Testing the performances of dual frequency GPS Real Time in The operations of implanting and survey

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Key words: Real Time GPS, dual frequency, total station, survey, implanting.

Summary

The fields of applications of GPS are becoming increasingly wide and diversified. In particular, the Real Time Global Positioning System (RT-GPS) technique knows more and more developments and great expansion especially in the fields of geodesy, surveying, cartography and photogrammetry.

In Surveying engineering, GPS RTK techniques present some advantages with respect to the conventional methods. But dual frequency RT-GPS was not tested enough in the operations of implanting and surveys within a project of allotment. Private surveying engineering societies are interested to know the advantages of using such equipment in this kind of operations. This article tries to respond to this question.

Let's recall that, eight years ago, within the department of geodesy and surveying of the IAV HASSAN II, the one frequency Real Time Kinematic GPS was tested in urban allotment projects with success.

The present article presents another set of experimental tests using a dual frequency RT-GPS in two projects of allotment, which include implanting works and survey operations as well. Several experimental tests are conducted using GPS in different modes (RTK, RTK with post processing and STOP &GO).

In order to evaluate the performances of the dual frequency RT-GPS in this kind of surveys, results are compared to those achieved using total station.

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1. INTRODUCTION

The fields of applications of GPS are becoming increasingly wide and diversified. In particular, the Real Time Global Positioning System (RT-GPS) technique knows more and more developments and great expansion especially in the fields of geodesy, surveying, cartography and photogrammetry.

In Surveying engineering, GPS Real Time Kinematic (RTK) techniques present some advantages with respect to the conventional methods. But dual frequency RT-GPS was not tested enough in the operations of implanting and surveys within a project of allotment. Private surveying engineering societies are interested to know the advantages of using such equipment in this kind of operations. This article tries to give some lights to this issue.

The present article presents a set of experimental tests using a dual frequency RT-GPS in two projects of allotment, which include implanting works and survey operations as well. Several experimental tests are conducted using GPS in different modes (RTK, RTK with post processing and STOP &GO).

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2. THE REAL TIME KINEMATIC GPS

Compared to the conventional methods, the Global Positioning System has several qualities. In fact, the observations can be carried out day and night, whatever the weather conditions are, and it exceeds the problem of inter-visibility (Dupraz, 1997). GPS method can be used in differential mode or in real time kinematic mode. Using GPS in differential mode, results are available only after data processing with suitable software.

The advantage of using GPS in real time kinematic mode is that, data collected by the base receiver (the reference station) are immediately transmitted to the rover receiver by means of a radio link from the base receiver to the rover. Therefore, data of the two receivers are combined and treated by a software in the mobile receiver. Consequently, the results are available immediately after data collection and processing in the field.

3. EXPERIMENTAL TESTS

The experimental tests were conducted in two projects of allotment located in the in the surrounding area of Casblanca city. The firts allotment is limited North, and Est by constructed allotments. While the second allotment is surrounded by unbuilt lands.

3.1 Methodology

For a suitable testing of the performances of dual frequency RT-GPS in implanting and survey project, the following methodology was adopted.

- Densification using total station and GPS as well,
- implantation using GPS,
- survey operations using total station,
- survey operations using GPS in three modes:
  - a) RTK,
  - b) RTK with post processing;
  - c) RTK Stop & GO mode.
- comparison of results for different tests,
- analysis of results.

In the two projects of experimental tests, after implanting using GPS, we have done four surveying tests that consist in:

Case n°1: surveying observations using total station.
Case n°2: surveying observations using GPS RTK mode.
Case n°3: observations using GPS RTK in post processing mode.
Case n°4: observations using GPS stop & go mode.

3.2 Equipment used in the experimental tests

The equipment used during this experimental study is composed of:

- Three receivers of the type TRIMBLE 5800/R8, dual frequency
- Two electronic notebooks.
- Two radio operator modems allowing data transmission and reception.
- Other GPS accessories.
- Total station Topcon GTS 312: that has the following accuracies :
  ± 2 mm + 2 ppm for distances measurements
  ± 30 mgon for angular measurements.
- Field survey accessories.
- GPS & Surveying softwares

Note that GPS RTK mode and GPS RTK with registration mode observations are carried out respecting the following standards:

- Occupation time : 30 sec.
- Interval of registration: 5 sec.

On the other hand, GPS Stop & GO mode observations are carried out respecting the following standards:

- Initialization time : 10 min.

– Occupation time : 30 sec.
– Interval of registration: 5 sec.

