RESEARCHERID
THOMSON REUTERS

[Leopold* 5(11): November, 2018] ISSN 2349-4506
Impact Factor: 3.799

Global Journal of Engineering Science and Research Management

PROBLEM OF THE USE OF DUAL-FREQUENCY GNSS RECEIVERS IN BENIN

Léopold Degbegnon*, Ambroise Koumolou
* Doctor in Geodesy, Department of Civil Engineering of the Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, Benin
Geometry Engineer, National Geographical Institute of Benin

DOI: 10.5281/zenodo.1745459

KEYWORDS: Land security, permanent station, attachment, RTK, free pivot, dual-frequency.

ABSTRACT
Despite several approaches, Benin has always had difficulties in securing land. Among the causes of this insecurity are technical reasons, which are either related to the working methods or to the tools used. To overcome these difficulties, a good number of surveyors nowadays are increasingly equipped with the latest generation tools that are dual-frequency GPS / GNSS receivers for an efficient execution of works.

Indeed, according to the standards and the technical and administrative requirements, all these works should be in a single system, the National Geodetic Network which is that of the permanent stations.

The objective is to evaluate not only the statistics of effective use of GPS / GNSS bi-frequency receivers in surveying and mapping work in Benin but also to study the observation modes used by the users of the GPS / GNSS receivers.

The present study has allowed us to show the limits of the attachment methods commonly used by users of these GPS / GNSS receivers, and then to propose a procedure manual for the one hand the execution of the topographic survey works in RTK mode with pivot free of charge and, on the other hand, to ensure a better connection of the topographical work carried out to the system of the network of permanent stations.

INTRODUCTION
Like most developing countries, Benin has difficulties in controlling space and controlling the expansion of its living environment. Many large projects whose realization could have given another face to the country with major economic dividends are often announced. But because of the lack of land guarantees, these projects cannot be known for the day.

These problems of land insecurity will find a solution to the establishment of a unique geodetic reference system throughout the national territory for the realization of topography, mapping, sanitation and urban planning (Degbegnon & Houinou, 2012).

With the evolution of technology, the satellite positioning system has made GPS geolocation[1] possible to democratize. So GNSS has[2] become a key tool for geodesy, the basis of all cartographic and topographic operations. Introduced in Benin in the 90s with the National Geographical Institute, the use of GNSS was accentuated from the year 2010 thanks to the project Millennium Challenge Account (MCA-Benin) through its component "access to land". Through this project, a network of permanent stations has been set up in Benin which should serve as a unique reference system for the execution of various topographic and cartographic works. Thus, the use of GPS based on the permanent stations begins to fit into the habits of the surveyors especially as the ex-Directorate of domains, registration and stamp imposes for example that the survey of registration and fragmentation are systematically attached to the geodetic network of these permanent stations. However GNSS observations are often not surrounded by all the usual precautions. This impacts the quality of the determinations.

[1] Global Positioning System
[2] Global Navigation Satellite System

RESEARCHERID
THOMSON REUTERS

[Leopold* 5(11): November, 2018] ISSN 2349-4506
Impact Factor: 3.799

Global Journal of Engineering Science and Research Management

This is the purpose of this study which aims to draw the attention of the various users of GPS / GNSS bi-frequency receivers on possible errors made due to their daily practice.

PROBLEM STATEMENT

Positioning in kinematic mode in real time (RTK[3]) is nowadays a common technique for surveying in Benin. This mode provides relative positioning with centimeter accuracy when executed with best working practices. This positioning assumes that the position of the base is determined relative to the permanent stations. Thus, if the position of the base is known in the system of permanent stations then all work in relation to this base are attached to this system. But for most cases, the base point is not always known, because of the low rate of densification of good geodesics on the national territory. This base must therefore be observed in static mode and determined in post-treatment. Under these conditions, to successfully link the work to the reference system, two computations are required when returning to the office for data processing.

