

FINAL REPORT CERGOP-2/ENVIRONMENT WP2 STATION QUALITY ASSESSMENT AND UPGRADE

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INTRODUCTION

The main objectives of CERGOP Work Package No. 2 (WP-2) are defined in the project as “Setting and upgrading standards for a high level performance of the GPS network”, “Development, maintenance and extension of the CEGRN permanent and epoch station network” and “Development of CEGRN stations to provide near real time data for rapid services”.

This Work Package carried out his activity by Hungarian leadership. The partners were the member Institutes of Austria, Germany and Czech Republic.

This Final report is focused to the Hungarian activities. The activities of Austria, Germany and Czech Republic related to WP-2 can be found in the final reports of WP-1, WP-4 and WP-8.

THE STATUS OF THE CENTRAL EUROPEAN GPS GEODYNAMIC REFERENCE NETWORK (CEGRN)

Before the starting of EU project (April 2003) the CEGRN network consisted of 63 accepted (official) sites in 14 Central-European Countries. From these 63 accepted sites the number of permanent stations were 29 (but 2 stations did not operate), while the number of epoch stations were 34.

The procedure of acceptance of new CEGRN sites is initiated by the national investigator sending the CEGRN Site Quality Checklist and site description (including photos) of the candidate points to the chairman of WP-2. Then according to the available a priori information the WP-2 chairman makes his quality evaluations and recommendations on acceptance to the CEGRN Consortium Governing Board (CCGB). Finally the CCGB accepts officially the new CEGRN sites.

During the EU project the following CEGRN Network related decisions were made by the CEGRN Consortium Governing Board.

At the Kick Off Meeting (May 2003, Graz, Austria), 5 Romanian permanent stations (SUCE, BRAI, TIMI, SIBI, CLUJ) were accepted as official sites. The Italian site UPAD was replaced by PADO, while 2 planned permanent stations (TIRA, TOSK) and 4 epoch sites (KIRS, GIL2, IAS3, VAT1) were omitted from the official list.

At the CEGRN Consortium Governing Board Meeting, held in November 2005, Sarajevo, Bosnia and Herzegovina, the following permanent stations were accepted as official sites: Austria TRFB; Bulgaria ROZH and VARN; Czech Republic SNEC; Hungary SUME; Italy ASIA, CAME and ROVI; Romania CONT.

At the Final Meeting (July 2006, Graz, Austria), the following permanent stations were accepted Poland SACZ; Romania CRAI and ORAD; Slovakia LOMS and RISO; Serbia SUBO, LOZN, LJIG, PRIJ, LESK. Notice: The Serbian permanent stations and the (former accepted) Ukrainian SHAZ station are considered as epoch stations till the daily data transfer to Graz Data Centre.

After the Final meeting the Bosnian representative proposed two permanent stations (MOST, LUKA) and three epoch stations (KUDB, LEOT, TURI) into the CEGRN. These stations are in candidate status. There are in candidate status two Slovenian (MRZL, SNEZ) and one Ukrainian (IVAN) epoch sites, because there is no enough information about these stations. Decision of acceptance will be later.

Currently, the CEGRN network consists of 82 accepted (official) sites in 14 Central-European countries, from which the number of permanent stations are 46, while the number of epoch sites 36. There are 8 candidate sites from which the epoch sites took part in the CEGRN 2005 campaign. The network consists of 6 inactive or damaged sites. On these points, GPS measurements were carried out in the former campaign, but in the last two campaign measurements were not done. These points are damaged or replaced by permanent GPS stations.

The the list of the official CEGRN sites can be found in Table 1 and the natural map of CEGRN can be seen in Figure 1. The updated list and the natural map of the CEGRN network can also be seen on the web site of CEGRN Consortium (<http://www.fomi.hu/cegrn>).

Table 1. The sites of CEGRN (status 24. 07. 2006.)

