The Kinematics Measurements " Stop and Go " Used in Cadastre Elevations from Localities

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Abstract*: Se prezintă efectuarea măsurătorilor prin tehnologia GPS, metoda de măsurare cinematică stop and go în localităţi, pentru efectuarea măsurătorilor cadastrale. Se prezintă metoda de măsurare stop and go teoretic şi un studiu de caz practic în intravilan, în oraşul Fieni. Datele sunt comparate cu măsurătorile efectuate cu ajutorul staţiilor totale. În final se prezintă concluziile ce se desprind din prezenta lucrare.*

1. " Stop and Go " Kinematics Measurements Method

Similar to the RAPID – STATIC method, the difference is that the RP generates a summary for each measured point(data is gathered in a time from 30-50 seconds till 2 minutes) and , instead of P code of modulation of L1 and L2 carriers used in RAPID-STATIC case , it uses only L1 carriers which is modulated with the code C/A

The number of Receptors Necessary for the Kinematics Measurements. The Kinematics Measurements can be accomplished if we use two receptors: one used as base station (fixed) and the other as ' rover' (mobile). But their efficiency can be increased if a number no matter how big of mobile receptors is introduced in the measurements and also if the additional base stations are used.

The essential advantages drawn from the additional base stations utilization are:

- It contributes to the outrun of the problems regarding the length of action radius around
- The base station.
- The measurements can be done on a larger field (territory)
- It offers protection to the measurements in the case that the contact with the satellites is lost for the base station.
- It permits gathering of supplementary information which can be used to the measurements result verification

The Satellites Disponibity (Availability)

In order to achieve a kinematics measurement data gathered simultaneously from 4 satellites are necessary. The receptors have a parameter, which indicates the number of connected satellites during the measurement operation.

This can be set-up in the way that it allows the using of more satellites than necessary.

Practically, the achievement of a kinematics measurement takes place when at least 5 satellites are available at moment (so it`s recommended).

Using a larger number of satellites than necessary protects a non satisfactory configuration of satellites on orbits (PDOP-high) and offers the safety that: when a satellite is no more positioned in the covering area of the receptor then the measurement can continue gathering data from the other four satellites.

A point I.D. Identification (of reference or STOP and GO measured)

Each reference point or determined point by stop-and-go method must be recognized by an unique identifier (ID). This is not valid for continue kinematics measurements which are specially stationed.

This way any point in a measurement must be uniquely identified on the base of its IS: the ID is composed of eight characters and eliminates the problem which can appear as a result of mistaking points.

The most recommended way of solving this problem is that of giving an ID to each

Point since the moment of measurement planning. In the situations when the points are chosen in the very moment of measurement achievement, the operator must understand very well the importance of this fact and the ID of the point, ID which is introduced in receptor must be clearly written down in the field notebook.

If the mobile receptor is equipped with a “ measurement controller ” then besides the point ID can be easily introduced other comments.

2. The Equipment and Software Necessary for Kinematics Measurements

The necessary equipment for a base station:

- A receptor with the option to measure in kinematics mode
- Energy adequate supply
- Antennas and 3-5 m length antenna cable
- Two tripods and a fixation rod of the antenna at a constant height
- The necessary equipment for each mobile receptor
- A receptor with the option of kinematics measurements
- An adequate portable power supply
- Antenna and 3-5 m length cable (the antennas are of the same sort as those for base stations if the measurements are initiated by antennas interexchange)
- A back bag for an easiest receptor transportation
- Optionally: a measurement controller

3. Methods of Kinematics Measurements Initialization

3.1. Kinematics Measurements with Fixed base Initialization

The methods needs the knowledge of 2 reference points coordinates in WGS 84 system with an accuracy of +/- 5 cm.

There isn’t a limit for the distance value between those two reference points but when the weather conditions are not appropriate the kinematics measurements initialization could be impossible when the initializing base is more than 10 m .

