USING GNSS TECHNOLOGY IN GENERAL CADASTRE

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Abstract. *Topographic plans and maps as a basis of cadastral documents for both mining areas and country area start from geodesic support network used to achieve any topo-cadastral survey. Developing and optimising support networks are the starting point in solving topographic and general and specialised cadastral issues. Linking national geodesic network and local geodesic networks to achieve general and specialised cadastre is of main importance in current and perspective topographic and geodesic cadastre. Achieving optimal, high-precision networks with minimal errors is of importance in the qualitative field of topography and cadastre issues. This paper also deals with issues related to geodesic networks achievement, with measure overtaking and processing methods using modern techniques and technologies of measurement and processing.*

Keywords: *geodesic networks, GPS, receptor, static, GNSS, measurement planning*

INTRODUCTION

A GNSS receiver measures the time necessary for a signal to propagate from satellite to receiver. Distance measurements made by the receiver are affected by the clock error of the satellite and receiver; this is why they call them pseudo-distances (Dima, 2005).

Using synchronised clocks and in the absence of other perturbing influences and measuring a single distance to the satellite one can determine the receiver's position somewhere on a sphere focused on the satellite with a ray equal to the distance measured. Making simultaneous measurements to the two satellites, the receiver's position will be a circle representing the intersection place of the two spheres focused on the satellites. Making a third simultaneous distance measurement, one gets a third sphere intersecting the other two in only two points. One of these points can be removed right away as the receiver's position because it is somewhere far in space.

As a principle, simultaneous distance measurements to three satellites ensure enough information to determine a fixed position in three dimensions.

If we admit the existence of receiver clock error Δt and considering that the receiver's clock is not synchronised with the satellite's clock in GPS time, then it is mathematically impossible to determine in a unique way the values of the 4 parameters (x, y, z, Δt) relying on only three measurements. This means that we need to measure simultaneously an additional pseudo-distance to a fourth satellite assuming that the clock error was removed.

MATERIAL AND METHOD

Once defined the position of the points in the national geodesic network to be stationed with GNSS receivers based on the existing topographic map (scale 1:50000) we proceeded to recognising in the field their existence and state to check the possibility of stationing on the project points and to define the ones to become station points.

This is how we recognised the points in the national geodesic network below (Table 1).

Table 1.

Points in the national geodesic network at Sinersig, Timis County, Romania

NR.CRT.	NUME	ORDIN	TIP
1	VADUL OHABEI	III	SEMNAL
2	CAPAT	III	SEMNAL
3	BOLDUR BAZA VEST	II	SEMNAL
4	OBIANDA	IV	SEMNAL
5	GRUNI	II	SEMNAL
6	SILHA	IV	SEMNAL
7	GHIMON	IV	SEMNAL
8	DEALUL MARCONILOR	III	SEMNAL
9	HONORICI SUD	IV	SEMNAL
10	DEALUL CULMEA	II	SEMNAL
11	DEALUL CORNETULUI	IV	SEMNAL
12	OGASEL	IV	SEMNAL
13	INTRE HOTARE	IV	SEMNAL

Of all these points, only 5 points had good landmarks; the others had no landmarks at all or they were damaged (Figure 1)

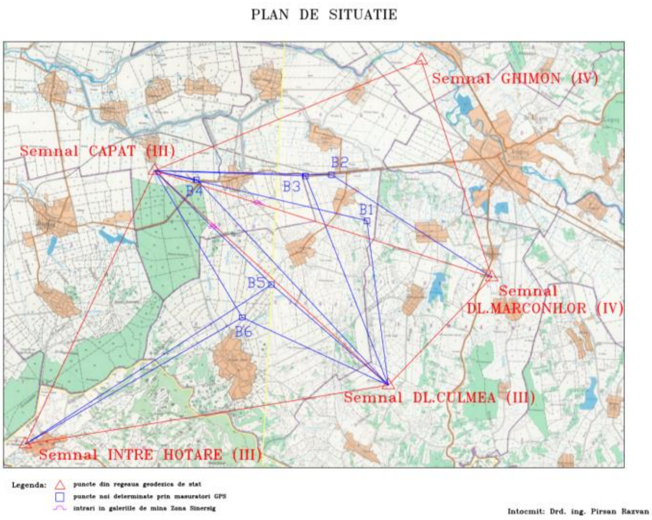

Figure 1. Plan of geodesic network points

Due to proper recognition in the field of both points of national geodesic network and of points in the thickening network, the scheme of the network was defined. What we need now is to plan in detail the GPS measurements to be made in the field in each point (Figures 2 and 3).

