3608520,120	1141388,068	5116893,445
14	CHOS	3694305,714	1018555,341	5081594,446
15	DRWP	3655958,944	1035735,815	5105717,057

16	DZIA	3591709,250	1319169,702	5086093,672
17	ELBL	3530686,977	1243375,254	5146944,388
18	GDAN	3529800,593	1190807,695	5159896,621
19	GIZY	3486403,538	1392187,351	5139218,669
20	GLOG	3809340,992	1097657,661	4979900,711
21	GNIE	3706494,248	1174619,760	5039231,980
22	GOLE	3670268,119	972331,400	5107777,002
23	GRAJ	3501476,426	1446944,919	5113951,709
24	GRUD	3601223,867	1222799,205	5103133,549
25	GWWL	3734526,173	1015012,795	5053042,551
26	HAJN	3547044,024	1547151,589	5053300,621
27	HOZD	3756467,280	1622631,032	4876495,331
28	HRUB	3693100,698	1635499,278	4920024,115
29	ILAW	3575246,012	1270835,514	5109730,156
30	JLGR	3878289,748	1092566,847	4928217,851
31	JOZ2	3664880,908	1409190,383	5009618,280
32	KALI	3760909,808	1228903,459	4986013,183
33	KATO	3862992,378	1332822,661	4881105,459
34	KEPN	3802580,903	1234328,943	4953272,142
35	KLCE	3774368,848	1420921,172	4925093,011
36	KLDZ	3900141,948	1166529,635	4894068,327
37	KLOB	3812245,530	1307966,526	4927157,467
38	KONI	3718009,906	1226301,697	5018514,604
39	KOSC	3563310,147	1156522,680	5144920,878
40	KOSZ	3590530,401	1042990,545	5150117,643
41	KRAW	3856936,166	1397750,473	4867719,440
42	KROS	3840336,478	1534053,851	4840009,363
43	KROT	3779936,746	1187254,315	4981792,359
44	KUTN	3693480,887	1298866,456	5018375,419
45	LAMA	3524523,257	1329693,429	5129846,164
46	LEGN	3846687,764	1114288,337	4947658,622
47	LELO	3814251,013	1360360,147	4911504,887
48	LESZ	3784869,914	1126771,339	4991967,945
49	LODZ	3728601,881	1317402,261	4987811,131
50	LOMZ	3550311,328	1440214,395	5082321,510
51	LUBL	3694475,296	1534437,469	4951248,697
52	MILO	3804457,773	1534914,669	4867705,490
53	MIMA	3644974,550	1440149,893	5015356,657
54	MYSZ	3550868,830	1387537,311	5096451,358
55	NODW	3645290,977	1378210,099	5032291,558
56	NTML	3753277,922	1084607,100	5024800,449
57	NWSC	3873461,760	1462888,145	4835656,016
58	NWTG	3901050,876	1422373,042	4826032,291
59	NYSA	3882469,847	1211762,857	4896966,227
60	OLST	3538409,429	1322052,557	5122295,721
61	OPLE	3854338,103	1246354,209	4910366,298
62	OPLU	3717924,465	1500320,580	4944130,980

