

# COMPARATIVE STUDY ON THE USE OF GNSS TECHNOLOGY AND TOTAL STATIONS IN THE GENERAL CADASTRE WORKS IN ROMANIA

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## **Abstract:**

*It presents the use of GNSS technology and total stations in the general cadastre works in Romania and a comparative study between the two methods of measurement, and their use together.*

*When using total stations and other " classical " measurement methods, it is imperative to reduce projection distance before compensating for the measurements and then determining the coordinates.*

*The widespread use in Romania of measurement methods using GNSS technology and the RTK measurement method, especially the latter for detail points, is beneficial because distance reduction is no longer necessary and generally there are no problems as before when distances are measured with total stations if it is not reduced to the projection plan.*

*Finally, conclusions are drawn from the use of GNSS technology and total stations separately and together in cadastral elevations for the general cadastre.*

*Conclusions on the methods of measurement and the study compared to the two methods of measurement are auspicious and should be learned by those working for the implementation of the general cadastre in Romania.*

## INTRODUCTION

A comparative study on measurements using GNSS technology and total stations in the outskirts of Oncesti Commune, Maramureș County, is presented. The measurement method using GNSS technology is RTK, and with total stations, the classic methods: routing and point surveying. The case study is chosen outside the Onesti Commune, Maramureș County. General cadastre works (systematic cadastre) are performed with the help of new GNSS technologies and total stations, here a comparative study and the conclusions to be drawn from this article.

## WORK METOHDS

For the GPS measurements, the following operations were carried out: planning and design of kinematic measurements, making kinematic measurements, processing of kinematic measurements.

In the case of kinematic measurements, some of the principles of static measurements also apply. The fundamental condition to be observed for kinematic measurements is the permanent reception of the signals emitted by at least four satellites (currently received during both stationary and time intervals from one station to another).

Designing cinematic measurements was done in the office on the basis of gender planning programs, but it was found that a very detailed recognition should be made on the ground without which it was not possible to make real-time cinematic measurements, in a stylish, professional, efficient and timely manner.

Measurement planning was done at the office after careful land and satellite reconnaissance, GNSS real-time positioning equipment and post-processing GNSS positioning.

The measurements were completed in the out of town for the introduction of the general cadastre (systematic cadastre).

For measurements in the out of town of Oncești commune, Maramureș County, measurements were made during the autumn.

-The observation plan for each location was projected at the office based on the information gathered during the land recognition phase and taking into account that 2 GNSS receivers are available to perform the measurements:

- a first design criterion was to cover the required area of interest and to choose the common points for connecting to the reference systems.

-a second criterion was the efficiency during the measurements, in particular optimization of the time between points and between observation sessions.

-a third criterion was staying in at least two independent sessions of each benchmark and establishing at least two links to adjacent points to achieve the required precision and confidence parameters.

The observation plan was compiled on the computer through Ashley's MULTI SITE MISSION PLANNING program. A project called "ONCEȘTI.PRJ" was created that included all the points selected for GPS observations.

The basis of the observation program was:

➤ geographic coordinates and approximate altitudes of points, extracted from map sheets 1:25 000 (or already known);

➤ Recognition sheets prepared during the land recognition operation for the points which ensured for the entire horizon an open window above the elevation of 15 °.

Planning has been done for the present example for three receivers so that the following conditions are met:

➤ at least 6-9 satellites received at the same time by the three receivers;

➤ The PDOP value, as a measure of expected accuracy and imposed by the satellite constellation geometry, is below 5;

➤ Minimum observation time between 10-20 seconds and up to 1 minute;

In the Oncești commune in Maramureș County, kinematic measurement method was used to determine the coordinates of the detailed cadastral points, the coordinates were determined in real time, using two HITARGHET type GNSS receivers. These receivers or used for real-time measurement, the transcalc coefficients in the WGS-84 system were introduced in the Stereo 70 system so that the coordinates were determined directly in the field in the national projection Stereo 70 (TransDAT Program).

This was possible by using a type controller that is very convenient and easy to handle.

During the measurements, it was intended to receive at least five satellites, as the interruption of signals from a satellite can occur and thus the reception of at least 4 satellites is sufficient to determine the coordinates. Even if during a measurement session the constellation changes, the measurements will not be compromised. It is not necessary to receive signals from the same satellites from the beginning and until the end of the measurements.

For cinematic measurements, it is very important to choose the correct path to ensure that the signals are received permanently. At any time and at any point of the route, at least four satellites must be visible. This assumed that before the measurements begin, the proposed route will be traced and identified the obstacles that could prevent the reception of satellite signals in good condition.

During the fieldwork, various situations have been encountered for solving different solutions, namely:

➤ For the points on the boundaries of the sectors or property bodies (in the areas of coverage), or high "eccentric" auxiliary points on the line from which the distance to the point to be raised was measured with the roulette.

