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RESEARCH ON THE USE OF MODERN GEODETIC AND TOPOGRAPHIC METHODS TO ACHIEVE THE SUPPORT NETWORK NEEDED FOR LOCATING AND MONITORING VARIOUS OBJECTIVES IN THE AREA OF UASVM DIDACTIC AND EXPERIMENTAL RESORT FROM COJOCNA, CLUJ COUNTY

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Abstract

According with the theme, the project will include implementation of a geodetic support network using modern geodetic and topographic methods in the Experimental Teaching Resort of UASVM – Cojocna, to locate and monitor various existing and future objectives and analyzing mathematical models used to determine the parameters grid points and positioning precision indices. Also, the network will serve as a geodesic polygon in which students from MTC department will conduct their annual practice. The need for a new geodetic support network in Cojocna Experimental Resort area, with an area of 667.5 hectares, lies in the fact that the point signals from the triangulation network and their terminals, in most of them, were destroyed. Creating the support network through modern methods, targeting global positioning new technologies and advanced instruments that will lead to obtaining high accuracy in point positioning, compared to the old technology and shorten the measurements execution and calculations. In essence, research team aims, after the recognition of the land, to realize location, measurement and processing of functional-stochastic models, to determine the coordinates of the support network points, used delineation and monitoring various objectives of the resort. The project will also include, digital support of the support network, and a comparative study of the accuracy of positioning points obtained by global positioning methods and trilateration method.

***Key words**: GPS network, accuracy, station, RTK*

INTRODUCTION

Creating the network support aims, through modern methods, to use new global positioning technology and powerful, performant tools that will lead to achieving high accuracy in positioning points compared to the old technology and shorten the execution of measurements and calculations, also reducing cost price (Bos et al., 2007).

Global positioning system belongs to the U.S. DOD and its main purpose is locating an object in the air, on water and on land, at any time of day, whatever the weather, initially being used for military purposes.

Basically GPS system is based on three main components or segments, which ensure its functioning (Figure 1). These are:

- Space segment - consisting of the constellation of GPS satellites;
- Control segment - consisting of ground stations that monitor the system;
- User segment – consisting of civil and military users, using GPS receivers equipped with antenna and necessary annexes.

Currently, besides the GPS system, works in parallel GLONASS system, belonging to the Russian Federation. The two systems are similar in terms of design, the functioning and performance given to the users. European Union countries are in the process of implementing a system called Galileo (Neuner, 2000; Nitu, 2008).

Currently, besides the state geodetic network, which is in full process of damage, ANCPI has created a network of permanent stations of

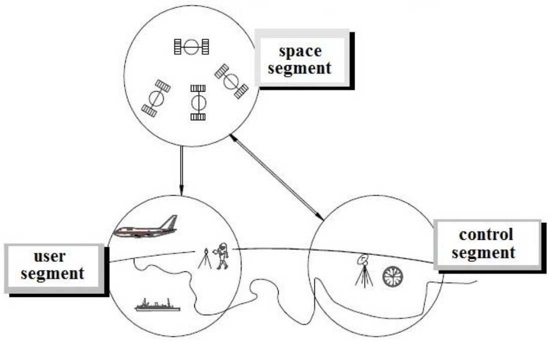

Figure 1. GPS segments

class A, consisting of 69 stations (2012) and are expected to reach a total of 73 stations. To the network will be added marks of class B, C and D.

Permanent stations network was designed to work with the ROMPOS® (Romanian Position Determination System) and is complementary for position determination in European reference system and coordinates, ETRS89 (Figure 2).

ROMPOS® is based on Global Navigation Satellite Systems (GNSS) including GPS, GLONASS and GALILEO. The system was developed to provide users with additional information beyond those received directly from GNSS satellites in order to achieve positioning accuracy in real-time at decimeter or centimeter level (Paunescu et al., 2006).

ROMPOS® includes the following services:

- ROMPOS® DGNSS - for kinematic applications in real-time with positioning accuracy of 3 m and 0.5 m;
- ROMPOS® RTK – for kinematic applications in real-time with positioning accuracy to 2cm;
- ROMPOS® GEO - for post-processing applications and a positioning accuracy of less than 2 cm.

Figure 2. Current national network of reference stations ROMPOS®

MATERIALS AND METHODS

In satellite geodesy, GPS measurements can be performed using static and kinematic methods, with variations related (Veres, 2006).

Static method

The static method is the most used method for achieving geodetic networks, which offers good accuracy. This is used when the GPS receivers are surveying class.