63	OSMZ	3585797,851	1440877,978	5057302,715
64	PILA	3670393,093	1103842,664	5081135,097
65	PITR	3754198,671	1343527,053	4961743,293
66	POZN	3728247,083	1135211,720	5032258,358
67	PROS	3837829,012	1418779,902	4876685,605
68	PRZM	3804695,727	1595660,834	4848106,476
69	RADM	3719233,611	1439894,742	4961004,275
70	REDZ	3550066,919	1093331,791	5167561,947
71	RWMZ	3711199,605	1369172,496	4986762,215
72	RYKI	3680883,347	1481736,395	4977132,290
73	SIDZ	3762313,386	1274760,028	4973563,604
74	SIED	3628142,730	1487581,674	5013729,241
75	SIPC	3634432,521	1298646,405	5061077,573
76	SOCH	3673992,756	1354866,157	5017844,745
77	SOKL	3494482,058	1519135,047	5097954,768
78	STRG	3565383,732	1195036,130	5134648,656
79	SWIB	3770280,699	1048163,258	5019843,488
80	SWKI	3452304,864	1460314,595	5143362,416
81	TABG	3772239,497	1498958,707	4903535,392
82	TARG	3851054,936	1315388,290	4895185,867
83	TORU	3643532,300	1228658,572	5071868,445
84	TRNW	3834315,756	1470638,345	4864150,741
85	USDL	3837558,220	1596303,040	4822409,632
86	WAT1	3655223,170	1396074,441	5020262,372
87	WLAD	3496345,077	1164350,005	5188401,669
88	WLBR	3880292,345	1133211,870	4917654,522
89	WLDW	3643581,012	1588599,375	4971661,160
90	WLOC	3664306,901	1266512,319	5047681,821
91	WODZ	3896698,780	1300673,698	4863029,362
92	WRKI	3715836,369	1091591,988	5050832,184
93	WROC	3835751,627	1177249,747	4941605,053
94	ZARY	3828791,773	1036393,347	4978198,283
95	ZIGR	3796760,096	1053954,782	4998889,410
96	ZYWI	3904633,328	1360191,886	4840630,785

4. SYSTEM USAGE STATISTICS IN THE FIRST YEAR

In the first year of operation (from June 2008 to June 2009) the ASG-EUPOS system has been constantly growing, taking into account the number of registered users (see Fig. 5). At the end of June 2009 this number exceeded 4200 which is surprisingly high compared to the estimations made during the system realisation. Associated with the above – the number of www.asgeupos.pl webpage visitors is also growing fast.

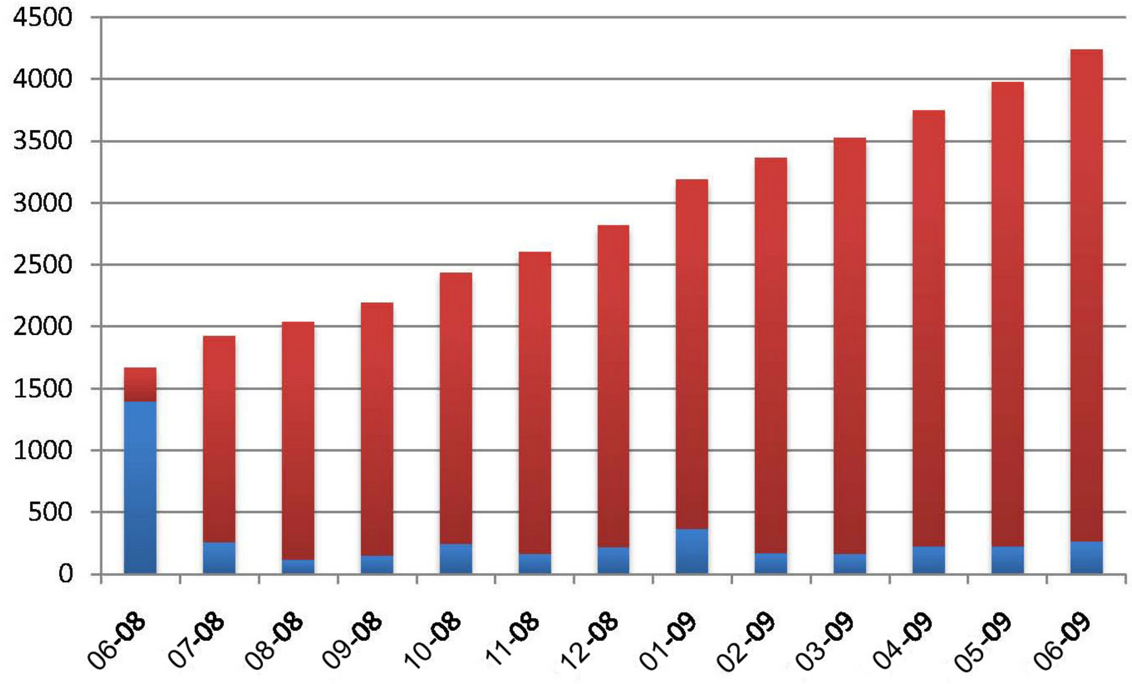


Fig. 5. Number of registered users in each month. The red colour indicates total number of system users.