Count	Site	Code	P/ E	Latitude	Longitude	Elev.	Remarks
AUT	Graz	GRAZ	P	47° 04' 01.67"	15° 29' 36.53"	538.3 m	
	Reisseck	GRMS	P	46° 55' 03.24"	13° 22' 23.38"	2378.9 m	Permanent !
	Reisseck	GRMT	E	46° 55' 02.37"	13° 22' 24.43"	2380.4 m	Epoch marker !
	Innsbruck	HFLK	P	47° 18' 46.46"	11° 23' 09.93"	2384.1 m	
	Hutbiegl	AT01	E	48° 39' 16.40"	15° 35' 54.27"	457.6 m	
	Salzburg	SBGZ	P	47° 48' 12.31"	13° 06' 37.55"	1323.5 m	
	Trafelberg	TRFB	P	47° 55' 40.67"	15° 51' 32.08"	1092.6 m	
BIH	Sarajevo	SRJV	P	43° 52' 04.27"	18° 24' 50.02"	645.8 m	
	Mostar	MOST	E	43° 21'	17° 48'		CANDIDATE !!! Permanent*
	Banja Luka	LUKA	E				CANDIDATE !!! Permanent*
	Kudic Brdo	KUDB	E	45° 03' 14.51"	15° 52' 06.45"	567.7 m	CANDIDATE !!!
	Leotar	LEOT	E	42° 44' 37.11"	18° 20' 58.95"	1193.9 m	CANDIDATE !!!
	Turic	TURI	E	44° 52' 05.98"	18° 28' 47.34"	259.6 m	CANDIDATE !!!
BUL	Gabrovo	GABR	E	42° 57' 46.48"	25° 16' 36.48"	619.6 m	
	Harmanli	HARM	E	41° 53' 03.99"	25° 50' 46.80"	281.9 m	
	Kavarna	KAVA	E	43° 24' 48.53"	28° 22' 24.14"	145.9 m	
	Sofia	SOFI	P	42° 33' 21.94"	23° 23' 41.04"	1119.5 m	
	Rozhen	ROZH	P	41° 41' 43.99"	24° 44' 25.80"	1780.8 m	
	Varna	VARN	P	43° 12' 08.93"	27° 55' 21.82"	61.6 m	
CRO	Brusnik	BRSK	E	45° 34' 42.91"	15° 34' 12.84"	269.0 m	
	Dubrovnik	DUBR	P	42° 38' 59.94"	18° 06' 37.56"	454.3 m	
	Hvar	HVAR	E	43° 10' 38.61"	16° 26' 56.12"	286.6 m	
	Osijek	OSJE	P	45° 33' 38.76"	18° 40' 49.74"	153.9 m	
CZE	Pecny	GOPE	P	49° 54' 49.34"	14° 47' 08.24"	592.6 m	
	Lysa Hora	LYSA	E	49° 32' 45.55"	18° 26' 50.20"	1371.7 m	
	Polom	POL1	E	50° 21' 00.56"	16° 19' 20.09"	791.7 m	Replaced POLO
	Brno	TUBO	P	49° 12' 21.22"	16° 35' 34.22"	324.3 m	
	Snezka	SNEC	P	50° 44' 09.17"	15° 44' 23.08"	1651.6 m	
GER	Dresden	DRES	P	51° 01' 47.37"	13° 43' 46.90"	203.0 m	
	Hohenpeissenberg	HOHE	E	47° 48' 03.46"	11° 01' 04.40"	1005.7 m	
	Kirschberg	KIRS	E	51° 12' 51.29"	14° 17' 10.42"	261.3 m	Inactive !!!
	Potsdam	POTS	P	52° 22' 45.47"	13° 03' 57.93"	144.4 m	
	Wetzell	WTZR	P	49° 08' 39.11"	12° 52' 44.08"	666.0 m	
HUN	Csanádalberty	CSAN	E	46° 19' 10.45"	20° 40' 14.81"	142.4 m	
	Csarnóta	CSAR	E	45° 53' 01.03"	18° 13' 01.82"	314.4 m	
	Diszel	DISZ	E	46° 53' 02.05"	17° 29' 28.90"	191.6 m	
	Penc	PENC	P	47° 47' 22.57"	19° 16' 53.50"	291.7 m	
	Tarpa	TARP	E	48° 07' 46.39"	22° 32' 56.95"	193.6 m	
	Sümeg	SUME	P	46° 57' 51.38"	17° 17' 30.52"	242.3 m	
ITA	Trieste	BASO	E	45° 38' 34.42"	13° 52' 30.07"	446.5 m	Inactive !!!
	Bolzano	BZRG	P	46° 29' 56.49"	11° 20' 12.47"	329.1 m	
	Matera	MATE	P	40° 38' 56.87"	16° 42' 16.05"	535.6 m	
	Medicina	MEDI	P	44° 31' 11.85"	11° 38' 48.53"	50.0 m	
	Padova	PADO	P	45° 24' 40.15"	11° 53' 45.82"	64.7 m	Replaced UPAD
	Perugia	UNPG	P	43° 07' 09.81"	12° 21' 20.53"	351.1 m	
	Camerino	CAME	P	43° 06' 43.15"	13° 07' 26.39"	498.7 m	
	Asiago	ASIA	P	45° 51' 58.81"	11° 31' 31.46"	1093.6 m	
	Rovigo	ROVI	P	45° 05' 11.62"	11° 46' 57.93"	62.8 m	