This method is used for the re-initializing of interrupted taking into account the fact that the reference points are dispersed on a pretty large zone.

The practical achievement mode on the (field) is the following:

1. On each of the two reference points, from the ends of the base, the antenna is calibrated.
2. Each receptor is connected to its antenna and to a suitable power source. The antennas are measured and these values are introduced into receptors.
3. The soft-keys of LOG DATA recording is made active for the base station and, on the screen , its corresponding menu will appears.
4. The receptor screen shows the menu of kinematics measurements.
5. The point ID is introduced now.
6. The parameters antenna introduced.
7. The steps from 3 to 6 are repeated now paying a good attention to the point ID and to the antenna height.

8. Those two receptors are let to collect at least 8 époques of simultaneously recording, for better results at least 2 minutes of data are collected.

9. After enough data are collected, at the mobile receptor the key ROVE is pressed and then its antenna can be moved from the point. The receptor must not be stopped for any moment in order to keep the coupling with the satellites. At this moment everything is ready for the beginning of kinematics measurements.

3.2. Kinematics Measurements Initializing by Antennas Interchange

For this method the coordinates of reference point must be known with accuracy at least equal with the accuracy necessary for measurements.

Another point, which is called secondary point, will have to be fixed and materialized next to the reference point at a distance from 2.5 m to 5 m .

To this point an ID is attached it's materialized because there is a possibility to become restationary.

The coordinates of this point must be known in WGS84 systems. The reference station and the mobile receptor must have the same kind of antenna .

The steps of initializing by interchange achievement.

1. A tripod is put on the reference point. On the tripod the antenna is assembled. Similarly for the second point.
2. At the reference station receptor LOG DATA is pressed and the following menu results.
3. a) The case of double frequency receptors
   b) Receptors with simple frequency
4. The receptor shows the menu of kinematics measurements
5. The point ID is introduced
6. The antenna parameters are introduced now
7. The steps from 2 to 6 are repeated also for the mobile receptor
8. The receptor must be let to record at least 80 époques of simultaneously recording
9. The key ROVE is pressed at each receptor.
10. The receptor antennas are disassembled and they are inter-changed : the tripods must not be moved from their positions and the receptors must not be closed.
11. The static KEY is pressed now at each receptor, the points ID are introduced and also the antenna heights
12. The receptor are let to gather at least 20~25 époque or at least 2 minutes of data
13. The antennas are inter-changed again and the steps from 9 to 12 are repeated
14. At the mobile receptor the key ROVE is pressed and its antenna is moved from the tripod and a stick with constant height.

At this moment on, everything is set for the kinematics measurement to begin

4. The Multiple Reference Stations Used At The Kinematics Measurements

At a kinematics measurement, two or more reference stations can be used. These stations are placed in a dispersed way in a interested zone.

This way of kinematics measurements approaching has some advantages.

- It offers protection against the contact breaking at the reference station because it is supposed that no matter what problem would affect one of them it wouldn't affects the others
- It permits a larger measurement zone than in the case of single station witch can cover an area with a 1 km radius at most

- The multiple reference stations give the possibility that: at the data post – processing a variety of problems can be detected . These problems regards the data gathering as a high PDOP , for instance , or a weak initializing of measurements from a technical point of view.

The kinematics measurements solving , measurements of multiple base, implies the fact that each measured point must be stationed as many times as the numbers of reference stations and at an interval of time between stationing of at least 15 minutes.

This way it will be corrected with a set of independent observations and enough to validity at maximum the installed reference stations.

The procedure of a kinematics measurement achievement with stations of multiple base is a direct one : the step of initializing is simply repeated for each reference stations. For instance : if there are two reference stations and two receptors then it will be accomplished 4 initializing procedures (each mobile receptors with each station).

The initializing of a kinematics measurement method with fixed bases has the advantage that it can initialize any number of base stations and mobile receptors at the same time: the receptors on all points of reference are simply initializing and they are arranged the way, that the stations can collect data simultaneously.