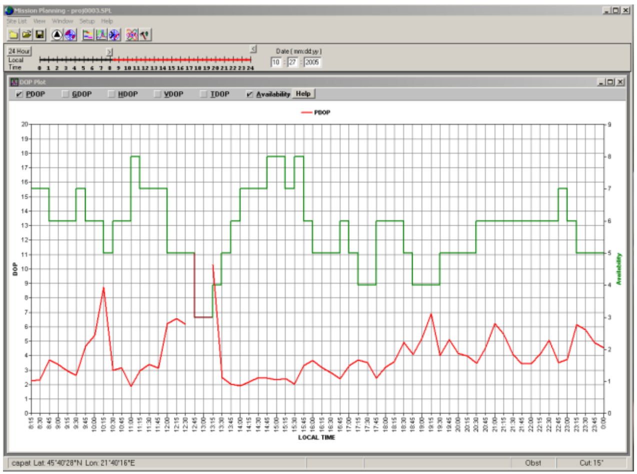

Figure 2. Planning GPS measurement sessions

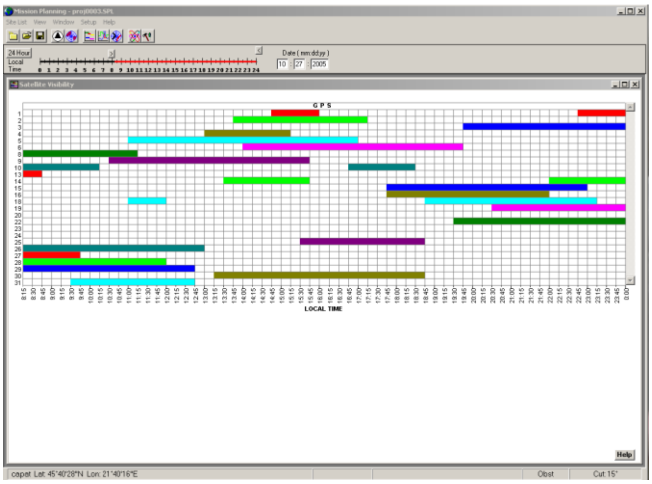

Figure 3. Satellite visibility during measurement sessions

RESULTS AND DISCUSSIONS

Measurements were made in the field with 4 GNSS receivers and using the static method. We observed the planning of measurement sessions and the time necessary to reach the points in the national network.

We made 2 GNSS measurement sessions in the field because of the unfavourable weather conditions during the following days.

Before starting field measurements (DIMA *ET AL*., 2005), we controlled with accuracy the list of necessary equipment and materials. We made a checklist for the moment the teams were to leave to avoid unpleasant surprises and time loss.

A checklist could contain receivers, antenna, antenna cable, receiver battery cable, reserve battery or adapter for car loading, tripod, flashlight (for night), rolling meter, available information about the points to be determined (descriptions, etc.), paper and pencils (route map), mobile phones, programme of observations, phone numbers of all the people involved including the project manager, map, etc.

We achieved the thickening map by stationing on the points of the national geodesic network and on the survey network. The time of session starting was 10:00 a.m. and the time for ending it was 13:00. The time for stationing on each point in the survey network was 45 minutes (the bases between fixed and mobile points were maximum 10 km).

During the phase of measurements, we edited session charts in which we indicated the following parameters:

- Name of the station;
- Apparatus height;
- Measurement starting time;
- Measurement ending time;
- Existing satellites;
- Pdop value.

During GNSS measurement sessions, we kept in touch with the project manager to avoid possible surprises.