Count	Site	Code	P/ E	Latitude	Longitude	Elev.	Remarks
POL	Borowiec	BOR1	P	52° 16' 37.04"	17° 04' 24.44"	124.3 m	
	Grybow	GRYB	E	49° 37' 43.05"	20° 56' 49.12"	407.5 m	
	Jozefoslaw	JOZE	P	52° 05' 50.19"	21° 01' 53.54"	141.4 m	
	Lamkowko	LAMA	P	53° 53' 32.64"	20° 40' 11.79"	187.0 m	
	Sniezka	SNIE	E	50° 44' 11.30"	15° 44' 24.41"	1645.4 m	
	Wroclaw	WROC	P	51° 06' 47.74"	17° 03' 43.34"	180.8 m	
	Nowy Sacz	SACZ	P	49° 37' 06.36"	20° 41' 24.08"	334.7 m	
ROM	Braila	BRAI	P	45° 16' 03.62"	27° 58' 23.75"	68.3 m	
	Bucharest (Magurele)	BUCA	E	44° 21' 00.56"	26° 03' 03.03"	111.7 m	
	Bucharest	BUCU	P	44° 27' 50.20"	26° 07' 32.67"	143.2 m	
	Cluj	CLUJ	P	46° 45' 27.87"	23° 35' 11.54"	470.1 m	
	Fundata	FUN3	E	45° 24' 39.59"	25° 14' 36.74"	1252.5 m	Replaced FUND
	Macin	MAC2	E	45° 14' 33.95"	28° 11' 23.75"	116.4 m	Replaced MACI
	Sibiu	SIBI	P	45° 46' 54.04"	24° 08' 46.47"	487.1 m	
	Suceava	SUCE	P	47° 38' 09.29"	26° 14' 13.06"	415.2 m	
	Timisoara	TIMI	P	45° 44' 43.68"	21° 13' 47.77"	161.7 m	
	Tismana	TIS3	E	45° 07' 31.85"	23° 07' 36.27"	452.1 m	
	Vrancea	VRN1	E	45° 51' 04.02"	26° 38' 58.68"	655.1 m	
	Constanca	COST	P	44° 09' 41.40"	28° 39' 27.11"	46.2 m	
	Craiova	CRAI	P	44° 20' 16.83"	23° 45' 52.40"	143.2 m	
	Oradea	ORAD	P	47° 03' 33.18"	21° 56' 29.94"	197.2 m	
	Gilau	GIL2	E	46° 40' 42.27"	23° 02' 30.65"	1190.6 m	Replaced GILA Damaged !!!
	Iasi-Repeda	IAS3	E	47° 05' 22.89"	27° 38' 38.27"	384.3 m	Damaged !!!
Vatra Dornei	VAT1	E	47° 27' 24.98"	25° 20' 54.27"	1151.0 m	Replaced VATR Damaged	
SER	Ljig (A015)	LJIG	E	44° 13' 33.59"	20° 14' 21.08"	213.7 m	Permanent*
	Leskovac (A027)	LESK	E	42° 59' 51.23"	21° 56' 52.36"	294.9 m	Permanent*
	Loznica	LOZN	E	44° 32' 06.73"	19° 13' 28.29"	185.0 m	Permanent*
	Prijepolje	PRIJ	E	43° 23' 07.95"	19° 38' 32.98"	514.5 m	Permanent*
	Subotica	SUBO	E	46° 06' 02.22"	19° 39' 45.25"	169.8 m	Permanent*
SVK	Kamenica nad Cirochou	KAME	E	48° 56' 05.04"	21° 59' 39.74"	214.9 m	
	Modra-Piesky	MOPI	P	48° 22' 21.82"	17° 16' 25.96"	579.0 m	
	Partizánske	PART	E	48° 37' 48.43"	18° 20' 26.39"	250.0 m	
	Skalnate Pleso	SKPL	E	49° 11' 15.07"	20° 13' 52.80"	1814.7 m	
	Strazna Hora	STHO	E	48° 13' 28.12"	19° 31' 53.54"	360.2 m	
	Lomnický Stit	LOMS	P	49° 11' 42.53"	20° 12' 46.95"	2676.3 m	
	Rimavska Sobota	RISO	P	48° 22' 26.93"	20° 00' 18.27"	270.5 m	
SLO	Bozica	BOZI	E	46° 16' 25.19"	13° 29' 06.40"	1444.7 m	
	Lendavske gorice	LEND	E	46° 33' 57.19"	16° 28' 36.86"	385.2 m	Inactive !!!
	Ljubljana	LJUB	E	46° 02' 44.92"	14° 29' 43.42"	367.5 m	
	Malija	MALJ	E	45° 30' 13.64"	13° 38' 36.21"	323.1 m	
	Mrzlica	MRZL	E	46° 11' 19.65"	15° 06' 35.02"	1164.6 m	CANDIDATE !!!
	Sneznik	SNEZ	E	45° 35' 18.78"	14° 26' 51.41"	1842.4 m	CANDIDATE !!!
UKR	Lviv	LVIV	E	49° 55' 03.64"	23° 57' 15.13"	360.5 m	
	Shazk	SHAZ	E	51° 34' 12.26"	23° 54' 06.81"	205.6 m	Permanent*
	Sulp	SULP	P	49° 50' 08.12"	24° 00' 52.16"	370.5 m	
	Uzhgorod	UZHD	E	48° 33' 46.37"	22° 27' 09.44"	273.8 m	
	Uzhgorod	UZHL	P	48° 37' 55.12"	22° 17' 51.43"	232.0 m	
	Mount Pip-Ivan	IVAN	E	48° 02' 48.69"	24° 37' 38.42"	2065.1 m	CANDIDATE !!!

