Some Aspects of Using GNSS Technology in Project Management

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Abstract: GNSS technology is presented, with its main aspects and utilities regarding its use as support for making decisions concerning project management. It presents general aspects of GNSS positioning systems (NAVSTAR-GPS, GALILEO GLONASSM) and the facilities that these systems have, that are indispensable in most fields.

It presents kinematics measuring methods and RTK, but also the rapid static method with its own characteristics, while insuring visibility to satellites, a prerequisite needed to receive satellite signals and obtain the expected results in achieving the goal which is proposed.

Almost all areas are involved in the acquisition and use of equipment using GNSS technology (GPS, GLONASS, Galileo, COMPAS, etc.), this together with geographic information systems are now the trend and solve a lot of problems, especially in project management, as it provides useful information in making decisions in that area.

Environmental projects are of particular importance because they are current and they serve a number of institutions in the field and work towards solving problems in this area, along with information systems and GNSS technology, which helps to quickly and efficiently collect the necessary data for such projects.

Key words: project management, RTK, GNSS, GPS, GLONASS, GALILEO, EGNOS, environmental protection.

1. Overview Regarding Positioning Using GNSS Positioning Systems.

Positioning aims at determining the momentary position of an object, at rest or in motion. Establishing the position of a body in motion, on land, in the sea or air, and determining and correcting its course, are typical problems of navigation.

Determining the position results, in many cases, in the final product being coordinate in a certain reference system which was chosen. It is noted that the measurement and positioning operations therefore have a common goal, to determine the coordinates for different points in space.

But, a fundamental change has occurred, with the advent of positioning systems based on artificial Earth satellites.

With the use of positioning systems based on artificial satellites one can solve today a number of problems related to navigation on land, in the sea and air. Such systems, which have reached the final stage of completion, under certain conditions offer positioning accuracy in millimeters, and so the navigation system can be used very efficiently in current geodetic applications.

Hence the finding that satellite-based navigation systems - are systems of positioning and measurement. Navigation systems based on artificial satellites have emerged at the same time as the space programs of countries with tradition in this field, namely the U.S. and the then USSR, now Russia.

Starting from the fact that the NAVSTAR-GPS and GLONASS systems are systems administered by the military and belong to a single nation, the European Union decided to create their own navigation systems, providing an evolution in two phases:
- GNSS-1, first-generation system, which completes existing navigation system, like the NAVSTAR-GPS U.S. and the Russian GLONASS systems;
- GNSS-2, the second generation system, which provides navigation and positioning services which are controlled by civilian users.

EGNOS (European geostationary Navigation Overlay Service) is now part of the GNSS-1 generation, being mainly intended to supplement the performance of GPS and GLONASS systems in terms of accuracy and data integrity. The system is designed to use the Earth's infrastructure from its surface, composed of over 40 stations located mostly in Europe and three geostationary satellites: Imarsat-III Indian Ocean Region (IOR), Imarsat-III Atlntic Ocean Region East (AOR-E) and the telecommunications satellite ESA Artemis. EGNOS will be fully operational in 2004 and will provide an operational navigation service for Europe. The main objectives of the EGNOS system are:
- to transmit real-time information on the integrity and functioning (health) on each satellite of the GPS and GLONASS systems. This task was called GNSS Integrity Channel (GIC);
- to transmit additional measurement signals to supplement GPS signals. This task was called GIC Ranging (RGIC);
- to transmit differential corrections for both GPS and GLONASS systems, to increase the accuracy of the signals for civilian users;

EGNOS is a key element in the European strategy for development of GNSS, designed to be interoperable with other satellite systems similar to WAAS (Wide Area Augmentation System in the U.S. and Canada) and MTSAT-Satellite- Based Augmentation System in Japan.

Currently, the system is in the second phase of development called the AOC, which states:
- development and construction of various elements of the system;
- integration and verification of system components;
- transition to phase "initial operation.

The final FOC phase is scheduled for the end of 2004. Generation GNSS-2 has been defined as "second generation satellite-based system" designed exclusively for civilian users. The major objective for GNSS-2 is that it has to be compatible with "old" GPS, GLONASS, EGNOS systems, supplemented by regional sections and a combination of geostationary and non-geostationary satellites.

On March 26th 2002, the Council of Europe decided unanimously the launch of the Civil Satellite Navigation Program: **Galileo**. This will be the first positioning and navigation system based on satellites oriented on civil applications, currently being in a state of development and validation of the system. It is expected that the system will be operational in 2008.