Only the first half year of system operation allowed to point out the areas of high interest in network corrections offered in NAWGEO service. Statistical data concerning approximate user position helped in creating a map of ASG-EUPOS services usage in Poland (Fig. 6). It is easily noticeable that GNSS surveys are concentrated in the areas of large cities as well as along large investments in roads and railways.

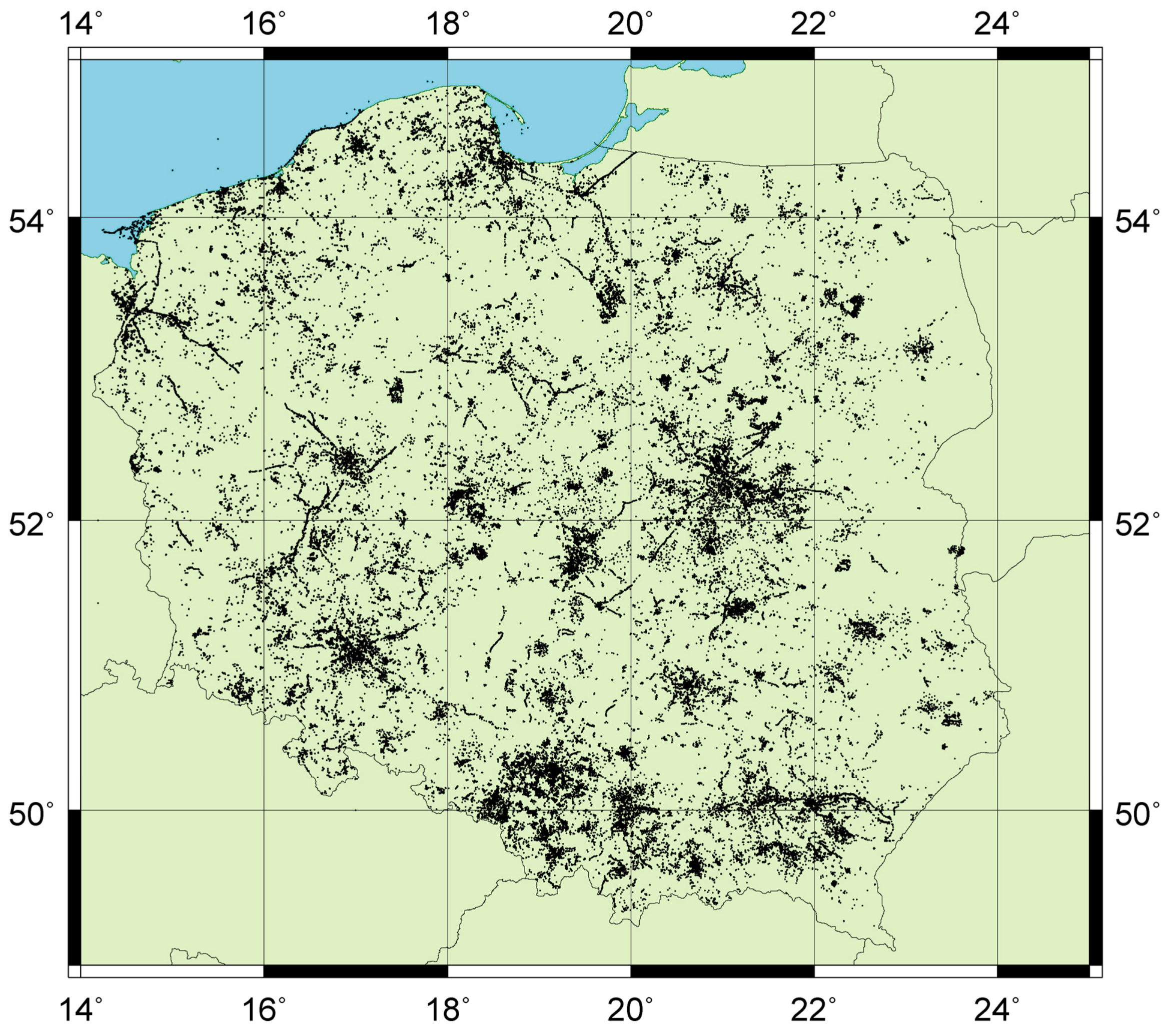


Fig. 6. The map of ASG-EUPOS system usage in Poland in 2008.