Permanent* : These stations are accepted as epoch stations till the daily data transfer to Graz Data Centre.



Figure 1. The accepted and candidate sites of the CEGRN (status 24. 07. 2006.)

SITE INSPECTIONS

Since the reliability of the CERGOP results depends strongly on the quality of the network, therefore very important to check whether the sites satisfy the CEGRN design concepts and site selection criteria. Other important things are the verification of the available a priori information and collection of auxiliary information related to the sites.

The formerly described methodology of inspection (Levai et al, 1998) was extended with horizon panorama photography using HOPP (Galambos and Fejes, 2003). Interference investigations were also performed using an ADVANTEST U3641 Series Spectrum Analyzer. The methodology of interference investigation were worked out in the Satellite Geodetic Observatory by Prof. Istvan Fejes and Dr. Sandor Nagy.

In the three years of EU project, 40 official sites and 2 planned permanent station were inspected in 10 countries. The inspected permanent and epoch stations can be seen in the Figure 2. with white symbols. The not inspected sites are marked with red symbols.

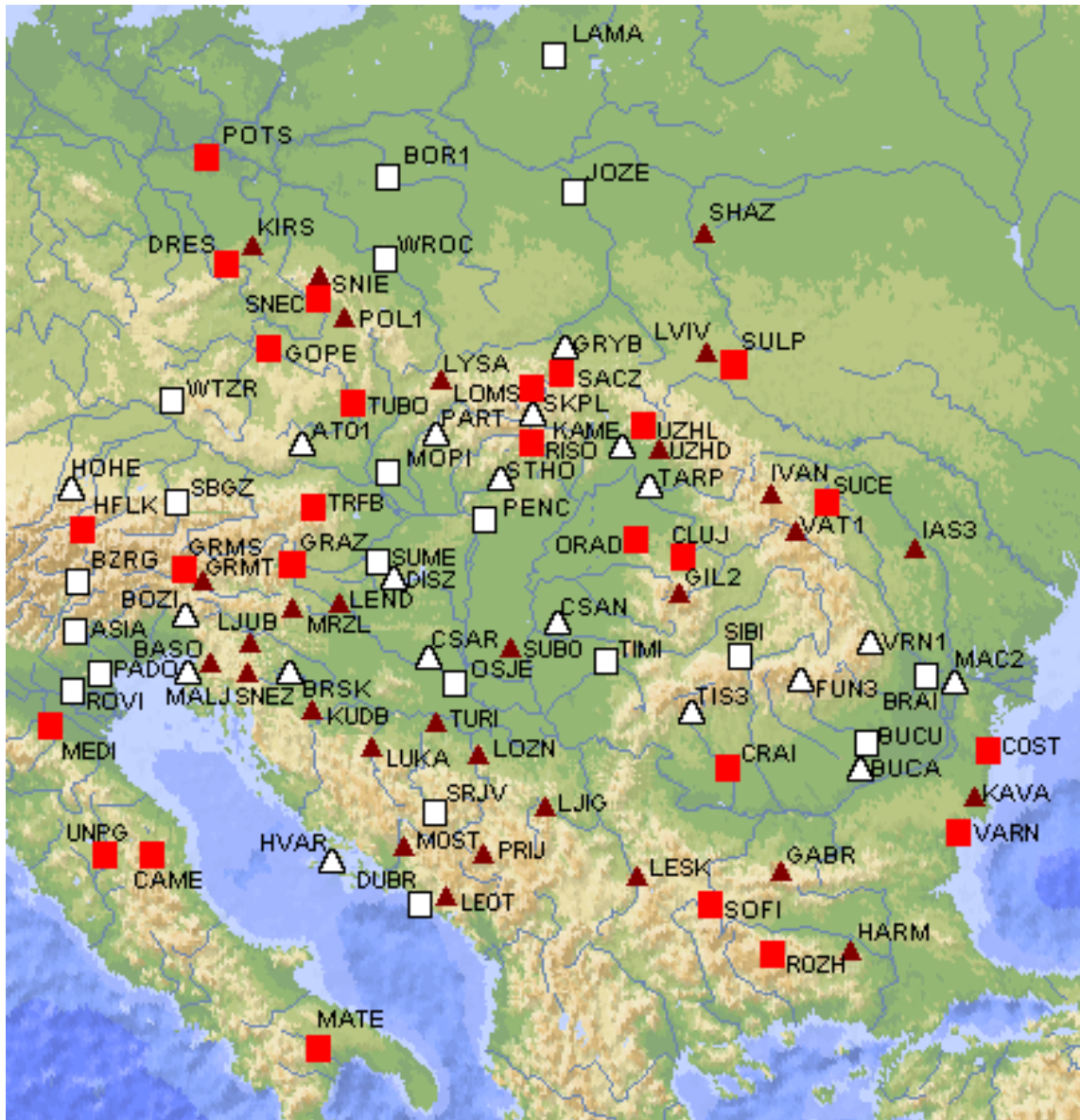


Figure 2. The inspected CEGRN sites (status 24. 07. 2006.)

In the period of EU project, the following permanent and epoch stations were inspected (chronological order):

HUN	PENC	Penc	2003. August	Permanent
CRO	BRUS	Brusnik	2003. September	Epoch
	DUBR	Dubrovnik	2003. September	Permanent
	HVAR	Hvar	2003. September	Epoch
	OSJE	Osijek	2003. September	Permanent
HUN	DISZ	Diszel	2004. March	Epoch
	TARP	Tarpa	2004. March	Epoch
	CSAN	Csanadalberti	2004. April	Epoch
	CSAR	Csarnota	2004. April	Epoch
SVK	MOPI	Modra-Pieska	2004. June	Permanent
	PART	Partizanske	2004. June	Epoch
	LIES	Liesek	2004. June	Planned
	SKPL	Skalnate Pleso	2004. June	Epoch
