SPATIAL CO-ORDINATES OPTIMIZATION OF CIVIL ENGINEERING AND BUILDING SERVICES FACULTY'S TOPOGRAPHIC NETWORK USING GPS TECHNOLOGY

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Abstract

This paper aims to optimize the spatial coordinates of the locating terminals points of our faculty, initially determined using GPS technology. Additional measurements were performed to one year interval with another GPS receiver. So was obtained a new set of coordinates that was used to obtain a better determination thereof by the average of the two determinations. In order to determine the coordinates of the new points was used GNSS Permanent Stations National Network using RTK method: RTCM (Radio Technical Commission for Maritime Services). Measurements were performed with GPS SOUTH S82T and GPS SOUTH S82V, whose field book has implemented software transcomputation real-time geographic coordinates obtained in STEREO-70 coordinate system. Network of permanent GNSS stations has used fixed station IASI_2.3 and virtual station RO_MAC_3.1_GG. Solutions for new measured points were fixed, the determination's accuracy being ranged from 0.034-0.010 meters. Following these two rounds of measurements of the spatial coordinates of locating points of the faculty network using GPS technology we obtained a set of coordinates that increase their accuracy. But also shows that errors occur are due the type of used receiver and satellite position based on the time of determination, or other types of influences. These errors will be highlighted in this study to show that sometimes it are important and can`t be neglected during training measurements with these modern tools.

Key words: spatial coordinates optimization, locating network, Global Positioning System – GPS

The purpose of this paper is to determine the position of the landmarks from the Faculty of civil Engineering with a medium accuracy using GPS technology. Were made two series of measurements (in two consecutive years) with two different GPS receivers. Were also highlighted the factors that could influence (in a manner more or less important) the determinations final accuracy of the landmarks spatial coordinates.

Setting-up a topographic reference network in order to increase the efficiency of the students classes is a necessity to develop the quality of learning which will substantially contribute to the understanding of the utility of the Surveying discipline which was considered (until recently) less important by all stakeholders in the educational process. Taking into account the signals received from employers which understands the importance of specific knowledge it is considered to be vital the approaching of the studied cases in order to be near the real problems from the sites where the future engineer is often put in difficulty. This it happen because he lacked the responsibility of working with the real values of coordinate's points from different applications and almost impossible to verify the final results with values of existing points.

Also topographic points will be used as benchmarks to in-time monitoring of the buildings behaviour surrounding the Faculty of Civil Engineering and Building Services.

MATERIAL AND METHOD

In order to create a reference network of four points arranged in our Faculty's area (*figure 1*), points that were prepared and then placed with the active participation of the students during practical classes.

The landmarks was cast from reinforced concrete and having a truncated pyramid shape with 0.20 m base, 0.15 m small base length and 0.50 m in height. The supports on the ground were performed by using bolts having 50 cm long attached with epoxy resin.

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Figure 1 **Situation plan with landmarks position**

RESULTS AND DISCUSSIONS

Recognising the potential of the determination techniques using GPS technology in order to achieve a modern and precise reference, were considered useful to determine the spatial coordinates of these points with its.

GPS technology is a technology of high performance and high precision depending on the following requirements in the recognition phase of land (*table 1*).

Table 1

Landscape recognition's exigencies

Satellites visibility from the station points	Obstacles absence Interference source's absence
The reference point's checks	Ground materialization of the points Its stability
Setting-up the logistic devices	Travelling manner Access and travelling time Special equipment (if it is required)

The errors that may occur by using GPS system in order to determine the spatial coordinates of a point are:

1. Number and integrity of orbital satellites (functional);
2. Delays in atmospheric layers and signal reflection;
3. Errors due to receiver clock and orbital errors;
4. The number of visible satellites, their position at a certain time and their selective availability (type of information access - free or secure).

It is relevant that the relief, the buildings, the electronic interference or sometimes even vegetation can block signal reception, causing position errors or even total lack of position. After placing the terminals according to the situation we proceeded to determine the spatial coordinates using GPS system with a device type that has a 0.001 ÷ 0.01 m.

The topic of in-time monitoring of the building's displacements must represent an important goal for all engineering structures especially for those of vital importance. Such monitoring, by topographic methods, can detect on time fissures, subsidence and spatial displacements of engineering structures. It can be ordered the measures to prevent disasters such as breakage or loss of structural stability of dams by the occurrence of uncontrollable events that have not was set at the design stage. Monitoring structural displacements (having high precision measurements) will be performed by cyclic measuring the angular and linear values using topo-geodetic methods and instruments.

In order to determine the coordinates of the new points was used GNSS Permanent Stations National Network using RTK method: RTCM (Radio Technical Commission for Maritime Services).