At the end of GNSS measurement sessions, we downloaded the data on a PC to free receiver memory so that we can use them the next day. A conclusion of this GNSS measurement campaign is that we obtained good planimetric precisions on the network survey points because we observed all requirements for the achievement of a GNSS measurement network.

We made sure that the new points in the main network and of the survey network included in the national geodesic network existing in the area observe favourability criteria for GNSS network measurements.

Control measurements rely on the logic of network compensation (the so-called minimum constraint solution) (DIMA *ET AL.*, 1999). Only after the solution was checked can precision estimation start (Figures 4 and 5).

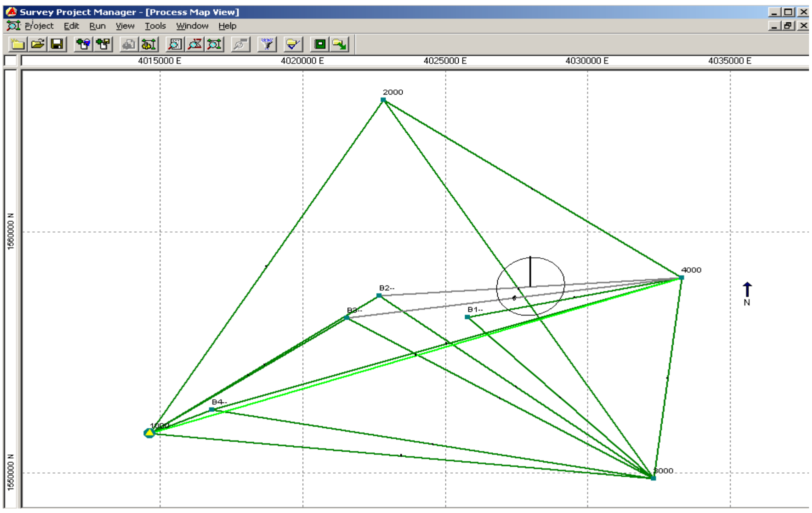

Figure 4. Sketch of main network with links to the national geodesic network during processing

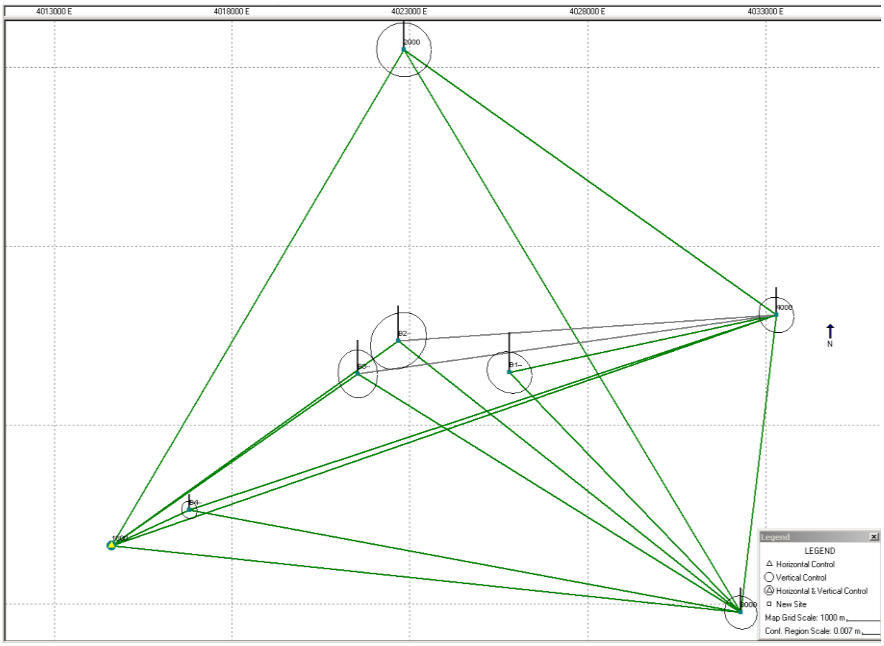

Figure 5. Sketch of the main network with links to national geodesic network points after compensation

We can achieve the following statistics regarding the compensation of this free network:

- Number of vectors: 19;
- Number of compensated points: 8;
- Precision: one sigma: 1;
- Standard deviation: 0.800 mm;
- Number of iterations: 1.