	KAME	Kamenica nad Chirocou	2004. June	Epoch
	STHO	Strazna Hora	2004. June	Epoch
POL	GRYB	Grybow	2004. August	Epoch
	JOZE	Jozefoslaw	2004. August	Permanent
	LAMA	Lamkowka	2004. August	Permanent
	BOR1	Borowiec	2004. August	Permanent
	WROC	Wroclaw	2004. August	Permanent
GER	HOHE	Hohenpeissenberg	2004. November	Epoch
	WTZR	Wetzell	2004. November	Permanent
AUT	SBGZ	Salzburg	2004. November	Permanent
	HUTB	Hutbiegl	2004. November	Epoch
HUN	SUME	Sumeg	2005. June	Permanent
ROM	TIMI	Timisoara	2005. August	Permanent
	TIS3	Tismana	2005. August	Epoch
	BUCA	Bucharest-Magurele	2005. August	Epoch
	BUCU	Bucharest	2005. August	Permanent
	BRAI	Braila	2005. August	Permanent
	MAC2	Macin	2005. August	Epoch
	VRN1	Vrancea	2005. August	Epoch
	FUN3	Fundata	2005. August	Epoch
	SIBI	Sibiu	2005. August	Permanent
BIH	SRJV	Sarajevo	2005. November	Permanent
ITA	(BRES)	Bressanone	2005. November	Planned
	BZRG	Bolzano	2005. November	Permanent
	ASIA	Asiago	2005. November	Permanent
	PADO	Padova	2005. November	Permanent
	ROVI	Rovogo	2005. November	Permanent
SLO	MALJ	Malija	2005. November	Epoch
	BOZI	Bozica	2005. November	Epoch

The typical antenna placement for permanent station is on top of the building anchored to the roof with steel construction. But fortunately there are some permanent stations where the geodynamical aspect of site selection was the most important. In MOPI, SUME, SBGZ, HFLK, GRMS, TRFB and CAME the antenna placed on concrete or metal pillar embedded into bedrock. The antenna of LAMA and JOZE are placed on deep-based concrete pillar in sediment. In Figure 3. the antenna of MOPI and SBGZ can be seen.



Figure 3. The antenna of MOPI (left) and SBGZ (right) stations

Most of antenna holder on top of building is suitable, but the holder of ASIA seemed the weakest construction among the inspected CEGRN sites. In March 2006 it was damaged probably due to weather conditions (Figure 4.).