The first concerns the determination of the position of the base with respect to the permanent stations of Benin, and the second relates to the determination of the points raised in relation to the base. However, surveys of expert surveyors and other users of dual-frequency GPS/GNSS Receivers report that this principle is not often respected. These users of GNSS receivers thinking of working in the system of permanent stations do not always bother to perform post-processing. This means that work performed under such conditions is not tied to the national geodetic network.

MATERIALS AND METHODS

SOURCE DATA

The data for the most part come from the IGN archives[4]. They are of two kinds:

- spatial data: maps of the network of permanent stations and the network of geodetic points of the city of Cotonou;
- the attribute data concerning the coordinates of the permanent stations adopted as retained by the Order 0068 / MUHRFLEC / DC / SGM / IGN / DGURF / SA of December 28th, 2009 and made available by the Service of the Geodesy and the Leveling of the IGN. Two of these permanent stations have been used in our work and their coordinates are shown in Table I as follows:

Table 1. Coordinates of permanent reference stations.

ID	East (Meter)	North (Meter)	Elevation (Meter)	Latitude	Longitude	Height (Meter)
BJAB	389645.265	794027.037	217.534	N7° 10'56,44639 "	E 2° 00'01,90159 "	243,752
BJCO	439177.058	705758.727	7.573	N6° 23'04,78382 "	E2° 27'00, 06951 "	30,726

Source: Department of Geodesy and Grading of the IGN, 2018

All the points used for GPS observations during our work are geodetic points consisting of sealed metal stakes set up by the Geodesy and Leveling Service of the IGN as part of the work to determine a Geoid for the Benign. These points were observed in static mode with the Trimble R7 and R8 GPS receivers and then calculated in post-processing to achieve centimeter accuracy with the TBC software. The altitude of these points is determined by direct leveling with a DNA03 level of Leica and an invar pattern of two (02) metres. These points had two observation seasons and the results obtained after comparison gave a difference of a few millimeters both in planimetry and altimetry.

Among these points, five (05) were used as RTK base station and their known coordinates obtained from the IGN archives are:

[3] Real Time Kinematic
[4] National Geographic Institute

Table 2. Coordinates of reference points

Point ID	East (m)	North (m)	Altitude RNGB (m)
BRNC06	432299.737	701953.070	5.167
BRNC15	431249.965	705613.069	5.116
BRNC20	434676.898	704321.393	5.564
BRNC31	436329.059	705565.231	2.291
IGN207	437988.234	702959.316	3.801

Source: IGN Archives Benin, 2018

INSTRUMENTS

The hardware consists mainly of dual frequency GPS / GNSS receivers: Trimble_R7, CHC_X91, ComNavT300 and StonexS9i and their accessories.

