Recent Developments in the Sector of Navigation Satellite System Reference Stations (GNSS) and Possible Links with the Typical Surveying Measurements Carried Out by the Surveyors

Bruno RAZZA, Italy

Key words:

SUMMARY

In the last decade, the potential benefits of the navigation satellite system (GNSS) have been analized very much; infact, a series of improvements have been realized within various applications, as the land, marine and aerial navigation.

The solutions more used and reliable are the differential GPS (DGPS) and the satellite systems of improvement (SBAS).

The goal of the above mentioned applications is the improvement, as much as possible, of the accuracy of the positioning through the only GPS, bearing in mind the characteristics and the requisites of the navigation services.

Both DGPS and SBAS lead to an increase of the number of the reference stations used (with different types of technique) for calculating the "differential" correction. The number of the stations and their availability depend on the politics and on the finances of various countries.

The atmosphere is the principal cause of mistakes found in the GPS, DGPS and SBAS positioning. A lot of scientific studies have tried to solve this problem in understanding the limits of these systems and suggesting probable modifications to produce in.

The atmospherics and their effects on the topographical and cadastral measures are studied in order to refine the quality of the typology of measures, today available, and to analyse in depth the current limits, having the aim of individualizing, with accuracy, the possibilities given by the GNSS systems in the near future.

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1. PREAMBLE

First, the GPS was realized and used only for military goals, for localizing strategic points on the land surface. Soon, its capacity was guessed and its use was introduced in different civilian applications, as the measure of the time, geodetic and cartographic measures, and in the air, ship, train and car navigation.
The use of alternative methods for the interpretation of GPS signals allowed to reach, in short time and without the access to the USA military codes, very high precisions.
Today, the use of GPS as co-operator in the different civilian applications is something that happens every day.

The military option seems just a little and particular case within the multitude of possibilities offered by this system.

All this brought to the formulation of the so-called GALILEO system.

2. GLOBAL NAVIGATION SATELLITE SYSTEM

The use of GPS as co-operator within the assisted navigation goes besides the simple positioning of a point on the land surface.

In this case, in fact, it must be imagined that the object to localize is in continuous movement and that the signal can be loosed frequently (above all in urban spaces), and that the precision of the measure must observe the requirements of the service in question. In the case of planes, the largest permitted mistake is of scarcely 7 meters! This precision can be big for receivers that are different from that commonly used for geodetic measures, as we know very precise.

Cause the object is in continuous movement (with a too high speed for planes) and cause the continuing updating of the position, the geodetic techniques, which calculate the position through averages of measures realized on long slots, are not anymore practicable.

Therefore, the receivers used for the navigation must necessarily calculate the position of the object in movement in a different way, penalizing so the precision of the measure.

Clearly, the precision required for a navigator mounted on a car will be different from that one mounted on a ship, on a train or on a plane. Moreover, the accuracy required for the measure of positioning of a plane will be different according to the position of the plane: in course or in landing.

In a similar way, the accuracy required in the measure of a ship depends on the dimension of the ship itself: it is useless, for example, to reach precision of centimeters if the ship is 100 meters long.

3. SATELLITE BASED AUGMENTATION SYSTEMS (SBAS)

The biggest complications are in the air navigation, where it must be obtained a good precision in short time. This operation, as said above, is very complicated because of the limits in the current GPS signals available for civilian goals. In order to exceed, as much as possible, these limits, some systems able to ameliorate the services of the satellite air navigation are been realized. These systems are called Satellite Based Augmentation System (SBAS) and we have to distinguish between the one used in the American sector (WAAS), the one used in the Euro-African sector (EGNOS) and the one used in the Asiatic sector (MSAS). There are others in planning stage, similar to the ones just mentioned, operative in the Indian sector, in the Brazilian and in the Canadian ones.

The developments of different systems (according to various areas) that flow into the global SBAS, is due to both political needs and different atmospheric effects according to the various parts of the world. The principal source of mistake within the GPS positioning is due to a part of the high land surface: the so-called ionosphere. It has different attitudes and peculiarity in the different sectors of longitude, cause of the particular structure of the land magnetic field that controls its electrodynamics.

The principle of running of these systems is very simple. In all these areas some monitoring stations (receivers of double frequency of the latest generation similar to those ones used for the geodetic measures) are placed on the land surface. These stations are used to calculate the mistake in the positioning due to the ionosphere every 5 minutes, for each part of the area covered by the service SBAS. This mistake is calculated by a data processing center, is transferred to a geostationary satellite and is transferred again to the users who navigate in the area covered by SBAS. The receivers able to analyze the SBAS corrections can better improve the precision of the positioning measure, in improving so the performance of the satellite navigation. The principal beneficiaries of this service are the satellite navigators who support the flight operations of the planes. But, this service can be used by everyone who has a receiver able to pick up SBAS correction.