The system is being mainly used by geodesists, as planned in the first period of operation, which is the reason for such imbalance of real-time services usage shown in Fig. 7. The users of other RT services – KODGIS and NAWGIS – mainly work in the field of navigation, GIS, vehicle tracking, etc.

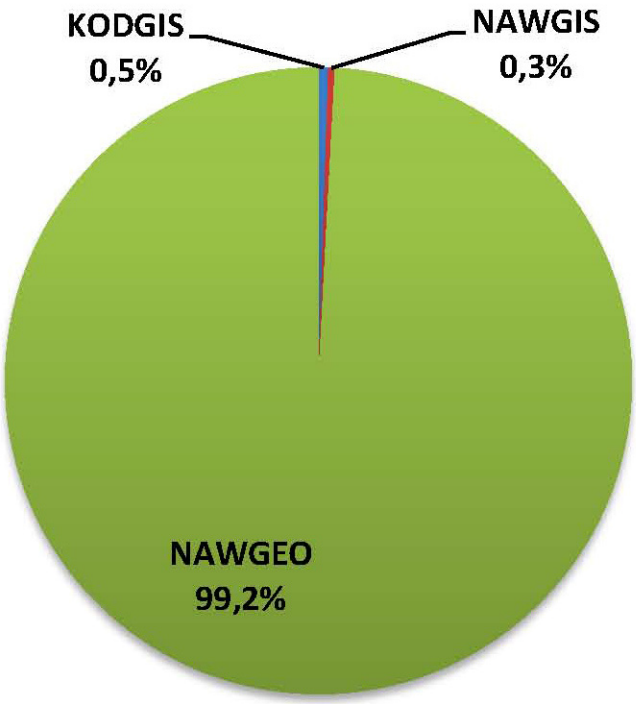


Fig. 7. The usage of ASG-EUPOS real-time services in the first year of operation.

Among the NAWGEO precise corrections, the most popular are VRS network corrections in the RTCM SC 104 version 3.1 format. More than half of the users connect each day (1200 connections daily on average) to the system selecting this correction format. One should notice that RTCM 3.1 VRS corrections have not been proven to give better or more accurate results compared to other network corrections offered in the NAWGEO service portfolio. The graph presenting the distribution of corrections in NAWGEO service is shown in Fig. 8. Fig. 9 presents distribution of real-time connections during an average day. It shows the biggest concentration of measurements conducted between 7-15 h UTC.