4. RESULTS OF TESTING THE PERFORMANCES OF GPS

In order to evaluate the performances of dual frequency GPS in surveying operations, we have compared the coordinates obtained using different GPS modes to those obtained by total station, using the following equations:

DX = X (case n° 2, 3, 4) - X (case n°1)
DY = Y (case n° 2, 3, 4) - Y (case n°1)

While the performances of dual frequency GPS in implanting operations are obtained by comparison of coordinates obtained using different modes to those obtained by implanting, as shown by the following equations:

DX = X (case n° 1, 2, 3, 4) - X (Implantation)
DY = Y (case n° 1, 2, 3, 4) - Y (Implantation)

4.1 Comparison of results in the first project

a) Results of surveying tests

In the first project, the number of control points used in the tests is limited to 16. The statistical parameters of differences between coordinates are summarized in table 1.

Statistical Parameters	*Differences between coordinates*					
	RTK		*RTKpp*		*STOP and GO*	
	DX (cm)	*DY (cm)*	*DX (cm)*	*DY (cm)*	*DX (cm)*	*DY (cm)*
Min	1	0	1	0	0	1
Max	5	4	5	5	5	5
Average	3	1	3	1	2	3
St dev	1	1	1	1	1	1

Table 1 : surveying statistical parameters of the first project

b) Results of Implanting tests

Parameters	*Differences between coordinates (cm)*

	total Station		*RTK*		*RTKpp*		*STOP and GO*	
	DX	***DY***	***DX***	***DY***	***DX***	***DY***	***DX***	***DY***
Min	*0*	*0*	*0*	*0*	*1*	*0*	*1*	*1*
Max	*7*	*5*	*4*	*5*	*5*	*6*	*4*	*8*
Average	*1*	*2*	*2*	*2*	*2*	*3*	*3*	*5*
St dev	*2*	*2*	*1*	*2*	*1*	*2*	*1*	*2*

Tableau 2 : implanting statistical parameters of the first project

Control: this control consists in comparing the distances (between control points) adopted to those obtained by different methods: this comparison gives differences which vary generally between 0 and 6 cm.

Parameters	***Differences between distances (cm)***			
	TS	***RTK***	***RTK pp***	***STOP &GO***
Min	*0*	*0*	*0*	*1*
Max	*4*	*6*	*4*	*4*
Average	*1*	*2*	*1*	*2*
St Dev	*1*	*2*	*1*	*1*

Table 3 : comparison of distances between control points

4.2 Comparison of results in the second project

a) Results of surveying tests

The number of control points in the second project is 11. In this second project, the differences between coordinates obtained using the four cases in surveying observation vary between 0 and 7cm in X, and between 0 and 5 cm in Y. the maximum standard deviations are 1cm and 2 cm in X and Y respectively.

b) **Results of Implanting operation tests**

In these tests, the differences in coordinates obtained using the four cases vary between 0 and 7 cm in X, and between 0 and 6 cm in Y. The maximum standard deviations are 2 cm in X and Y.

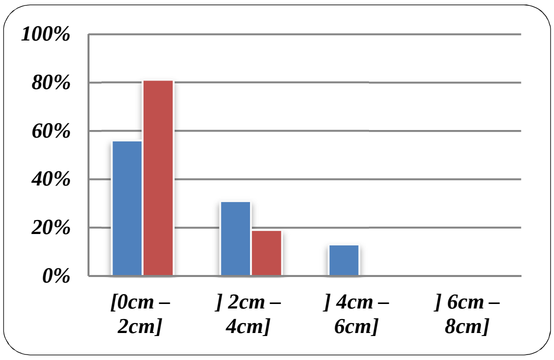
Control: In this second project the comparison of the distances adopted to those obtained by different methods gives values which vary generally between 0 and 7 cm.

5. INTERPRETATION OF RESULTS

In order to have an overview of the differences obtained, we represent the results as histograms, with four interval classes that represent the differences between coordinates using the three GPS modes. Each interval class is 2 cm range.

5.1 Interpretation of surveying operations results in the first project

a) Comparison between total station and GPS RTK



This chart represents the variation of coordinate differences between total station & GPS RTK mode. From this chart we can see that:

- 56% of the differences in X and 81% of the differences in Y belong to class one
- 31% of the differences in X and 19% of the Y differences belong to class two,
- Only 13% of the differences in X and 0% of Y differences belong to class three

b) Comparison between total station and GPS RTK post processing mode

In this case the differences are distributed as follow:

- 31% of the differences in X and 88% of the differences in Y belong to class one
- 56% of the variation in X and 6% of the variation in Y belong to class two.
- 13% of the variation in Y and 6% of the variation in X belong to class three

c) Comparison between total station & STOP and GO mode

In this third case the differences are distributed as follow:

- 56% of the differences in X and 39% of the differences in Y vary between 0 and 2 cm.
- 39% of the differences in X and 44% of the differences in Y vary between 2 and 4 cm.
- 6% of X differences and 17% of Y differences vary between 4 cm and 6 cm.