5. The Achievement of a Kinematics Measurement Stop-and-Go

Now it is supposed that the measurement has been initialized. The base station collects data in the reference point; the mobile receptor is in ROVE mode and the antenna is attached at the protection disc.

Achievement steps:

- The mobile receptor is moved to the first point;
- The antenna is centered on the point;
- The soft-key STATIC is pressed and on the screen appears STATIC WAIT state on first line.

The current point ID is introduced(of 8 characters): if the points measured consecutively have as ID-s consecutive numbers then naturally only the ID of the first point will have to be introduced.

The receptor will increment the last 4 characters of the ID each time when you press STATIC. During the measurements, the ID of each point is still verified to be sure that this is correct.

Only for the first point to measure the soft-key INPUT/CHANGES is pressed.

CHANGES are selected to fix the antenna parameters. This step is not necessary for the next points but only when the antenna height has been modified from any reason.

The mobile receptor is let to collect at least 2 data époques. When the message from the first line modifies from STATIC WAIT and appears the soft-key ROVE then the mobile receptor has collected sufficient information for a valid observation.

By collecting 8-10 époques, the quality and trust in measurements can be improved.

The soft-key ROVE is pressed.

If there are, more points to measure go back to step 1.

If the point to measure was the last one then the measurement ends.

In conclusion, during the measurement an important attention must be payed to the following steps:

- Press ROVE- key before moving the antenna to another point.
- When the antenna is moved, take care to avoid the lost of the signals from satellites in any of these moments.

6. Reinitializing of Measurement

The procedure of kinematics measurements is very sensitive to the loss of the contact with the satellites, effect caused by cyclical slides of them.

If the incidents which has interrupted the measurement might repeat then some measures to avoid it must be taken.

For instance: let us say that receptor lost the contact with the satellites because of some obstructions, then, it is recommended to follow another tract.

When the measurement is interrupted due to the loss of coupling with the satellites, the receptor emits a sonorous signal whose intensity can be modified. In this case, the receptor must be reinitialized before going to the effective measurement.

There are two modalities of receptor reinitializing:

- coming back to an already measured point;
- the achievement of one of the initializing procedure used at the beginning of measurement.

The method is a procedure of reinitializing by coming back to a previous measured point: could be any point successfully measured from the current measurement and not necessarily the lost one.

Any of the initializing procedure at the beginning of the kinematics measurement can be used here, too.

Practically the reinitializing on the fixed base is recommended because this is the only method which doesn't ask the turning back to the base station : the mobile receptor will be able to go to an any reference point.

If this point doesn't exists, one can be created in the respectively point (of interruption by a control measurement achievement)

This is an attractive approaching because the receptor has FST-STATIC function witch permits a very correct determination of a reference point in less than a 20 minutes observation.

To achieve a FAST-STATIC measurement, the mode of kinematics measurement must not be necessarily interrupted.

After assembling the antenna the key STATIC is simply pressed as if a kinematics measurement would have been achieved and information is collected during a properly time interval as :

- 8 minutes of recording if 6 satellites are contacted;
- 15 minutes of recording if 5 satellites are contacted;
- 20 minutes of recording if there are 4 satellites contacted;

During the periods with high PDOP or an improperly availability of satellites it is cautions to achieve a FAST-STATIC measurement because this has the possibility to announce when the observation is complete.

7. The Contact Loss at the Reference Station

The contact loss or a high PDOP recording at the reference station is the most seen cause of failure during the kinematics measurement , because it can't be known that is happened even the base station is permanent followed. That's why a plan of measurement must be done and the base station must be established very carefully in order to keep the coupling with the satellites.

We can find that such an incident took place at the base station by comparing the continual measurement from the mobile receptor.

