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GPS PRECISION IN FOREST ENVIRONMENTS

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Abstract: *Topographic measurements performed with GPS technology became frequently used in the recent decades. However, this technology has its limitations when it comes to the obstacles between the receiver and the signal received from the satellite. The errors that different obstacles may produce have different values. A special case is that of the errors we encounter for GPS measurements in the forest environment. The crown of broadleaved trees looks different throughout the year depending on the season. At the same time the measurement accuracy may be different depending on the method used. The present paper aims to determine the accuracy under the crown of broadleaved tree species within and outside the growing season using different measurement methods. The differences obtained by the two methods of static determination and RTK were between 0.4 m and 2 m, respectively, compared to the real coordinates determined by classical methods.*

Key words: *GPS, accuracy, forest, measurements.*

1. Introduction

The use of GPS technology was a revolutionary moment in determining the coordinates of a point. Before that moment the best technique for worldwide positioning were using astronomical technique with their limitation of accuracy while after on the satellite base Global Navigation Satellite System (GNSS) technology has been played as remarkable tool for positioning and mapping with high accuracy can be achieved in the easiest way [1, 2, 6, 10]. Being a relatively easy to use technology, there is a tendency to use it as much as possible, taking advantage of the advantages it offers, mainly in terms of the speed with which the determinations are made. However, this technology also has its limitations, being influenced by the environment and being very sensitive to obstacles that obstruct the visibility to satellites.

The GNSS indeed become a revolution in positioning on the 20th century. Nevertheless, few limitations are still recognized such as the capability of positioning under heavy satellite obstructions (e.g. in dense urban area, and in canopy area like forest), especially for the Real Time Kinematic (RTK) method (Figure 1).Obstruction will disturb the signal connection and produce cycle slip, and un-favor fixing the ambiguity [4, 8]. As

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for the RTK, in many cases it would give autonomous result, float solution, hardy waiting for resolved ambiguity, and or in some cases given the possibility of fixing to the wrong integer. Not to mention if we set up longer baseline, therefore the degradation in accuracy will more significant. This is the new challenge to be solved, since many applications are dealing with situation of positioning under heavy satellite obstruction such as for forest boundary surveys, rural urban parcel measurements, in between high rise building measurements, etc. Theoretically the availability of more satellites, the existence of another phase signal, and or stronger signal may answer the limitation [3].

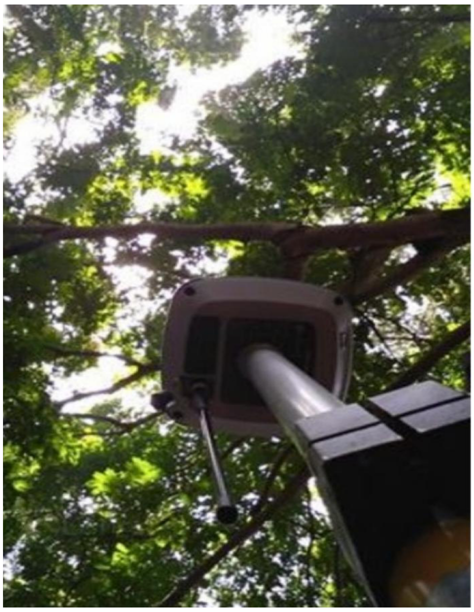

Fig. 1. *Satellites obstructions [3]*

The purpose of this research is to determine the accuracy of determining coordinates using the GPS positioning technique on land covered with forest vegetation and whether this technology can be satisfactory for its use in cadastral works.

2. Study Area

The studied area is at an altitude of approximately 160-170 m and is part of the Cosacu forest body, being at the intersection of compartment6A, 7A and 8C, UP II Bucovat, OS Craiova, Romania (Lat: 44.272586, Lon: 23.730904) where there are mixed oak forest consisting of *Quercus frainett*o [Ten.] and *Quercus cerris* [L.], having an age of approximately 70 years, with a consistency of 0.7, coming from shoots, having a medium productivity (Figure 2).