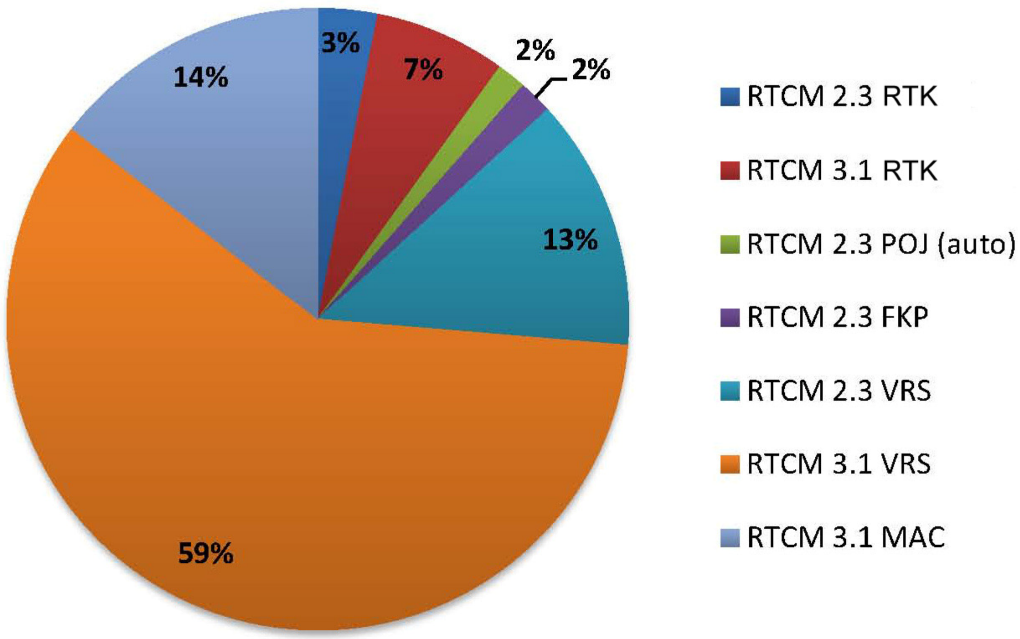


Fig 8. The distribution of corrections in NAVGEO service.

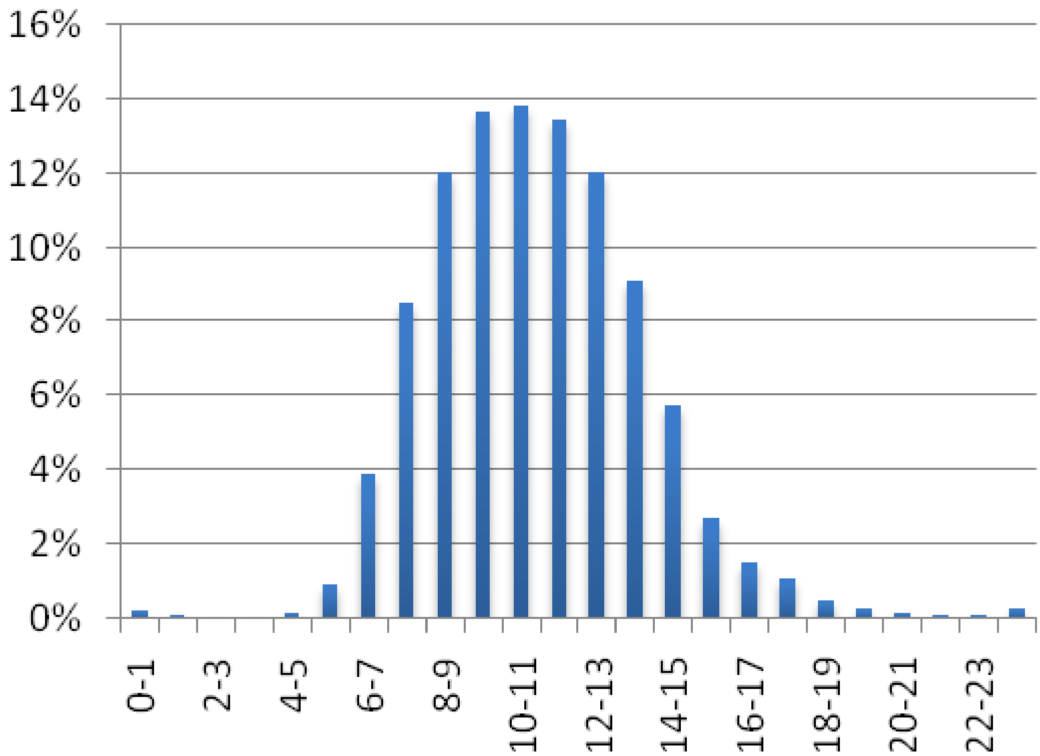


Fig. 9. Daily distribution of connection with real-time services of ASG-EUPOS (UTC).

On average the POZGEO service calculates each day approximately 30 files, which gives more than 10 000 files in the first year. Over 70% of the files are being solved automatically, in about 7% of cases a supporting action from the system operator is needed, which means that those files need to be calculated manually. Fig. 10 shows the distribution of calculated and rejected files in the first year of system operation. Statistics show that most of the files uploaded to the POZGEO service have length of 20-40 minutes of observations, which in some cases may not be sufficient enough concerning measurements in distracted conditions and observation of low number of satellites (below 6-7).