Figure 4. Antenna holder of ASIA originally (left) and after damage (right)

Nearby the point of DUBR and HVAR many kind of antennas (microwave, mobile phone, television etc...) can be found, which can decrease the quality of measurements. The results of the DUBR in the EUREF network confirm this possibility.

Site selection for epoch station was usually very good. Many epoch stations are placed directly into bedrock. Usually antenna set up is carried out with short forced adapter or tribach on pillar. Unfortunately there are some (former accepted) points

(HOHE, GABR, HARM, KAVA) where the antenna set up are performed with tripod. In this way the repeatability of antenna is worse than 0.5 mm. The monumentation of epoch sites are usually good expect four sites (TIS3, MAC2, VRN1, FUN3) where the marker is only a small bored hole in the bedrock (see Figure 5.) which is not satisfactory.



Figure 5. Marker of TIS3 and FUN3.

The environment of sites are usually suitable for GPS measurements, there is no significant obscuration above 15° (for example see the horizon photography of TIS3 in Figure 6.). But in PART (Figure 7.) a new metal surfaced building were placed beside the point marker, which cause a significant obscuration and multipath effect. In STHO (Figure 8.) the grown vegetation may cause a significant obscuration. In VRN1 near to the point marker a new fence was created (Figure 9.), which also causes significant obscuration.