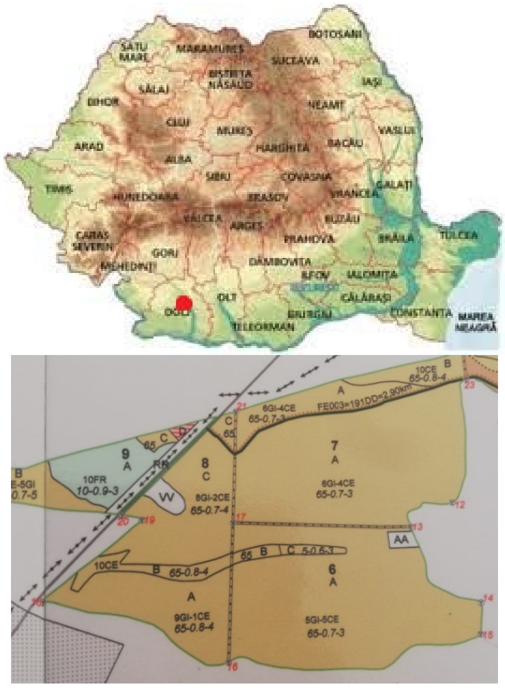

Fig. 2. *Study area*

3. Materials and Methods

This study is the first part of a larger one in several areas with different forest vegetation and landforms. In the study area a number of 3 landmarks located along a forest road in a deciduous forest were determined by 3 different methods.

In order to study the influence of the tree crown on the accuracy of the determinations depending on the degree of obstruction of the visibility to the satellites in different conditions. The determinations were made in winter, when there are no leaves in the crown of the trees as well as in summer when the coverage of the branches with leaves is maximum.

In order to determine the reference coordinates of the three points, they were determined by the classical method that is not influenced by the covering of the sky with obstacles. For this, a Leica TS 02 total station was used with the help of which a traverse supported on points determined with GPS technology was performed, points located at a sufficient distance so that the accuracy is not influenced by the presence of the forest. Thus, the coordinates with which we will compare the results obtained later were determined (Table 1).

Table 1. *The points coordinates*

Point	X(m)	Y(m)	Z(m)
4	308719,619	398743,475	162,965
5	308945,584	398754,694	162,729
6	309095,136	398761,626	162,861

The points (Figure 3) were materialized on a forest road and determinations were made both in winter (without leaves) and in summer (with leaves). The aim was to determine whether in particular RTK technology can be used to pick up details inside the forest such as plot boundaries, forest roads, etc. with satisfactory accuracy for cadastral works.

Fig.3. *GPS on points*

For the determination of each of the three points, a determination was performed by static method with duration of 30 min and two RTK determinations of 20 sec each. The base station from the national ROMPOS system located at a distance of around 7 km was used as a reference station.

a) b)

Fig. 4. *The GNSS technology used in research:*
a) the GNSS receiver Leica 1200+; b) reference station CRA

4. Results and Discussion

GPS receivers determine their distance from each visible satellite by comparing the satellite's clock time with the receiver's clock time. If the signal from a satellite is blocked, the receiver will choose another satellite, leading to a position calculated from a poorer satellite configuration and possibly containing more position error [6]. The accuracy of a GPS position depends on several components, one of which is the geometry of the satellites with respect the receiver [7]. Forest vegetation can block the signal from GPS satellites, causing the receiver to use a less than ideal satellite configuration. After the winter, when are no leaves in the trees, the measurements were processed by using the specialized software of the GPS receiver manufacturer, the following values were obtained (Table 2).

In summer, when the trees have a crown full of leaves were obtained the values presented in Table 3.

For a better visualization of the results they were represented graphically (Figures 4 to 6).

Using the static method and with a relatively long stationary time on the point, acceptable results were obtained only in winter when there are no leaves in the trees, but the method is not efficient and is time consuming. The static method could be used in winter in forests with species that lose their leaves but with great caution and only for determining fixed points with double checking on at least two reference stations. In this case a minimum four points must be determined and can possibly be used as fix points for a closed traverse.

Table 2

Values obtained for the measurements made after winter

Method	Coordinates			Differences (m)		
	X (m)	Y(m)	Z(m)	Δx	Δy	Δz
Point 4						
reference	308719,619	398743,475	162,965			
rtk1	308717,612	398741,135	166,560	2,01	2,34	-3,60
rtk2	308721,295	398743,215	162,308	-1,68	0,26	0,66
static	308719,792	398743,512	162,930	-0,17	-0,04	0,03
Point 5						
reference	308945,584	398754,694	162,729			
rtk1	308945,239	398756,787	167,620	0,34	-2,09	-4,89
rtk2	308945,264	398756,930	166,615	0,32	-2,24	-3,89
static	308945,670	398754,714	162,696	-0,09	-0,02	0,03
Point 6						
reference	309095,136	398761,626	162,861			
rtk1	309096,040	398762,215	167,690	-0,90	-0,59	-4,83
rtk2	309095,286	398762,130	163,800	-0,15	-0,50	-0,94
static	309095,215	398761,686	162,800	-0,08	-0,06	0,06