The parameters that currently are asked from a navigation system are:

- **Accuracy** (degree of conformity between the estimated position and the measured position) described by the characteristics of *predictability, repeatability and relativity;*
- **Integrity** - which refers to the capability of the system to send timely warnings to users, when the system is not available for navigation;
- **Availability** - system capability to provide coverage in areas specified;
- **Coverage** - defined as the area where the navigation system provides position information to a desired level of accuracy;
- **Continuity** - the possibility of a system, after a period of malfunction, to return to the operability conditions imposed;
- **Trust** – the probability to run for a period of time on specific functions and under certain circumstances;

Any GNSS system basically contains three major segments:

- **Space segment** - consisting of a constellation of satellites, each satellite transmitting RF signals modulated with codes and navigation messages. They are regarded as bearers of their own coordinates;
- **Control segment** - consisting of a network of control stations on the ground used for the surveillance of satellites and for the update of the satellite navigation messages;
- **User segment** - consists of all radio-navigation receivers specifically dedicated to the reception, decoding and processing of codes and navigation messages;

Caracteristicile sitemelor

	NAVSTAR-GPS	GLONASS	GALILEO
Înălțimea orbitelor	20200 km	19100 km	23616 km
Înclinarea orbitelor	55°	64,8°	56°
Timpul de revoluție	12 h	11 h 15 min 44 sec	14 h
Numărul sateliților	24 (în prezent 28)	24	30 (27+3)
Frecvența purtătoarelor	L1 = 1575,42 MHz L2 = 1227,60 MHz	L1=1602+k 0,5625 MHz L2=1246+k 0,4375 MHz	E5a=1176,45 MHz E5b=1196,91 – 1207,14 Mhz E6=1278.750 MHz E2-L1-E1= 1575,42 MHz
Modulația semnalelor	L1= C/A, P/Y(1), D L2= P/Y(2), D	L1=C/A; P (P1) L2= P (P2)	Nu a fost încă definitiv stabilită
Ceasurile din sateliți	2 Rubidiu, 2 Cesiu	3 Cesiu	2 Rubidiu, 2 Maser cu Hidrogen
Sistemul de timp	Timpul GPS	UTC (Moscova)	GST (Galileo System Time)
Sistemul de coordonate	WGS-84	PZ-90	ITRF (International Terrestrial Referen-ce System

2. Design of Networks And Measurements Using GNSS Technology.

On designing networks and measurements one should consider which positioning method is most appropriate to achieve the best possible measurements. To make a classification of methods of measurement, it is necessary to explain the concepts of "static " and "kinematic".

At static measurements, the receivers are still within the time set for readings – also called **"work sessions"**. The results are then deducted from successive receptor measurements, in certain predetermined time intervals called "eras of measurement", usually common to all receivers involved in a work session.

In the case of kinematic measurements, a part of the receivers are moving (rover), and the results are obtained from a single era, or a few epochs of measurement at each point. Unlike the static method, there must continue to a connection towards at least four satellites (preferably five, for safety) of the initial constellation. If you make phase measurements for carrier waves, the ambiguities must be previously known from the initialization phase, prompting them through various initialization processes, such as:

- The known base
- Permutation of antennas
- On the Flay or on the run

ISBN: 978-960-474-293-6

Planning a GNSS measurement project for geodetic purposes consists in choosing an optimal method of measuring, the necessary instrumentation as well as the actual planning of observations which are carried out.

Planning is essentially different from the planning of classical geodetic observations, since measurements made with GNSS systems can be performed virtually on any weather and at any time of day. In addition, visibility is not required to exist between network points, only one open horizon being needed to the sky from an elevation of 15 ° upwards.

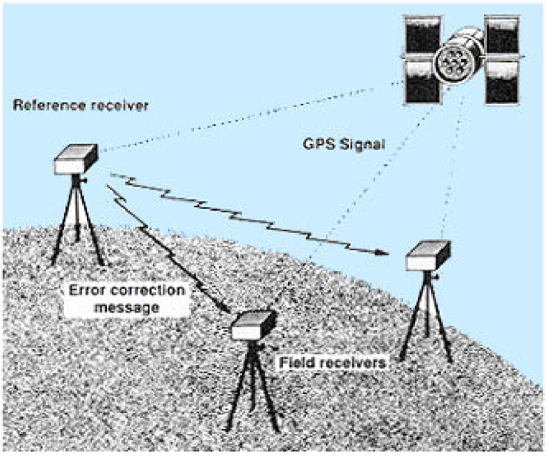

Fig.1. Measurement using GNSS technology

In planning the observations one must consider several factors:

-configuration of satellites;

- number and type of receivers at their disposal;

- economic aspects.

The configuration of the network plays a smaller role in this type of measurements, being necessary to have it in mind only when the network has to be connected to the national geodetic network.

3. The Use In Kinematic Measurements Of Multiple Reference Stations For RTK And Stop And Go GNNSMeasurements

In a kinematic measurement once can use two or more reference stations dispersedly located in an area of interest.

This approach regarding kinematic measurements has several advantages, namely:

- provides protection against broken contact at the reference station because it is assumed that any problem that would affect one of them does not affect the others as well, at least theoretically and practically;
- allows measurements to be conducted on a much larger area than if a single station would be used, which can cover an area for measuring not larger than 3-4 km radius and can stretch up to about 60-80 km;
- multiple reference stations enable, in the post-processing of the data, to detect a variety of issues related to data collection such as, for example, high PDOP or technically weak measurement initiation or, in the case of RTK, in carrying much better measurements.

Resolving kinematic measurements with multiple databases requires that each measured point be stationed by a number of times equal to the number of reference stations and at an interval of time between stations of at least 15 minutes.