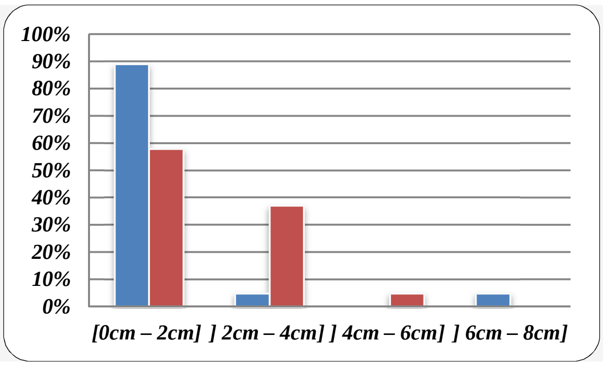
5.2 Interpretation of implantation operations results in the first project

This part concerns the interpretation of differences between the coordinates of implantation and those obtained by the four following methods:

- using total station
- using GPS RTK mode

– using GPS RTK post processing mode
– using GPS STOP and GO mode.

a) Comparison between implanting and total station coordinates



In this first case, the differences are distributed as follow:

– 89% of the differences in X and 58% of the differences in Y are less than 2 cm
– 6% of differences in X and 37% of the differences in Y are between 2 cm and 4 cm.
– 5% of Y and X differences are located between 4 cm and 6 cm.

b) Comparison between implanting and RTK mode coordinates

In this second case the differences are distributed as follow:

– 73% of the differences in X and 53% of differences in Y are less than 2 cm.
– 27% of the differences in X and 33% of differences in Y are located between 2 and 4 cm.
– 14% of differences in Y vary between 4 cm and 6 cm.

c) Comparison between implanting and RTK post processing coordinates

In this third case, the differences are distributed as follow:

– 69% of differences in X and 44% of differences in Y are less than 2 cm
– 25% of differences in X and 25% of differences in Y are between 2 and 4 cm.
– 6% of X differences and 31% of Y differences are between 4 cm and 6 cm.

d) Comparison between implanting and Stop & GO coordinates

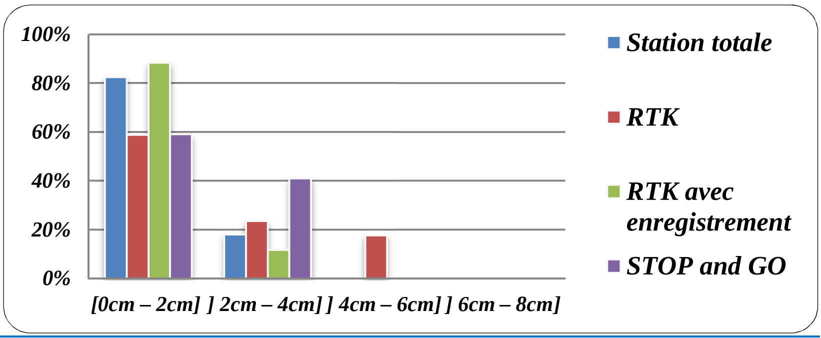
In this fourth case the differences are distributed as follow:

– 37% of the differences in X and 11% of the differences in Y are less than 2 cm.
– 63% of the differences in X and 26% of the differences in Y are between 2 and 4 cm.
– 42% of the variation in Y are between 4 cm and 6 cm.
– 21% of the variation in Y are between 6 cm and 8 cm.

From these comparisons we can conclude that in the first three cases the major differences in X and y are less than 2 cm.

Control of distances between control points

The following chart represnts the differences between the distances obtained using different methods versus distances calculated from the coordinates of implantation.



- 82% of the differences between the adopted distances and those calculated from the coordinates of the survey directly using the total station are less than 2 cm.
- 59% of the differences between the adopted distances and those calculated from the coordinates of the real-time survey vary between 0 and 2 cm.
- 88% of the differences between the adopted distances and those calculated from the coordinates of the real-time survey with post processing are less than 2 cm.
- 59% of the differences between the adopted distances and those calculated using STOP and GO survey coordinates are less than 2 cm.

6. CONCLUSION

The main purpose of the present study is to test and analyze the performances of the dual frequency GPS RTK in surveying and implanting as well.
The analysis concerns essentially two main levels: the accuracy and the practical field operations.

In terms of accuracy

- The differences between computed and observed distances using different methods of observation do not exceed 8 cm. In major cases, these differences are less than 2 cm.
- In this study the implanting coordinates have accuracies within 10 cm of the project coordinates.
- The results of RTK and RTK post processing modes are similar

From a practical point of view

- The Dual-frequency GPS is equivalent to the total station in case of a small area project

- The Dual-frequency GPS is more effective in the case of a large project area
- Densification of control points is easier and efficient using GPS dual frequency compared to total station (in terms of time and number of people).
- The number of GPS field stations needed for survey operations is very reduced copamred to total station needs.

Nevertheless, the GPS and the total station have each other qualities that can be more effective in a case without being powerful in another. Thus, we can say that the GPS and the total station can be used with enough accuracy in survey and implanting as well.

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