METHODOLOGICAL APPROACH

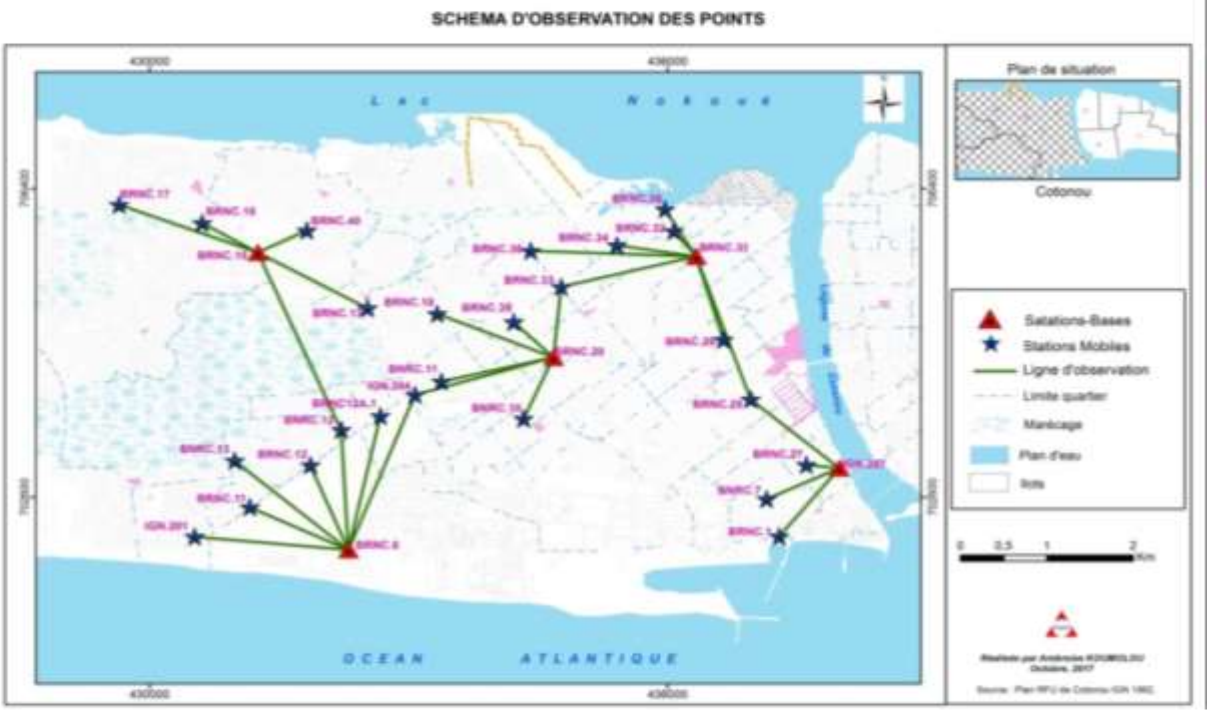
The methodological approach adopted is hereby declined as follows:

- A survey of geometer-experts and other users of GPS/GNSS receivers in Benin ;
- Series of GPS / GNSS observations in the field ;
- Processing of data from observations ;
- An analysis of the results in relation to the requirements of the standards applicable to topographic and cartographic works in the Republic of Benin.

CHOICE OF POINTS

For our experimentation, we put ourselves in the conditions of the RTK readings, the details to be noted are the points set up in the framework of the geoid determination in the western part of the city of Cotonou. We have chosen five (05) to serve as a base RTK in order to cover all of these points. They were observed in static mode with all the receivers selected for this study. Around each of these points, an average of six (06) other points were identified and observed in kinematic mode in five (05) seconds. Figure 1 shows the distribution of all the points retained among those existing in the field.

Figure 1. Location of points selected for GPS observations



The GPS observations were made in static positioning and the calculations were done in post-processing. The data from each GPS / GNSS receiver has been processed with most frequently used processing software (CGO, COMPASS, LGO and TBC) in order to appreciate the influence of various software on data processing. At the same time, we processed these same data not only in relation to the closest permanent station of the experimental site, COTONOU, but also in relation to a permanent station more than 100 km away, ABOMEY, to highlight the influence of the positioning of the permanent stations on the results.

RESULTS AND DISCUSSION

RESULTS

STUDY OF OBSERVATION MODES PRACTICED BY USERS OF GPS / GNSS RECEIVERS

Table 3. Synthesis of positioning mode practiced

Questioning	**Quantitative analysis of the survey**	**Comments / Observations**
Positioning mode practiced	Static: 27%	The surveyed firms practice static mode only for post-processing determination of the position of the point to be used as the basis for RTK operations
	Kinematics: 100% practicing the RTK in relative mode	80% with a geodesic point known as a reference.
		20% with base in free station without known point.

OBSERVATION RESULTS

The results of the treatment of the various observations are presented according to each GPS / GNSS receiver (ComNav T300, CHC X91, STONEX S9i), and by processing software (Compass Solution, CGO, LEICA Geo Office Combined, Trimble Business Center). Each result is compared to the reference coordinates and the gaps are highlighted.