Table 3

Values obtained for the measurements made in summer

Method	Coordinates			Differences (m)		
	X (m)	Y(m)	Z(m)	Δx	Δy	Δz
Point 4						
reference	308719,619	398743,475	162,965			
rtk1	308720,299	398743,487	163,770	-0,680	-0,012	-0,805
rtk2	308723,360	398742,768	166,251	-3,741	0,707	-3,286
static	308719,939	398743,833	163,869	-0,320	-0,358	-0,904
Point 5						
reference	308945,584	398754,694	162,729			
rtk1	308946,255	398755,111	163,550	-0,671	-0,417	-0,821
rtk2	308946,952	398755,550	164,700	-1,368	-0,856	-1,971
static	308945,961	398754,966	163,712	-0,377	-0,272	-0,983
Point 6						
reference	309095,136	398761,626	162,861			
rtk1	309093,831	398760,910	164,352	1,305	0,716	-1,491
rtk2	309092,372	398761,513	162,929	2,764	0,113	-0,068
static	309095,556	398761,952	163,961	-0,420	-0,326	-1,100

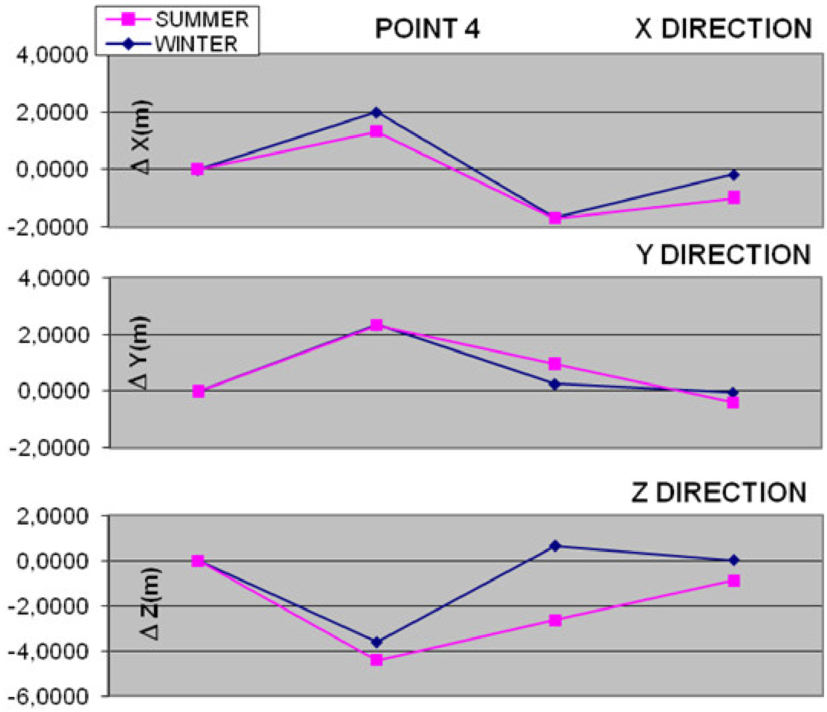

Fig. 5. *Differences obtained for point 4*

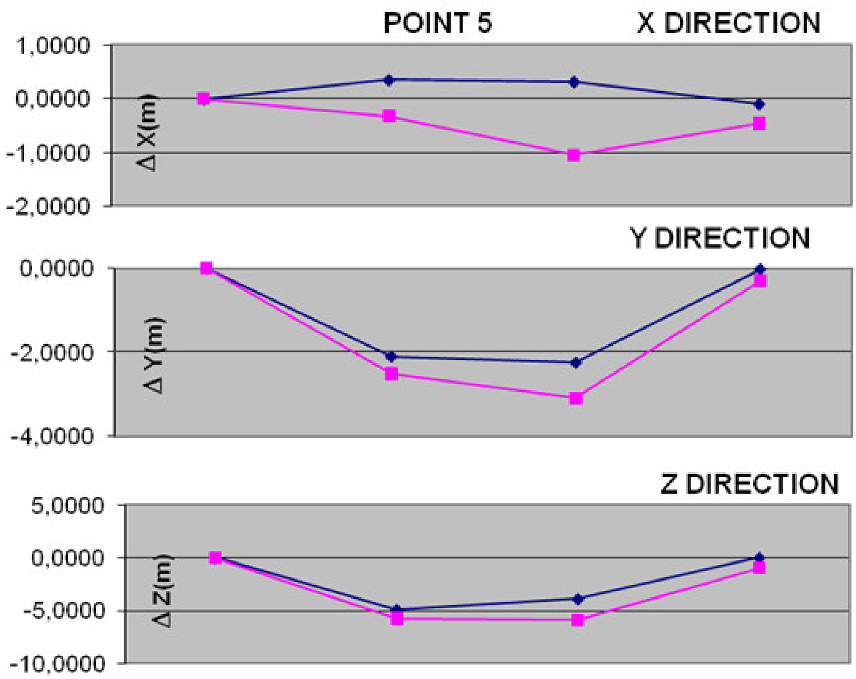

Fig. 6. *Differences obtained for point 5*

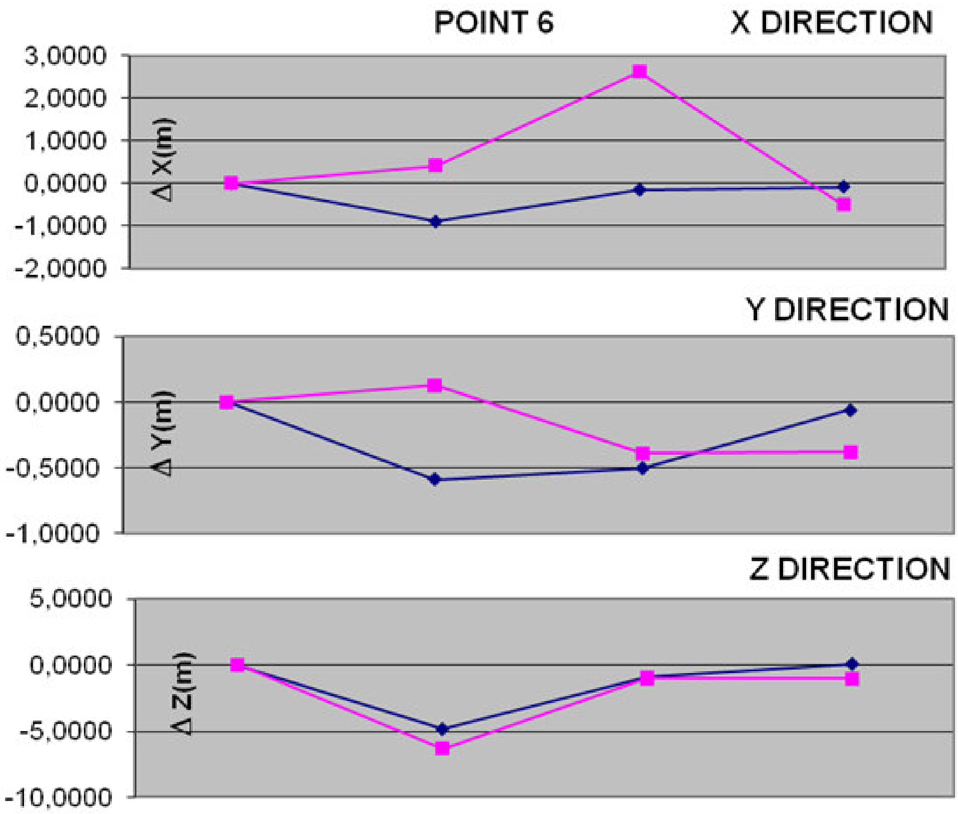

Fig. 7. *Differences obtained for point 6*

Similar future analysis might instead use values calculated of tolerable error as a threshold for optimum identification, as an alternative methodology that may provide results focused on the objectives of each survey. Some authors have calculated such admissible errors, which might depend on the forest variables themselves [9] or the remote sensing technique [5].

5. Conclusions

The differences obtained by the two methods of static determination and RTK were around 0.4 m and 2 m respectively compared to the real coordinates determined by classical methods.

The precision of determining the coordinates of a point in the forest using GPS RTK technology is not sufficient and does not fall within the tolerances provided by the cadastral legislation for determining the boundaries of the plots.

The static method does not provide the necessary accuracy for determining fix points even with long-term stationary time in summer when are leaves in the tree.

The absence of leaves did not significantly influence the accuracy obtained using RTK method, and we can conclude that the main obstacle that negatively influences the measurements is the branches themselves. Depending on location of branches, the arrangements (the form of crown, the density of branches), the thickness of branches depends on tree species from the study area another results from different type of forest trees, can be different.

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