Accordingly with the facts above, regarding the kinematics measurement STOP and GO method, cadastre detail points were measured also with the total stations. For a better appreciation of kinematics method precision we have the next example :

8. Study Case: Fieni Town

In the case study regarding measurements made in Fieni town, everything happened as following :

The interested zone was studied and the places for the stations placing were marked for the cadastre using total stations - their numbers : 13 stations being imposed by the conditions on the field , elevations time being of 3 days .

The points on the property edges were elevated, also on the corners of houses, stables , hencoops , edges between yards, buildings and gardens. Where this was impossible, then distances were measured with the tape-measure in order to determine the frames of constructions, time being very important .

The methodology of details collection necessary for the cadastre plans needed to use: drafts and specific code and unfolded itself in normal conditions.

Regarding the GPS technology used, here the kinematics measure method was used, the procedure: STOPandGO post processing .Two receptors were used , these being of Trimble

Hose type of geodetically class on two-wave length: L1, L2

On the field the operations were unfolded like

After a planning at the office , using the planning program of the Geomatics Office Trimble Soft “ Plan “ on the field were done:

- A study and discovering possible tracts to gather the cadastre details through specific points.
- And the fix station place was chosen as being the point GPS 35 , previously determined by GPS technology when Fieni town network was achieved.

This point had the coordinates determined in WGS 84 system and in national coordinates system that means in stereographical plan of projection (Stereo 70). The crew was an 3 person one and the measurements tooked two and a half days.

The result presentation is given in tables 1 and 2 and the Fieni data processing is presented also. The measurement in Fieni were done with Trimble 4000 SSE which works on two frequencies and the processing was done using the Trimble Geomatics Office Soft. This was possible because the data from the Trimble receptors were unloaded with the Trimble geomatics Office Soft.

During the measurement the geometry of satellites was periodically verified , expressed by the value of PDOP which was shown on the receptor screen especially when only 4 satellites were reception.

The stationing at kinematics measurements is very short that’s why the high values of PDOP influenced negatively the obtained results.

If the PDOP value is high and measurements are done in a point then the obtained results won`t have the proper acuracy.

So the measurements results for different PDOP levels can be resumed as:

- PDOP <3 – ideal for measurements;
- 5 < PDOP < 3 – still acceptable for measurements;
- PDOP > 5 – wait for PDOP decreasing;

It is not reccomended to do kinematic measurements when PDOP value is equal or greater than 5, this thing can lead to wrong results, with errors, because of the no satisfactory position of satellites.

The unfolding mode of kinematics measurements is not different, when we use an electronic notebook of field as receptor interface.

Information as: point characteristics, line or surface characteristics as long as the receptor is in the kinematics mode could be introduced.

Tables with comparative study for coordinates from Fieni intravillan town, Dambovita county , are presented in table 1 with coordinates in stereo to projection system classicaly determined with the total station and the by GPS technology, STOP and GO method.

In table 2 : coordinates in Stereo to projection system, classically determined with total station and determined by GPS technology STOP and GO method , with the accuracies for Fieni downtown.

In picture 2: the comparative study regarding the necessary time for cadastre details elevations both with total stations and with GPS technology. This study is presented: with percentage sin the second A picture , and as number of days in the second B picture.

Picture 1 presents the comparative study elevated surface with GPS technology comparing with total elevated surfaces.

Picture 1 presents the comparative study elevated surface with GPS technology comparing with total elevated surfaces : in percentage – picture 1 B , and in hectares –picture 1 A.

After the GPS kinematics measurements and analyzing the results in cadastre elevations (down town) the following conclusions must be précised :

- Kinematics measurements method in real time and "STOP and GO" post processing, assure a higher precision of measurement.
- Time of measurements is shorter because the number of station is much smaller than in total in total stations measurement case.
- Down town the measurement time is much smaller than the time with the total stations because it is not elevation points and the distances can be long (on L1 till approximatively 5 km and on L1, L2 over 5 km)
- Kinematics measurements in real time can be done if there is a network of
- Permanent stations dispersed at distances of 30 – 20 Km with fewer GPS apparatuses, because the role of the fixed station is taken by permanent stations.