The Comparison of differences between coo navigated data and reference coordinates is presented in the following Table IV:

Table 4. Result of the comparison of the coordinates navigated with the reference coordinates

Points	**Differences (Ec)**		**Position Difference (Ec pos)**	**Average Position Difference**	**Comparison of Ec pos at the values of the Thresholds.**	**Number of deviations exceeding the 1st Threshold**	**Number of deviations exceeding the 2nd threshold**	**Receivers**
	Ec X	**Ec Y**	**Ec pos (cm)**	**Emoy Pos (cm)**	**Ec pos is**			
BRNC06	-0,792	-0,43	90,12		> 2nd &> 1st Threshold			
BRNC15	0,543	-1,199	131,623		> 2nd &> 1st Threshold			ComNav T300
BRNC20	0,94	0,036	94,069	164,18	> 2nd &> 1st Threshold	5	5	
BRNC31	1,02	-0,929	137,965		> 2nd &> 1st Threshold			
IGN 207	2,359	2,813	367,122		> 2nd &> 1st Threshold			

BRNC15	-2,066	0,426	210,946		> 2nd &> 1st Threshold			
BRNC20	-0,971	0,429	106,155		> 2nd &> 1st Threshold			CHC X91
BRNC31	3,48	0,787	356,788	286.868	> 2nd &> 1st Threshold	5	5	
IGN 207	0,694	-2,506	260,032		> 2nd &> 1st Threshold			
IGN 207	2,953	4,04	500,418		> 2nd &> 1st Threshold			

BRNC06	-0,356	0,483	60,002		> 2nd &> 1st Threshold			
BRNC15	0,179	-0,024	18,06		> 2nd &> 1st Threshold			Stonex S9i
BRNC20	1,608	0,639	173,031	178,89	> 2nd &> 1st Threshold	5	5	
BRNC31	0,779	-0,696	104,463		> 2nd &> 1st Threshold			
IGN 207	2,983	4,488	538,892		> 2nd &> 1st Threshold			

DISCUSSION

EVALUATION OF STATISTICS OF EFFECTIVE USE OF DUAL-FREQUENCY GPS / GNSS RECEIVERS IN TOPOGRAPHY AND MAPPING

According to the firm's investigations, it appears that almost all the firms surveyed have at least one dual-frequency GPS/GNSS receiver, and even those who do not have it are assisted by the services of operators who have them. Most of these firms have various types of receivers often of Chinese origin with various types of software that can provide data post-processing. However, those who own Leica brand receivers do not always have a license for post-processing. They therefore opt for RTK positioning in relative mode. From the results of these surveys, it emerges that all the cabinets opt for positioning in RTK mode for most of the work. For this positioning mode, 100% uses a geodesic point as a base if there is one; 20% use it with the base in free station without known point.

CRITERIA FOR EVALUATION AND ANALYSIS OF RESULTS

Following the provisions of Order No. 0068 / MUHRFLEC / DC / SGM / IGN / DGURF / SA of 28/12/2009 laying down the standards and technical specifications applicable to topographic and cartographic work in the Republic of Benin, the accuracy class for the GNSS survey work is two (02) centimeters. For this class of precision, it is indicated the different tolerance thresholds to be applied. Thus for the five (05) points that served as the basis for this work, the following table summarizes the different criteria to be observed. Table V presents the thresholds for the 2cm precision class.

Table 5. Criteria for validation of observations

Number (N) of objects in the sample	5	k value	2,42
Requested accuracy class	2 (cm)	The average deviation in position must be less than	2,3 cm
Coefficient of security (C)	2	First threshold [T1]	5,4 cm
Number [n] of object coordinates	2	Second threshold (T2)	8,2 cm

		Maximum number allowed (N ') of deviations exceeding the first threshold	1
		Maximum allowed number of deviations exceeding the second threshold	0

It can be seen from Table IV that for all the types of receiver used, all the positional deviations which should be less than 2,3 cm are found beyond the meter; exceeding the tolerance thresholds set. It can therefore be held that the topographic work carried out with the two-frequency static-mode receivers without post-processing is not linked to the systems of the network of permanent stations, regardless of the degree of reliability of the said receivers.