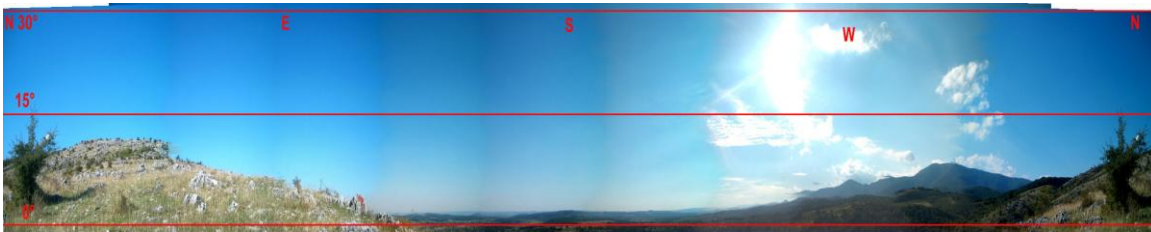


Figure 6. Horizon photography of TIS3

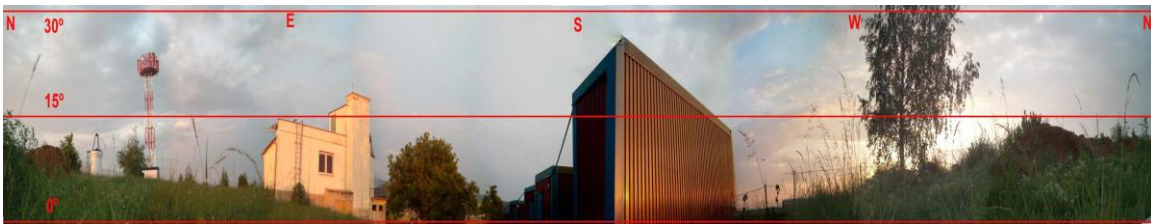


Figure 7. Horizon photography of PART



Figure 8. Horizon photography of STHO

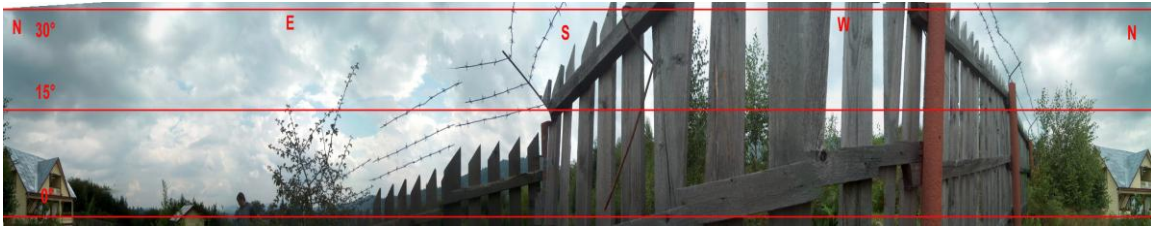


Figure 9. Horizon photography of VRN1

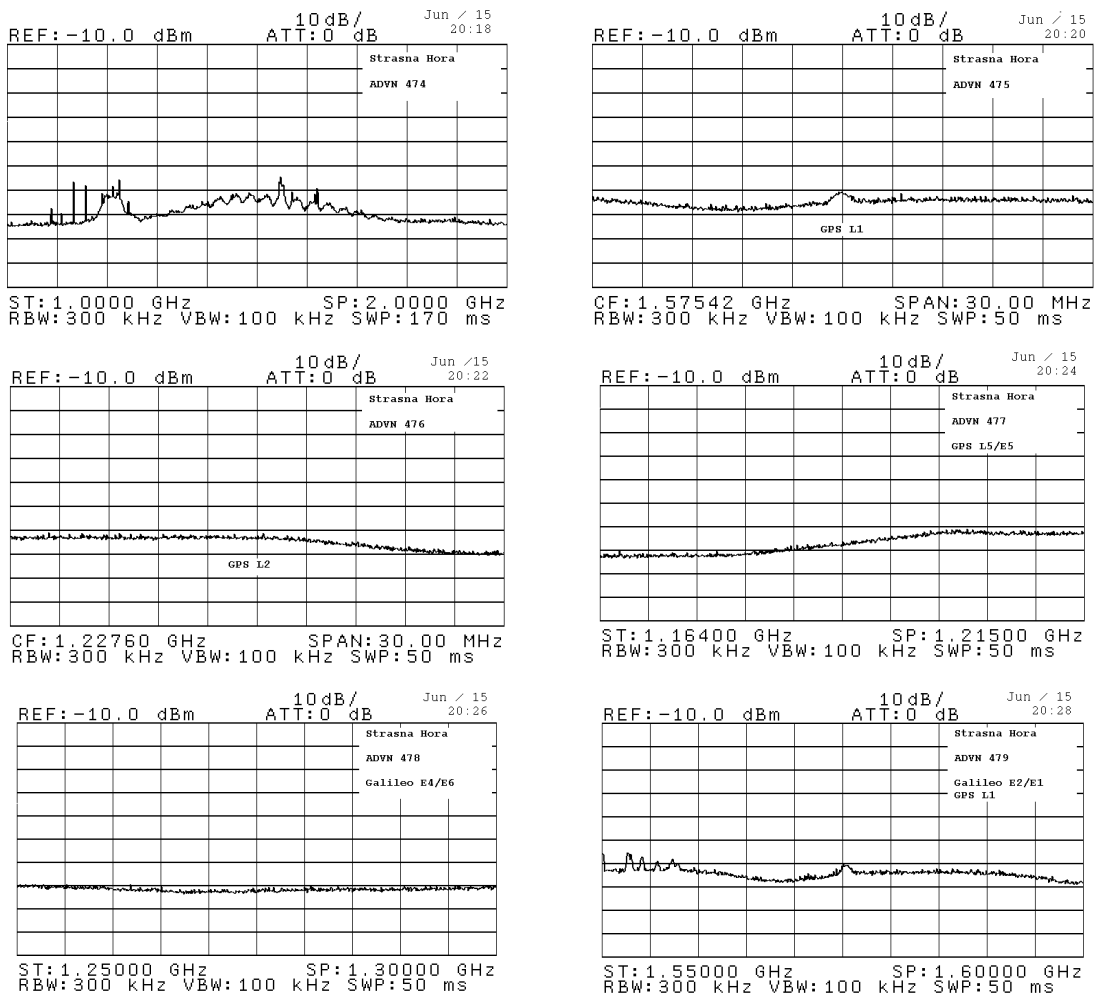


Figure 10. The investigated frequencies in STHO

The results of interference measurements usually show good conditions for GPS measurements (for example see the results in STHO in Figure 10.). But in some cases we found significant disturbing signals. The band near GPS L2 frequency was strongly disturbed in WROC, HOHE, WTZR and SBGZ (Figure 11.). In Salzburg (SBGZ) interference may be the cause of degraded quality of GPS measurements.