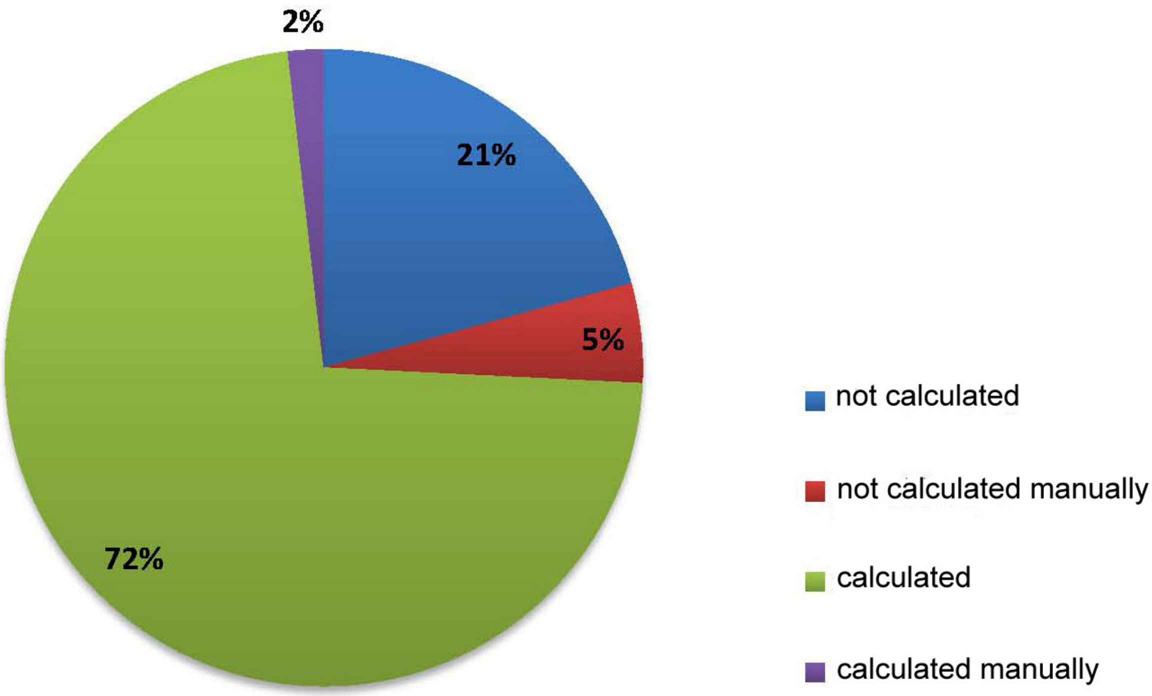


Fig. 10. Calculated and rejected files in the POZGEO service.

In opposite to the above, the users of POZGEO D service tend to download longer observation files – mostly between 6-12 hours of observations with 5 s interval (see Fig. 11). This is consistent with the group of academic users or those who demand highest precision and reliability of the results.

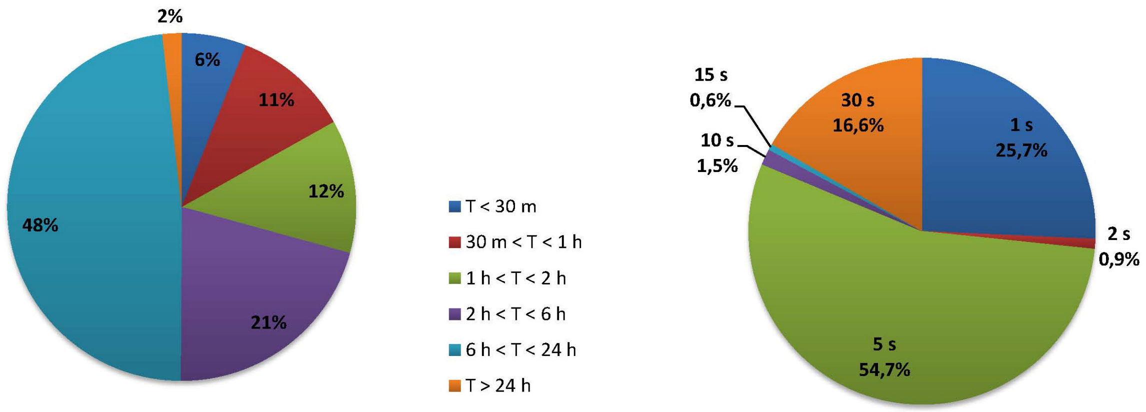


Fig. 11. Files downloaded in POZGEO D service
(file length – left, observation interval – right).