➤ For permanent constructions, the antenna is also placed in "auxiliary points" (eccentric), on the façade line (in extension), each time measuring the roulette distance to the points of the building.

➤ The buildings with stairs were taken from their corners and a corner of the building (directly or as an auxiliary point).

➤ For lifting the cadastral details of the property, there were raised points belonging to permanent elements, accessible by the type of the manholes, the corners of concrete fences etc., which can then be used to lift the other details by intersections of distances.

In order to make comparisons, the selected areas were also raised with the total stations using the known classical methods.

Throughout the measurements, much attention has been paid to:

➤ pressing the ROVE key before the antenna moves to another point;

➤ Handling the antenna in such a way as to avoid losing signals from the satellites at any of these times;

➤ placing hands under the flat surface of the antennas during their handling.

#### RTK method.

The real-time kinematic measurement method (RTK) was used for detailed cadastral elevations in the outskirts of Oncesti Commune, Maramureș County.

And in these cases, the observation plan was projected at the office using elements and respecting the same known criteria and conditions.

At the end of the daily observation session, recorded data is downloaded from the internal memory of the GPS receiver to a computer and DVDs. Downloading data is through a program included in the GPS software.

For land recognition, 1: 25,000 scale maps were used to identify triangulation points in the area.

The processing of GPS measurements has been made taking into account the known formulas. At the end of the daily observation session, the recorded data was downloaded from the internal memory of the GPS receiver to a computer and floppy disks. Downloading data is through a program included in the GPS software.

From the point of view of precision, the results are presented in the tables and from a careful visualization it can be seen that the accuracy of the measurements using the GNSS technology is superior to the one made with the total stations, with the accuracy of the GNSS technology being uniform.

In the tables are presented the coordinates in the Stereo 70 projection system, determined by classical RTG, with the corresponding values and the comparative study tables for: Oncești out-of-town, Maramureș County.

## **RESULTS AND DISCUSSIONS**

To carry out a comparative study, the areas of Oncesti commune, Maramureș County, were also raised with the total stations.

On the outskirts of Oncesti commune, Maramureș County, the operations were as follows:

The points on the characteristic details have been identified and raised, first the landings defined by the characteristic elements, namely: exploitation roads, irrigation

channels, fences, etc., were identified, and then the parcels included in the land plots were identified according to the parcel plan; and also measured.

In the out of town, the landings are identified and measured beforehand, and then the parcels that compose it are identified and measured. The surface of the landing must be the same as the sum of the plots of the parcels that make up it.

Dredging points were determined and the cadastral lifting points were radiated from them. The number of stations was 54, which was influenced by the concrete conditions on the ground, the lack of visibility between the stations, as well as between the stations and the points of cadastral lifting.

The area measured was about 650 ha and was composed of 12 land plots, which were cultivated with corn, alfalfa and fruit trees.

The time required for cadastral lifting with the total station amounted to 2,1 days, time for a team of three people.

In Oncesti commune, Maramureș County, the measurements using the total stations were carried out by a team of three people using a total Sokia station, two canes with 2 reflectors, a Suzuki land car.

It should also be mentioned here that the methodology for collecting the details, for the purpose of drawing up the cadastral plan, requires the drawing up of sketches and the attribution of codes characteristic of the types of details.

To compare the time required for lifting by each method, the relationship was used:

$$T = T_1 + T_2 + T_3, \text{ where}$$

T1 - it is the cumulative time at the office to carry out the lifting project as roughly 60 minutes for each method;

T3 - it is the time to process the measured data that is estimated at 0 minutes for GNSS elevations, because it is determined in real time and about one day for the total stations.

T2 - is the time required to raise the approximate detail points with the relation:

For the GNSS kinematic method:

$$T_2 = \frac{2(t_1 + t_2 + t_5)}{n} + \frac{t_{3(i)}}{m} + t_{4(i)}$$

5 -10 min. - selecting the location of the reference station (if the station is the value of the station is several tens of seconds);

10-15 min. - initialization of the reference station and the communication system (if the station is the value is several tens of seconds);

5 sec. - 1 min. - measuring in detail;

1 min. - processing detail point observations (zero for being instantly determined);

10 min. - tightening the reference station (if it is a parking station the value is several tens of seconds);

n = the total number of points of detail; m = number of mobile handsets;

For the GNSS method, the time is 10-30 seconds for a point of detail and for the whole area we have: 10-30 seconds min x no. points:

For the case of cadastral measurements on the outskirts of Oncesti locality in Maramureș County we have: 30 seconds x 1441 points = 43230 seconds / 3600 □ 12 hours □ 1/2 days

For lifting stations with total station results:

$$T_2 = \frac{2(t_1 + t_2 + t_5)}{n} + \frac{t_{3(i)}}{m} + t_{4(i)} - \text{Performing observations for a point of detail in}$$

which:

10-30 min. - recognition of the land and the point;

10-20 min. - Staging at the station station including installation of the instrument;

- 1 min. - aiming and measuring to the point of detail;
- 1 min. - processing comments for the point of detail;
- 10 min. - tightening the instrument and moving it to another station;
- n = the total number of points of detail; m = number of reflectors;

For the case of cadastral measurements on the outskirts of Oncești locality in Maramureș County we have:

$2 \text{ min} \times 1441 \text{ points} + [(t_1 + t_2) + t_5] = 176520 \text{ seconds} / 3600 \square 49 \text{ hours} \square 2,1 \text{ days}$

From the above, the following conclusions can be drawn:

➤ Its value is lower for metric measurements kinematic GPS, but this value is calculated if the measured points are determined from a station. This was done by the GNSS technology by the real-time kinematic method (RTK), and the time required to determine the 1441 points in the Oncești locality outside of Maramureș County was half a day for a team of three people.

At the measurements in Onesti commune in Maramureș County, over 650 ha of the total area of the commune were measured. Percentage of the surface is presented in annexes.

Measurements in the out-of-town area, in this case Oncesti commune in Maramureș County, using GNSS technology, were performed 100% in terms of cadastral details in the concrete conditions in the field. The cadastral details of the out of town were totally lifted because the field conditions were better than in the city, with no obstructions to the satellite signals.

In our case, the receivers used were two-wave geodetic class, resulting in much greater efficiency in cadastral elevations. Simple frequency receivers can also be used, but they have more stringent limitations than L1, L2.

The measurement process can be improved by using GNSS receivers that are also receiving the NAVSTAR-GPS satellites and GLONASS or satellite satellites of the GALILEO European system at least between 9-16 visible satellites, which is very good for cadastral measurements, here it takes at least 5 satellites.

Table 1 Comparative study common coordinate Oncești from Maramures – Outside

Detail Point	Determined with total stations		Determined GPS		Differences coordinates	
	X(m)	Y(m)	X(m)	Y(m)	$\Delta x$ (m)	$\Delta y$ (m)
1	707330.7157	423047.8679	707330.7165	423047.8690	-0.008	-0.011
2	707328.7656	423046.2479	707328.7677	423046.2468	-0.021	0.009
3	707326.7455	423044.1533	707326.7467	423044.1543	-0.012	-0.010
4	707323.9295	423058.3942	707323.9279	423058.3929	0.016	0.013
5	707321.9433	423056.8471	707321.9420	423056.8480	0.013	-0.009
6	707319.5747	423054.1839	707319.5719	423054.1864	0.028	-0.025
7	707316.7943	423068.0220	707316.7930	423068.0235	0.013	-0.015
8	707314.7848	423066.4369	707314.7857	423066.4352	-0.009	0.017

9	707310.9360	423063.3232	707310.9374	423063.3247	-0.014	-0.015
10	707303.8487	423089.8111	707303.8469	423089.8133	0.018	-0.022
11	707301.3899	423088.0592	707301.3877	423088.0572	-0.021	0.022
12	707295.8124	423082.2670	707295.8142	423082.2695	-0.018	-0.025
13	707274.6159	423063.3478	707274.6139	423063.3494	0.020	-0.016

## CONCLUSIONS

Following the results of the case study, the following conclusions and recommendations can be made:

- The most accurate GPS methods in terms of accuracy and speed for building cadastral details are Real Time Cinema Method (RTK).
- The use of the network of permanent stations (which take the role of fixed stations), bring great advantages in increasing the accuracy of lifting, reducing the cost price, the labor force and the working time in the field.
- It is recommended to use at least two mobile receivers for very high field efficiency.
- In order to increase the accuracy of high point determination, it is recommended to determine two vectors from each point of detail, preferably by scanning the points with a mobile handset at one end of the area, and with the second mobile handset at the other end of the area, each point is staked twice to obtain independent vectors and eliminating any errors associated with the mobile handset.
- all kinematic measurements must be initialized in time during their performance. There are several possibilities for initialization: By permuting the antennas, by measuring a known base, the OTF (On The Fly) process, the latter being used for the RTK measurement method.
- It is also recommended to reset the mobile handsets at the end of the kinematic measurements in order to have a safety, if initialization from the beginning is not OK.
- The use of GPS's combined with total stations does not have restrictions of use regardless of the type of area, and the yield increases both in terms of precision and cost.
- The comparative study on the use of GPS and total stations in cadastral elevations recommends GPS methods both in terms of precision and efficiency, with a ratio of about 4/1 in favor of them.
- The use of GNSS technology in cadastral elevations using NAVSTAR-GPS satellites and GLONASS or GALILEO satellites, as the number of visible satellites in a station would increase to 9-20, increasing safety, precision and lift performance.

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