Static method requires the existence of at least two GPS receivers located on two points, materialized in the field. Receivers have common stationary time (same epoch) and receive signal from the same minimum 4 satellites. The distance between the two receivers must be at least 2 meters and maximum distance is related to the visibility of the four common satellites. The longer distance is, the longer the time on site will be. This minimum of 4 satellites is not enough to determine a point with sufficient accuracy. To achieve better efficiency and better accuracy, the number of receivers chosen has to be larger, at which are added permanent stations (****Lecture: Space geodetic technologies).

In the static method, observations are performed with GPS receivers installed in a known point position (fixed) and one or more new points. GPS receivers located at new points remain in the same position during this session and receive signals from the same satellites. Observation time ranges from 30 minutes up to two hours for dual frequency receivers positioned on a base with a length of 15-20 km. Stationary duration may increase if single frequency receivers are used, respectively for different lengths of vector measurements, satellite configuration, weather conditions, etc. The accuracy of determination is high (5mm+1ppm) (Figure 3).

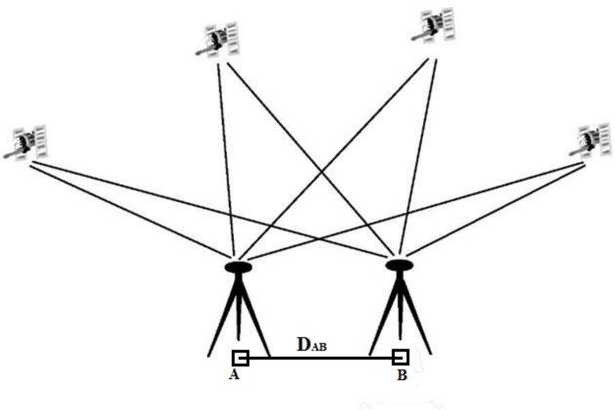

Figure 3. Static measurement method

The main sources of errors that occur on the accuracy of determining the relative coordinates in static mode are: satellite position errors, ionospheric and tropospheric refraction, error of fixing ambiguity, errors of the satellite clock and receivers. Ionosphere and troposphere errors decrease is based on algorithms.

Kinematic measuring method is a method of determining the positions of points in a very short time of observation at each point. It should be noted that at the beginning of the session of measurements, where there are measurements of phase, the ambiguities should be eliminated.

Thus, the receiver base is installed at point A and the rover receiver in point B. After a few minutes the records have been made on the carrier wave phase, we proceed to swap antennas. Without interrupting recording, the receiver is moved from A to B and vice versa. Further, one receiver remains fixed while the others become rovers and move successive in a driveline of new points. The stationary on a new point of detail (eg. traverse) does not exceed 5 seconds. Loss of contact with a satellite of initial configuration or signal interruption involves resetting on initially created base or restoring the receiver on the last point determined, operation that takes about 5 minutes (http://igs.bkg.bund.de/).

RTK GNSS dual-frequency systems (L1/L2 band) can be used both in static measurements and the real-time kinematic measurements.

To determine in real-time, with centimeter accuracy, the coordinates of the points is required that the GNSS RTK GPS devices to receive corrections from permanent stations. This is done either by high frequency radio UHF (Ultra High Frequency) from a permanent basis (as need 2 receivers base and rover) or using GSM modems to connect to the internet and receiving RTK corrections from permanent fixed stations (in Romania - ROMPOS®) (http://www.ancpi.ro/pages/home.php). GSM modules work with GSM web card from local mobile operators.

RTK allows the determination and rapid knowledge of the coordinates of the receiver`s antenna, including the checking of measurements` quality, correlation and distance error correction with data transmission using the methods listed above.

A condition for RTK GPS measurements is that the controller`s software has implemented the algorithm transformation from WGS84 coordinate system to national coordinates system of each country (in Romania - TRANSDAT 4.04 – for transformation and stereographic projection 1970 as national system) (http://www.rompos.ro/).