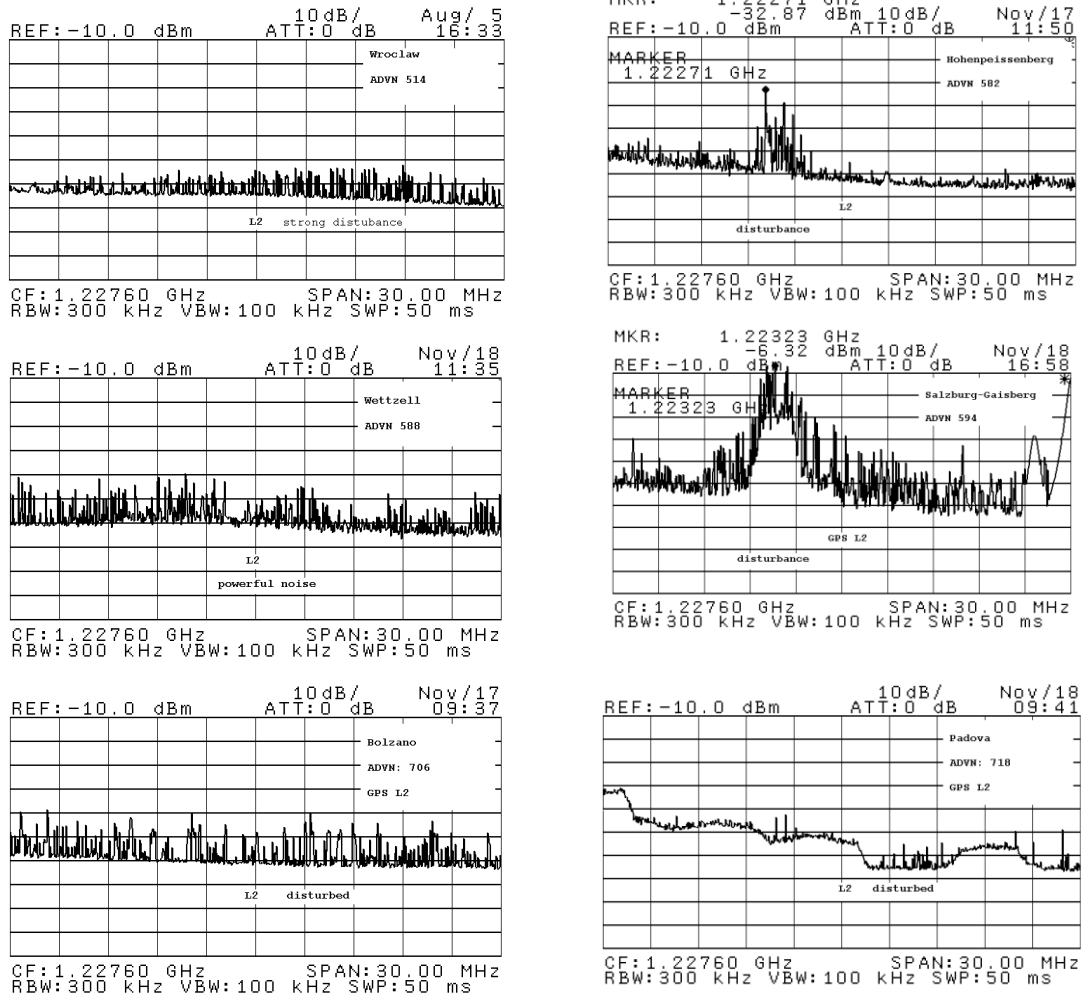


Figure 11. The band near GPS L2 frequency in WROC, HOHE, WTZR, SBGZ, BZRG and PADO

SITE CATALOGUE

New format of CEGRN Site Description was created for the Site Catalogue. This documents contains the most important information about the sites as well as site name, site code, Dome number (at permanent stations), responsible institute with contact person, coordinates, monumentation, picture, site sketch, topographic map and horizon photography (if the point were inspected). For example see the Site Description of AT01 in Figure 12.


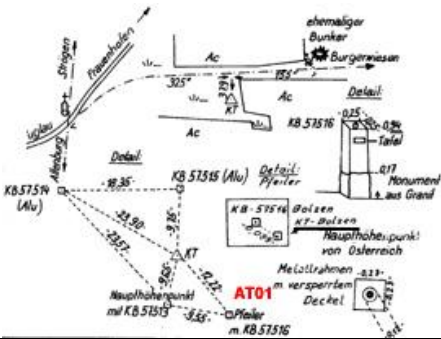


CEGRN Central European GPS Geodynamic Reference Network SITE DESCRIPTION		
Status: OFFICIAL		
Country: AUSTRIA		
Site Name: Hutbiegl	Site Code: AT01	Dome Number: 11027M002
Responsible Institute: Space Research Institute Postal address: Schmidlstrasse 6, A-8042 Graz, Austria		
Contact person: Dr. Peter Pesec Phone: +43 316 412 0711 Fax: +43 316 412 0790 E-mail: peter.pesec@oeaw.ac.at	Approximately coordinates (WGS-84): Latitude: 48° 39' 16.40" Longitude: 15° 35' 54.27" Ellipsoidal height: 457.6m	
EPOCH STATION		
Member of other GPS network: EUREF, EUVN		
Geology: EURASIAN PLATE, Bohemian Massif		
Type of monumentation Pillar on bedrock.	Monumentation picture 	
Site sketch 	Topographic map Scale 1:25000 	
Horizon photography of the point		
		

Figure 12. Site Description of AT01

Site description in new format were done for all accepted sites, but in most of description are missing some data. One of our important task in the future is to complete this catalogue.

The site descriptions can be found at the web page of the CEGRN consortium:
<http://www.fomi.hu/cegrn>

The results of interference measurements can be found in the GNSS Interference Monitoring Database:

http://www.sgo.fomi.hu/56-gnss-interf_eng.html

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