Measurements were performed with two GPS receivers: SOUTH S82T (*figure 2* left) and SOUTH S82V (*figure 2* right), who's field book has implemented software transcomputation real-time geographic coordinates obtained in STEREO-70 co-ordinate system. The determinations were made in 2013 July (for the first set) and 2014 May.

Figure 2 **GPS SOUTH S82T and S82V system receivers**

From the permanent GNSS stations network were used fixed station IASI_2.3 and virtual station RO_MAC_3.1_GG. Solutions for new measured points were fixed, the determination's accuracy being ranged from 0.034-0.010 meters (see *table 2*).

Table 2

Spatial Coordinates

Land mark No.		Spatial Coordinates [m] Receiver – S82T	Spatial Coordinates [m] Receiver – S82V	Average Coordinates [m]
1	X	631322.925	631322.877	631322.901
	Y	696501.349	696501.341	696501.345
	Z	42.2927	42.352	42.322
2	X	631330.945	631330.949	631330.947
	Y	696470.343	696470.413	696470.378
	Z	42.316	42.357	42.337
3	X	631339.146	631339.102	631339.124
	Y	696436.915	696436.989	696436.952
	Z	43.879	44.046	43.963
4	X	631291.465	631291.417	631291.441
	Y	696407.848	696407.865	696407.857
	Z	43.836	43.827	43.832

While the GPS signal passes the layers of the atmosphere that is affected by a number of errors. These are presented in the *table 3*.

There are a number of ways to minimize such errors. For example we can (through a numerical modelling) to predict the delay which will occur in a typical day, but atmospheric conditions are rarely the same. For this reason these modelling will never be very reliable.

Table 3

GPS's errors

Errors sources	Error range [meters]	Typically error [meters]
Ionosphere	5.0	0.4
Troposphere	0.5	0.2
Ephemerides	2.5	0
Satellites watch deviations	1.5	0
Multipath effect	0.6	0.6
Measurement noise	0.3	0.3
Total	~ 15	~ 10

In addition to these errors, the GPS measurement can be influenced also by the choosing of the service's period for which you must take into account four main factors:

1. base length
2. the number of visible satellites
3. satellite constellation geometry (PDOP)
4. signal / noise ratio for satellite signal (Signal to Noise Ratio – SNR).

Depending on the basis length, the work session's length can be estimated in relation to the desired accuracy according to *table 4*.

Table 4

The work session's length in relation to the base's length

Base length [km]	Work session's length [minutes]
0-1	10-30
1-5	30-60
5-10	60-90
10-15	90-120

Systematic errors that occur during the measurement's process could be underlined by the GPS receivers in the final report by the following parameters (*table 5*):

1. Horizontal dilution of precision - HDOP
2. Vertical dilution of precision – VDOP
3. Tridimensional dilution of precision – PDOP
4. Number of visible satellites – SATS

Table 5

Parameters used to estimate the GPS's accuracy

Land mark No.	GPS Information	Measurement Accuracy Receiver – S82T	Measurement Accuracy Receiver – S82V
1	SATS	10	6
	PDOP	2.916	3.248
	HDOP	1.205	2.167
	VDOP	2.655	2.419
2	SATS	12	7
	PDOP	1.828	2.242
	HDOP	0.998	1.393
	VDOP	1.531	1.757
3	SATS	6	4
	PDOP	8.281	19.106
	HDOP	1.711	7.148
	VDOP	8,103	17.719
4	SATS	8	6
	PDOP	2.999	2.34
	HDOP	1.464	1.433
	VDOP	2.617	1.850

Could be considered (from the *table 5*) that the measurements carried out with Receiver-S82T were more appropriate than those carried out with Receiver-S82V, this is because of several factors that had influenced the determinations.

CONCLUSIONS

In this paper we determined the optimal coordinates of the terminals of landmarks of Faculty of Civil Engineering using GPS technology. The process of with this technology is how fast and also complex due to the multitude of factors that may influence (sometimes significant manner) the accuracy of the determination.

In this context the measurements were influenced firstly by the existence of adjacent buildings which has disrupted the visibility of satellites and by the existence of vegetation (trees) that we had sometimes blocked the signal.

The reference network is optimum territorial distributed; covering much of the area associated with our Faculty and will help to determine the precise coordinates of all points used in the practical applications, ensuring efficiency and usefulness of this discipline and rigorous training of our graduates.

The improving of the quality of teaching and learning can be done by specific means of each discipline. Land Surveying specific to civil engineers could be improved by actions and requirements (specific to the didactic manner) that contribute effectively to the educational process.

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