In the area where the measurements are performed, the GSM signal must be sufficiently strong to connect to the internet. Otherwise, for the RTK GPS measurements will be needed at

least 2 devices (base and rover) and the ability to establish UHF radio connection between them.
For determining the position of points covered by the case study, we used GPS dual frequency RTK Stonex S9 (Figure 4). The equipment consists of S9 GNSS antenna and controller Stonex S3, with the following characteristics (http://www.nbtrade.ro/):
Antenna:

- Accuracy of determination:
  - Static Horizontal: +/-2.5 mm + 1ppm,
  - Static Vertical: +/-5 mm + 1ppm,
  - RTK Horizontal: +/-1 cm + 1ppm,
  - RTK Vertical: +/-2 cm + 1ppm;
- Resistant to dust and water immersion to a depth of 1 m or 100% humidity;
- Resistant to vibration and shock caused by free fall onto concrete from a height of 2 m;
- S9 GNSS receiver has a total of 220 channels, module for GPRS / GSM wireless and internal radio modem;

Controller:

- Equipped with the latest version of software Carlson SurvCE with stereo projection 70 for RTK work;
- TRANSDAT 4.01 implemented;
- Shock: made to withstand a free fall onto concrete from a height of 1.5 m;
- Operating temperature: -20 to +60°C.

Figure 4. GPS RTK Stonex S9 system

RESULTS AND DISCUSSIONS

Instrumental observations related to the topic studied were carried out in the Teaching Resort Cojocna, owned by The University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca.
The topic under study aims to establish a support network required within various didactic works. The support network will also constitute a geodetic-topographic polygon where students from Land Measurements and Cadaster specialization will perform summer practice. This polygon consists of 15 marks, of which 4 are from the national network of order V.
Since this paper is part of a research contract made by the Department of Land and Science Measurements, the case study analysis will refer to the precision and accuracy for 2 of the network`s points.
Precision and accuracy are terms used to describe processes (systems and methods) that estimate or predict probable and true value that a physical size has. As is known, the measurement process provides a measured value we want as close to the true value. Hence, precision is given by the dispersion of measurements from the most probable value of the measured size, and positioning accuracy represents deviation of parameters to be determined from their real value.
With the help of the GNSS Solutions program of Spectra Precision company, there were processed and adjusted points chosen in several sessions, with various lengths of vectors using as reference ROMPOS® permanent stations.
Case 1
The first case shows the process of the points S1 and S2 using as control points the reference stations BAIA, BACA, DEVA (ROMPOS-EUREF) (Figure 5). The results are given in national and international system, and transformations were performed with TRANSDAT 4.04 and noted in Table 1.

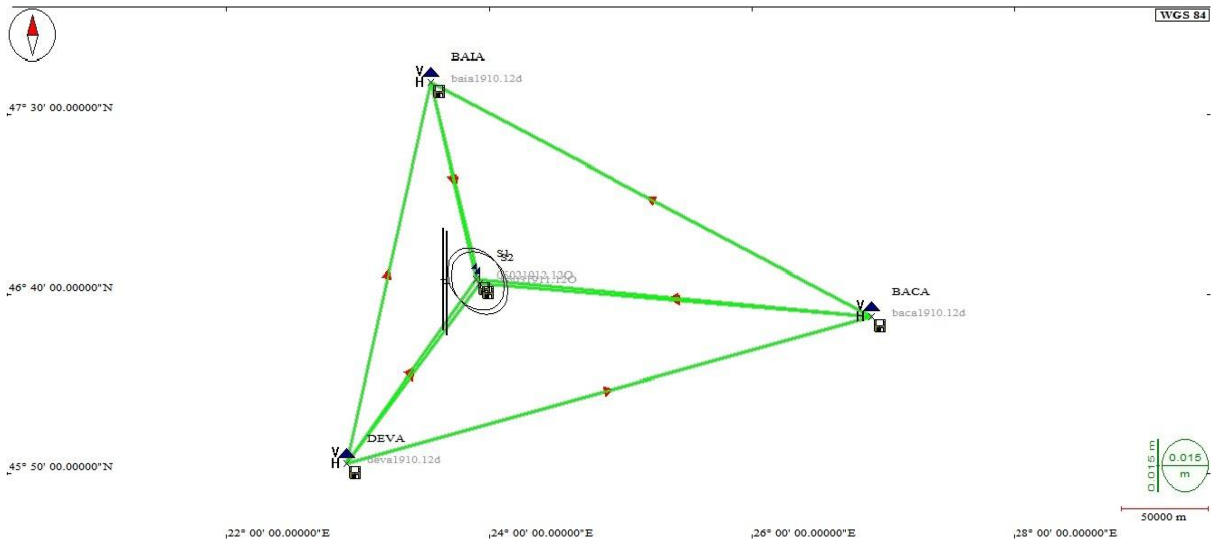

Figure 5. Static with long vector

Table 1. Points coordinates

Nr. Point	X	Y	Z	B	L	H
S1	582571.811	416090.802	435.856	46°44'14.88802"N	23°54'01.02629"E	475.772
S2	580573.778	417907.853	503.025	46°43'10.98817"N	23°55'27.89917"E	543.177
BAIA	684618.168	391774.808	231.482	47°39'06.42446"N	23°33'27.75920"E	271.026
BACA	564260.459	646698.752	185.686	46°33'43.40958"N	26°54'43.95540"E	219.193
DEVA	488639.781	338192.350	203.487	45°52'42.29505"N	22°54'48.71898"E	246.602