The Comparative Study-Coordinates Differeces Fieni Town – Intravillan

Table 1

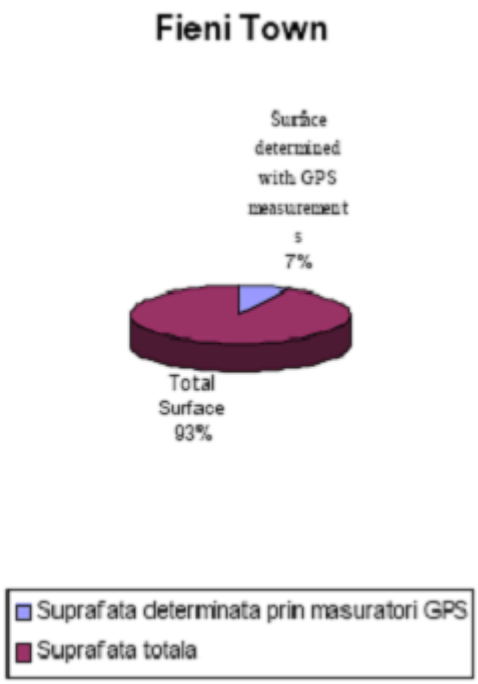
Point Number	Determined with total stations		Determined GPS		Differences coordinates	
	X(m)	**Y(m)**	**X(m)**	**Y(m)**	Δx (m)	Δy (m)
1	386133.310	382988.480	386133.321	382988.498	-0.011	-0.018
2	386131.490	382993.300	386131.486	382993.324	0.004	-0.024
3	386127.980	382992.110	386127.972	382992.124	0.008	-0.014
4	386127.070	382994.330	386127.082	382994.346	-0.012	-0.016
5	386123.290	382992.880	386123.272	382992.895	0.018	-0.015
6	386126.060	382985.650	386126.071	382985.634	-0.011	0.016
7	386131.710	382993.510	386131.732	382993.525	-0.022	-0.015
8	386130.690	382996.100	386130.682	382996.085	0.008	0.015
9	386130.470	382962.690	386130.485	382962.682	-0.015	0.008
10	386121.510	382984.460	386121.524	382984.445	-0.014	0.015
11	386115.780	382982.180	386115.776	382982.196	0.004	-0.016
12	386118.600	382975.100	386118.621	382975.122	-0.021	-0.022
13	386116.400	382974.210	386116.418	382974.232	-0.018	-0.022
14	386117.630	382970.880	386117.618	382970.895	0.012	-0.015
15	386119.200	382967.110	386119.213	382967.116	-0.013	-0.006
16	386123.840	382969.040	386123.852	382969.059	-0.012	-0.019