The bases rejected by the statistics test are marked. The network position and orientation were established without constraints from control points. We can see in Table 5 that that error ellipses in both old and new points suggest that measurements were properly made. We can see from the network processing and compensation reports that it was not detected as having an unfavourable position in the WGS'86 positioning system.

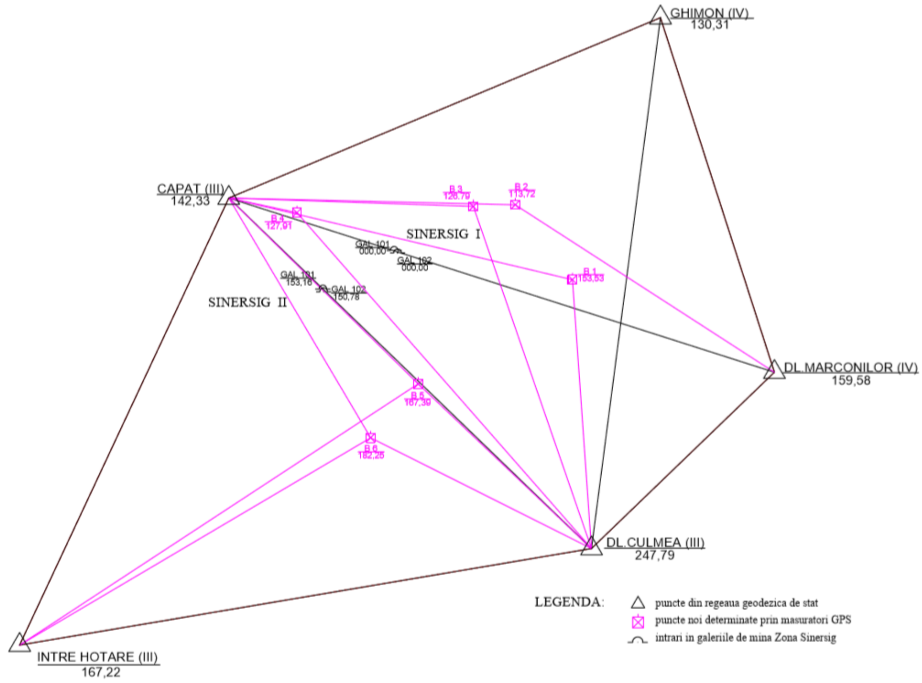

Figure 6. Triangulation network with thickening points, Sinersig area

CONCLUSIONS

To have a precision of +/- 5cm means to range the thickening network made through GPS measurements within order 1st or 4th points in the national geodesic network to ensure observance of this condition. In this case, it was not possible because points of order 1st and 2nd were at a large distance – 15 km, the maximum distance at which one can use receivers L1 to measure with high precision.

Name	Order	Type
CAPAT	III	SIGNAL
GHIMON	IV	SIGNAL
DEALUL MARCONILOR	III	SIGNAL
DEALUL CULMEA	II	SIGNAL
INTRE HOTARE	IV	SIGNAL

The table below shows that, due to the use of several points of different orders within the national geodesic network whose quotas are not part of the national network of precision levelling we got a precision of the thickening network of 8 cm.

Name	X	Y	z

CAPAT	469232.73 469232.729	240717.59 240717.589	142.333 142.333
GHIMON	474966.21 474966.214	254471.41 254471.440	-
DEALUL MARCONILOR	463693.31 463693.308	258103.02 258103.020	159.584 159.584
DEALUL CULMEA	458085.40 458085.483	252273.74 252773.753	247.798 233.133
INTRE HOTARE	455012.78 455012.778	234054.66 234054.660	167.226 167.226

In the future, to have a precision of +/-5 cm of the network to achieve a mining cadastre we need to thicken the networks by GPS measurements in a single measurement session and that the points stationed in the national geodesic network to be part of the network of the 1st or 4th order, and their quotas to be part of the precision levelling network.

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