In Table 2. are listed the accuracies of the points, vector lengths, time spent on point with GPS, number of satellites and PDOP. These data were extracted from the GPS process report.

Tabel 2. Precision of point determination

Vector	DX	DY	DZ	Length[m]	Time on site	Satellites	PDOP
S1-BAIA	-0.001	-0.008	-0.012	104916.173	3h51'30"	8	1.7
S1-DEVA	-0.084	0.018	-0.017	122052.934		8	1.7
S1-BACA	0.004	0.008	0.012	231376.326		8	1.7
S2-BAIA	0.015	0.004	0.009	107290.087	6h03'40"	9	1.4
S2-DEVA	0.050	-0.003	0.044	121705.227		8	1.6
S2-BACA	0.024	0.029	0.023	229415.680		9	1.4

Case 2

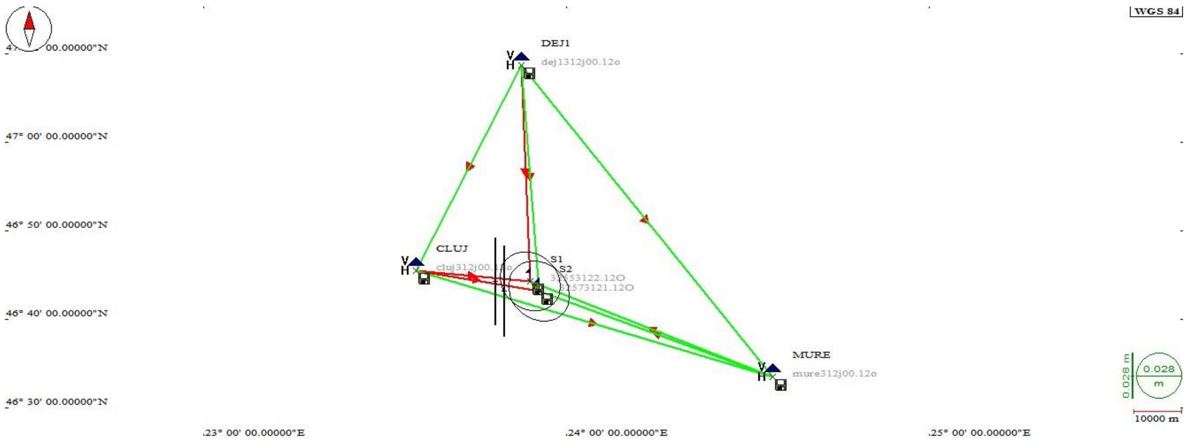

Figure 6. Static with short vectors

Next case shows results of points S1 and S2 using closer permanent stations (CLUJ, MURE, DEJ) so vector length is shorter (Figure 6). The results will be placed in tables 3. and 4. as well as in the previous case.

Table 3. Points coordinates

Nr. Point	X	Y	Z	B	L	H
S1	582571.683	416090.828	435.495	46°44'14.88391"N	23°54'01.02759"E	475.681
S2	580573.676	417907.899	502.990	46°43'10.98491"N	23°55'27.90139"E	543.142
CLUJ	585205.300	392158.497	429.212	46°45'27.86162"N	23°35'11.52347"E	470.098
DEJ	627903.489	414905.941	251.226	47°08'42.36773"N	23°52'34.84282"E	291.042
MURE	562148.827	466893.884	326.491	46°33'29.31123"N	24°33'59.72628"E	365.703

Table 4. Precision of point determination

Vector	DX	DY	DZ	Length [m]	Time on site	Satellites	PDOP
S1-CLUJ	-0.015	-0.009	0.013	24082.204	3h46’10”	11	1.3
S1-MURE	0.033	0.095	0.022	54768.762		8	2.1
S1-DEJ	0.058	-0.036	0.018	45356.206		10	1.4
S2-CLUJ	-0.018	-0.014	0.011	26168.747	3h49’00”	11	1.3
S2-MURE	0.026	0.060	-0.082	52350.776		8	2.1
S2-DEJ	-0.047	-0.031	-0.055	47434.852		10	1.6

Case 3

This case is considered particular and most preferable from the results point of view. It has been chosen only one reference station at the nearest distance to the points S1 and S2 (Figure 7). As well, results were written in the tables 5 and 6.