INFLUENCE OF SOFTWARE
The analysis of the results shows that the differences in position on the same points vary from one processing software to another while remaining for the most part less than the required tolerances.

However, anomalies noticed during the treatment of certain points require interrogations. Thus, the data relating to the determination of the BRNC15 could not be processed by the LGO software while the treatment with the COMPASS and CGO software gives satisfactory results. On the other hand, the TBC gives a particular result which indicates a change of position of the BRNC15 between the initial situation and the post-treatment. Nevertheless, the baseline processing report indicates "fixed" as the solution type with very good Ratio and RMS. The treatment of this baseline taken from the permanent stations of Cotonou and Abomey, failed on both sides of any of the satellites selected for treatment.

On the other hand, when processing data from the ComNav T300 receiver, the Compass software was unable to process this data from the Abomey permanent station, while the CGO was able to do the post-processing. This confirms the hypothesis that software significantly influences the results of post-processing. The BRNC31 and IGN207 points of the position deviations greater than 9cm (greater than the required tolerances) are found on the processing done by the CGO, while the software TBC, Compass and LGO give with these same basic data differences in positions Less than tolerance. What further confirms this hypothesis.

INFLUENCE OF PERMANENT STATIONS
It is noted that the comparative study of the results obtained after the treatment with the permanent station of Abomey, and the results obtained after the treatment with the permanent station of Cotonou, shows no significant difference. This confirms that as soon as the distance criterion is mastered with the increase in observation time, the choice of permanent stations does not unduly influence the results of data processing.

CONCLUSION
GPS topography has become widespread because of the many advantages it offers in terms of accuracy and time savings. However, the techniques employed are radically different from those of conventional topography. GPS measurements are relatively simple and provide good results if certain basic rules are followed. From a practical point of view, it is essential for any GPS / GNSS tool user in general and, more particularly, survey technicians to master the basic rules relating to the planning, collection and processing of data. Thus, it would be desirable for managers of firms and all other structures working with GNSS to appropriate deep theoretical knowledge for better monitoring and efficient project management. It is very important to introduce redundancy into the network being measured. This implies determining certain points several times (at least two) and introducing controls to detect errors that otherwise would have been unnoticed. As prospects for the use of GNSS in Benin, we suggest the implementation as planned, on existing permanent stations, of devices that can allow the realization of real-time kinematic surveys, in network mode. Such a network could be started by permanent stations in large urban centers such as Cotonou and Parakou. Then follow the other permanent stations, waiting for the densification of the network by nine (09) other permanent stations. Finally, the order of expert geometricians must be activated for the pooling of efforts by pooling the means of the cabinets for the creation of a system of GNSS station private relay, in addition to the public network of the IGN. This system in the long run could turn into a private GNSS network.

REFERENCES

1. DEGBEGNON L. & HOUINOU G. (2012). Challenges and perspectives of the Beninese geodetic network with the establishment of permanent stations, Journal of Scientific Research of the University of Lome - Vol 14, No 1 (2012). pp. 73-78.
2. Delegation for Territorial Planning (DAT), (2006). "Land Reform in Benin: Towards the formulation of a comprehensive program", Provisional version, December 2006. Presidency of the Republic. Civil Cabinet. p 5.
3. DURAND S. (2003) Improvement of the accuracy of real-time differential localization by phase measurement of GNSS systems: detailed study of observation equations and the problem of solving entire ambiguities.249p.
4. KIKI S. (2008) Contribution of GPS / GNSS technology to land security in Benin.2p.
5. LAHAYE R. and LADET S., (2014). Differential correction networks. 9p.
6. Law n° 2017-15 modifying and completing the law 2013-01 of 14 August 2013 in the Republic of Benin. 172p
7. MOREL L. - DURAND S. (2008) XYZ Review N° 115. 2nd quarter.
8. VUILLEMEY A (2006). Optimization of the use of GPS for land and bathymetric missions in the Rhône-Alpes region. 4p.