The number of the monitoring stations depends on the capacity in calculating the mistake given by the ionosphere every 5 minutes in all the sectors of the area covered by the SBAS service.

It is useless to have 10 stations in an area of 10 km if we can obtain the same result with only 2 stations.

A similar approach is attempted also in the field of the cadastral measures: reference stations localized on the territory allow to use some differential corrections in the cadastral survey, do not realized anymore through theodolite but through GPS.

On this subject we have to underline a series of aspects for which there is a difference between the “surveying” application from the “navigation” one, important for the improvements of the use of satellite techniques in the measure of “surveying”(above all in the cadastral ones).

Possible links between “navigation” and “surveying”.

Cadastral measures can be divided into 2 categories: the ones on large scale and the ones on little scale.

The measures on large scale refer to the survey of big elements, as lots, roads or motorways, bridges: usually elements whose dimensions and distances to measure exceed the largest distance in which a theodolite can be used. In these cases, in opposition to what happens with the use of a classic theodolite, the GPS technique allows to carry out the survey in an easier way because the points to examine with GPS can also be not visible between themselves. In this way, it is possible to cover the big dimension of the element in question in short time with considerable precisions (also in centimeters if the measure is well done).

The measures on little scale refer to the survey of small elements as the perimeter of a building in a urban area (surrounded by other buildings in the near area). The cadastral measure, usually, consists in determining the dimension of the building calculating its perimeter and its form and localizing it within link of existing points. In this case, a measure through GPS is not advisable cause of the big difference to what the antenna of the receiver are subject in places in which parts of the sky are darkened by other buildings or by vegetation near there. These interferences imply a deterioration of the precision of the measure and, in the most complicated cases, they can make impossible the use of GPS. Moreover, the GPS antenna can not be positioned close to the corners of the building to survey (unlike the prism of the theodolite), and make so the measure through GPS subject to further mistakes. There is the same problem when you have to consider the link of the existing points, because the most time these points coincide with the same elements of other buildings. In this case, therefore, the use of GPS is counterproductive both in terms of performance (that means in the precision of the measure and in the time necessary for realizing the measure) and in terms of costs (easy to understand if you compare the price of a common theodolite with the price of GPS).

Finally, while the air navigation presents standard functions and requisites which do not depend on the place, the use of GPS for cadastral measures presents different limits, according to the realization of measures of large or small scale. All this, together with the different degrees of urbanization that can be met in the different reality of the world, makes extremely unhomogeneous the possible cases of measure. This implies a great difficulty in making uniform and compatible (in terms of precision of the measure) the nets of the reference system, since different will be the conditions of measure in the various parts of the world. All this, can seem more complicated considering the different and numerous effects of the ionosphere on the basis of the longitude and of the latitude.

4. CONCLUSIONS

The GPS technique could be very useful not only in the measure of elements of big dimensions but also in the definition of the triangle of the reference points in which there must be put the survey of detail on small scale. Through GPS, in fact, the reference points can be surveyed with the only measure of each point, avoiding so the measures in the intermediate and visible points between themselves (those between the detail and the reference points, or better, the tacheometric stations indispensable for obtaining the visibility of the reference points, usually more than the ones necessary for the survey). This is the big benefit that the GPS technique could bring to the surveyors for their daily cadastral measures in urban reality as Italy. In this way, in fact, we can link together the GPS technique, reserved to the survey of the triangle of the reference points, to the "elettro-ottica" technique, reserved to the survey of detail to insert into the triangle of the reference points. All this could support the saving of the necessary moving between the detail and the closer reference points, which must be considered through a direct and visual measure with the "elettro-ottica" technique. In this case, it would be right to do again a definition of the principal reference points and the secondary ones, so to make them usable by GPS instruments (visibility of the sky, field free of obstacles that can ruin the reception of the satellites). This use allows to reach good results in short time, since it would not be necessary a very precise measure of the reference points which would be known from the beginning and that would be used to arrange the position of the detail within the link of the reference points: the coordinates and the position of the object on small scale to survey. The form of the object itself, instead, could be defined through the "elettro-ottici" instruments, as usually happen.'

CONTACTS

Geom. Bruno Razza
Consiglio Nazionale Geometri
via Barberini 68
I-00187 Rome
ITALY
Tel. + 39 06 420 3161
Fax + 39 06 481 4026
Email: cng@cng.it