The Comparative Study – coordinated precisions Fieni Town – Intravillan

Table 2

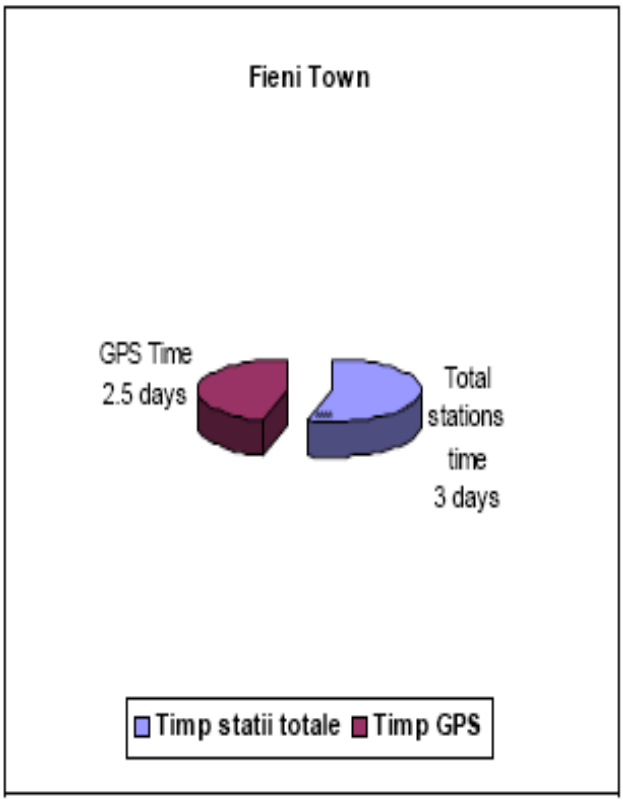
Point Number	Determined with total stations		Precisions	Determined GPS		Precisions
	X(m)	Y(m)	st(m)	X(m)	Y(m)	st(m)
1	386133.310	382988.480	0.043	386133.321	382988.498	0.021
2	386131.490	382993.300	0.043	386131.486	382993.324	0.022
3	386127.980	382992.110	0.043	386127.972	382992.124	0.020
4	386127.070	382994.330	0.043	386127.082	382994.346	0.022
5	386123.290	382992.880	0.043	386123.272	382992.895	0.023
6	386126.060	382985.650	0.043	386126.071	382985.634	0.022
7	386131.710	382993.510	0.043	386131.732	382993.525	0.022
8	386130.690	382996.100	0.043	386130.682	382996.085	0.024
9	386130.470	382962.690	0.043	386130.485	382962.682	0.022
10	386121.510	382984.460	0.043	386121.524	382984.445	0.021
11	386115.780	382982.180	0.043	386115.776	382982.196	0.022
12	386118.600	382975.100	0.043	386118.621	382975.122	0.023
13	386116.400	382974.210	0.043	386116.418	382974.232	0.022
14	386117.630	382970.880	0.043	386117.618	382970.895	0.020
15	386119.200	382967.110	0.043	386119.213	382967.116	0.022
16	386123.840	382969.040	0.043	386123.852	382969.059	0.023

Picture. 1.a

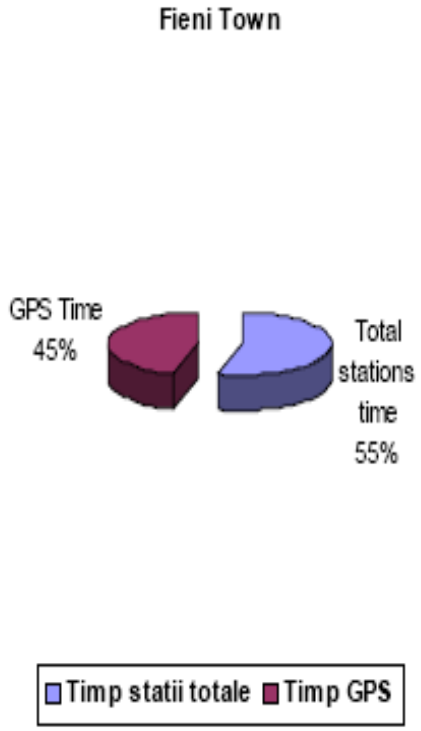


Picture. 1.b

The comparative study regarding the necessary time for cadastre detail elevations with total stations and with GPS technology.



Picture. 2.b



Picture. 2.a

According with the met situations , the following ***conclusion*** can be drawn:

- In towns and cities with an average density of buildings , the GPS method can be used at a percentage of 70-80 %, using also auxiliary points;
- In towns and cities with a high density GPs methods can be used a percentage of 50-60% with auxiliary points and combining them with classical elevations.

The case study did measurements using GPS technology in cadastre elevations using measurements only from the NAVSTAR-GPS system satellites and , in this case , the results are very good. If the GLONASS system satellites or the new GALILEO European System satellites were used instead then we would have at least 6~12 visible satellites which is very well for cadastre measurements , here being necessary at least 4 satellites.

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