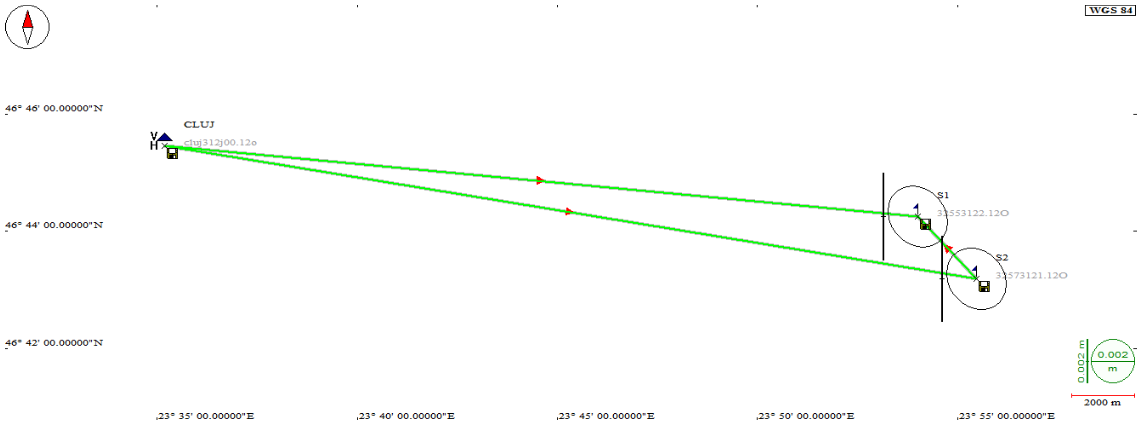

Figure 7. Static with one ref. station and short distance

Table 5. Points coordinates

Nr. Point	X	Y	Z	B	L	H
S1	582571.623	416090.807	435.493	46°44'14.88194"N	23°54'01.02661"E	475.679
S2	580573.614	417907.872	502.985	46°43'10.98287"N	23°55'27.90018"E	543.137
CLUJ	585205.300	392158.497	429.212	46°45'27.86162"N	23°35'11.52347"E	470.098

Table 6. Precision of point determination

Vector	DX	DY	DZ	Length [m]	Time on site	Satellites	PDOP
S1-CLUJ	0.002	0.002	0.002	24082.210	3h46'10"	11	1.3
S2-CLUJ	-0.001	-0.002	-0.001	26168.755	3h49'00"	11	1.3

Additional observations were made on these two points, using RTK method, which are presented in Table 7.

From Romania`s inventory of coordinates were extracted the coordinates of S1 and S2 (noted as 8 and 18) as known marks, listed in Table 8.

Table 7. Points coordinates

	Code	B	L	H	X	Y	Z
S1 RTK	8	46°44'14.8859"	23°54'01.027"	475.758	582571.744	416090.806	435.572
S2 RTK	18	46°43'10.9875"	23°55'27.9"	546.135	580573.756	417907.866	502.983

Table 8. Points coordinates

	Code	B	L	H	X	Y	Z
S1 mark	8	46°44'15.910"	23°54'06.754"	475.03	582571.574	416090.898	435.800
S2 mark	18	46°43'12.014"	23°55'33.617"	543.35	580573.690	417907.772	503.200

CONCLUSIONS

After analyzing the results it was concluded that the computed coordinates of the points, S1 and S2, in case 3 are the most precisely determined points.

In the processing of the points is recommended the use of the nearest permanent stations, to reduce costs and stationary time and so, increase productivity and accuracy in determining the final results.

To note that, although the distance from the points calculated with DEVA is shorter compared to the distance from the points with BACA, accuracy is poor.

More observations and work sessions will be needed to study this issue.

In the future several issues will be studied on this case:

- Performing the same parameters in different working epochs;
- Checking coordinates accuracy obtained with receiver L1-L1/L2;
- Computing the 7 parameters of Helmert's transformation (3 rotations, 3 deviations and 1 scale factor) for the zone of interest;
- Analyzing the accuracy of processed points using different softwares for computing, compensating and adjusting networks.

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