In this way it will be corrected with a set of independent and sufficient observations to make the most of the reference stations installed.

The procedure for performing a kinematic measurement with multiple base stations is straightforward: simply repeat the setup phase for each reference station. For example, if there are two reference stations and two receivers, then there will be made four initializations (each mobile receiver with each station).

The initiation method of a kinematic measurement with a fixed base has the advantage that it can initialize any number of base stations and mobile receivers at once: simply initialize all receivers for all appropriate reference points and then arrange them in such a way that the stations are able to collect data simultaneously.

4. Performance of a Stop-And-Go Kinematic Measurement

Further, it is assumed that the measurement has been initialized. The base station collects data at the point of reference; the mobile receiver is set to ROVE mode, and the antenna is attached to the protection disc.

Stages of development:

- mobile receiver is moved in the first point;

- antenna is centered on the point;
- STATIC-soft key is pressed and the state STATIC WAIT appears on the front line of the screen.

Enter the ID of the current point (8 characters): if the points that were measured consecutively have consecutive ID numbers, then, normally, only the ID of the first point shall be entered. The receiver will increment the last four digits of the ID every time you press STATIC. During the measurement, however, check each ID for each point, to be sure it is correct.

Only for the first measuring point the soft INPUT / CHNGS key is pressed. The key CHANGES is then selected, to set the antenna parameters. This step is not necessary for the following points, only when the antenna's height has changed from some reason.

It allows the mobile receiver to collect at least two epochs of data. The mobile receiver has collected sufficient information for a valid observation when the message on the first line changes from **STATIC-WAIT** and soft key **ROVE** appears.

By collecting 8-10 epochs, one is able to improve the quality and confidence given to measurements. Press the soft key-ROVE.

If there are still points that have to be measured return to step one. If the point measured was the last one the measurement ends.

In conclusion, throughout the measurement, one should pay great attention to the following steps:
- ROVE is pressed prior to moving the antenna at another point;
- when handling the dish, one should do it in such a way as to avoid loss of signals from satellites in any of these moments;

5. Resetting the Measurement After Losing The Connection To The Base Station Or Stations

Kinematic measurement process is very sensitive to loss of contact with the satellites, an effect caused by cyclic sliding thereof.

If the incident which stopped it is possible to repeat, measures will have to be taken to prevent it. For example, if the receiver has lost contact with the satellite, because of obstruction, it is advisable to follow a different route.

When the measurement is interrupted due to a loss of connection with the satellites, the receiver emits an audible signal whose intensity can be changed. In this case, the receiver must be reset before proceeding with the actual measurement.

Essentially, there are two ways to reset the receiver:
- by returning to a point which had already been measured;
- by performing one of the initialization procedures used at the beginning of the measurement.

The method is a reset procedure by returning to a previous measured point: it can be any point successfully observed in the current measurement and not necessarily the last one.

In principle, each one of the initialization procedures used at the start of a kinematic measurement can also be used here.

In practical terms, the reset is recommended be done on a fixed base because it is the only method that does not require a return to the base station: the mobile receiver will be able to go in a certain reference point. If this does not exist, you can create one at that point (breaking point) making a control measurement.

This approach is attractive because the receiver has the FAST-STAT that allows a very accurate determination of a reference point, in less than 20 minutes of observation.

To achieve a FAST-STAT measurement, you need not necessarily interrupt the kinematic measurement mode. Simply, after the antenna is installed, press STATIC as if it were a kinematic measurement and then collect the information in an appropriate time, say:
- 8 minutes of recording if 6 satellites are contacted;
- 15 minutes of recording if 5 satellites are contacted;
- 20 minutes of recording if 4 satellites are contacted.

In periods of high PDOP or inadequate availability of satellites it is prudent to perform a FAST-STATIC measurement because it is able to notify you when the observation is complete.

6. Loss of Contact at the Reference Station

Loss of contact or the recording of a high PDOP at the reference station is the most common cause of failure in the case of kinematic measurements.

This is because one cannot know that this has happened even if the base station is permanently monitored. Thus, we must establish a measurement plan and very carefully choose the base station, so that the loss of contact with the satellites cannot happen. Nevertheless, we can find out that there was an incident at the base station by comparing the number of continuous measurements at this station with the file of all measurements from the mobile receiver.

In accordance with the above stated aspects regarding the stop and go kinematic method of measuring, the points were measured with total stations and land detail, and for a better understanding of the accuracy of the kinematic method, we have the following example.

7. Conclusions

Almost all areas are involved in the acquisition and use of equipment using GNSS technology (GPS, GLONASS, Galileo, COMPAS, etc.), this together with geographic information systems are the main means for data collection, inquiry, transmission and analysis, especially in project management, as they provide information useful in making decisions in areas that are closely related to project management and environmental protection, respectively in every field that uses them.

Environmental projects are of particular importance because they are current and they serve a number of institutions in the field and work towards solving problems in this area along with information systems and GNSS technology, which helps to quickly and efficiently collect the necessary data for such projects, but also in the field of project management.

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