5. CURRENT DEVELOPMENTS AND FUTURE PLANS

The ASG-EUPOS system is an organism that needs constant improvements and implementation of recent technologies in order to remain competitive and useful. Currently a lot of effort is being made to more and more tailor system services to the user demands. For that, the system needs additional financing which is being searched among European Union programmes and funds.

To help the users communicate better with the ASG-EUPOS administrators team and gain access to various resources associated with GNSS and ASG-EUPOS, a new, refreshed informative website has been created. It is accessible under the same address www.asgeupos.pl. Users can find there updated information on system status, its architecture and services. Additionally a user forum has been set up to allow users to exchange information concerning the system. Confronting numerous repeated problems and questions arising from ASG-EUPOS users, a list of Frequently Asked Questions has been prepared to help current and potential users in their work. The questions (FAQ) are listed on the updated website of the system (ASG-EUPOS, 2009).

Current plans on system development, including densification of reference station network, transformation to partially and – eventually – fully support GLONASS and Galileo GNSS signals, further development and utilization of meteorological sensors collocated with GNSS receivers, supporting institutional users with dedicated services, are being transformed into project proposals and sufficient funding is being looked for. Additionally, a second stage of the calibration campaign is being started, including establishing of accessory points for reference stations to enable vertical measurements with classical methods to the stations.

6. CONLUSIONS

Establishment of the ASG-EUPOS system enabled users in various sectors of Polish economy, to precisely and efficiently determine their spatial position. The uniformity of the system gives new opportunities, so far not accessible to the users. This is one of the reasons, why ASG-EUPOS system gained such a large number of customers in a relatively short time period. But the system needs constant evolution to fulfil the demands in the future. Current projects prepared by the Head Office of Geodesy and Cartography aim at further development of the system.

BIBLIOGRAPHY

1. Bosy J., Graszka W., Leończyk M. (2007), ASG-EUPOS - A multifunctional precise satellite positioning system in Poland, European Journal of Navigation, vol. 5 (4) September 2007, pp. 2-6
2. Bosy J., Oruba A., Graszka W., Leończyk M., Ryczywolski M. (2008), ASG-EUPOS densification of EPN on the territory of Poland, EUREF 2008 Symposium, Brussels, Belgium, 12-21 June 2008
3. Szafranek K., Figurski M., Kamiński P., Kroszczyński K. (2009) ASG-EUPOS Monitoring with reference to EPN, EUREF 2009 Symposium, Florence, Italy, 27-30 May 2009

4. Graszka W. (2007), Wielofunkcyjny system precyzyjnego pozycjonowania satelitarnego ASG-EUPOS (Multifunctional precise satellite positioning system ASG-EUPOS), Geodeta, Geoinformational Magazine, vol. 2 (141), Feb. 2007, pp. 4-8
5. Graszka W., Leończyk M., Oruba A. (2009), Implementation of ASG-EUPOS within national control network, EUREF 2009 Symposium, Florence, Italy, 27-30 May 2009
6. Kryński J., Figurski M. (2006) , Results of re-processing of GPS data from EUREF-POL, POLREF and EUVN campaigns using EPN standards, Symposium of the IAG Subcommission for Europe, Riga, Latvia, 14-17 June 2006
7. Somla J., Wajda S., Oruba A., Ryczywolski M., Leończyk M., Bosy J. (2008), ASG-EUPOS w fazie testów (ASG-EUPOS testing in progress), Geodeta, Geoinformational Magazine, vol. 2. (153), Feb. 2008, pp. 4-8 (NAWI)
8. ASG-EUPOS (2009), Information about the ASG-EUPOS system, September 2009, http://www.asgeupos.pl/
9. GUGiK (2005), Technical project of multifunctional precise satellite positioning system ASG-EUPOS in Poland, Head Office of Geodesy and Cartography, 2005
10. PAS SRC (2008), Testing of reference stations and operative ASG-EUPOS system – report, Polish Academy of Sciences – Space Research Centre, 2008