Australian Journal of Basic and Applied Sciences
2019 August; 13(8): pages 147-153
DOI: 10.22587/ajbas.2019.13.8.19
Original paper
AENSI Publications
Journal home page: www.ajbasweb.com

Studying the Effects of Broadcast and Precise Ephemeris form GNSS and GPS only on Position Accuracy

Nasr El-Mohammedy Sabaa[1]*, and Ahmed Abd-Elhai Ahmed[2]

[1] Lecturer in Oct 6 University, Faculty of Engineering, Department of Civil Engineering, Egypt
[2] Lecturer in Benha University, Faculty of Engineering, Department of surveying Engineering, Egypt

Corresponding authors: Nasr El-Mohammedy Sabaa
Lecturer in Oct 6 University, Faculty of Engineering, Department of Civil Engineering, Egypt
Email: Nasr.saba.eng@o6u.edu.eg

Received date: 18 May 2019, Accepted date: 28 July 2019, Online date: 29 July 2019

Abstract
GLONASS signals enabled users to obtained positioning from GNSS constellation. Receiving signals from GNSS allows users to evaluate and control the positioning performance and data collected session. In this paper, the position performance of a baseline observed for nearly 3-hours has a length of 205 km was assessed. Precise and broadcast ephemeris from GPS only and form GLONASS and GPS combination (GNSS) were used. Data processing using LGO (Leica Geo Office 8.4) under different processing conditions and different session of data collection (0.5,1, 2, and 3 - hours) was done to obtain the positions of the unknown point (s2) related to the reference one (s1) for the selected baseline. Results indicate that systematic bias exists between GNSS and GPS-only for all conditions. In the smallest time observation (0.5-hour) only GNSS ephemeris has the capability of solving baseline ambiguity and obtain accepted position performance. A slight change in position performance within a few millimeters noted using ephemeris from GNSS and GPS (precise and broadcast ephemeris) in the case of using the entire full observation session (3-hours). 1- and 2-hours observations session got results very close to each other, only a few millimeter's deference indicated in 3-hour of the observation. The paper indicates that there is no solution before half of the hour of observation session except using GNSS broadcast ephemeris for this baseline length. Compared the solutions from GPS-only, the integration of GPS and GLONASS data can improve the 3-dimensional positions accuracy and reduced observation to 1/6 in baselines Within 200 km length.

Keywords: GNSS, GLONAS, GPS, Precise, Broadcast, Ephemeris

INTRODUCTION

Due to the expansion of GNSS (Global Navigation Satellite System), GNSS now is considered as standard for satellite measurements. Regarding GPS, GPS was the first element in GNSS; the first GPS satellite was launched in 1978. GPS constellation completed in 1995 as a first GNSS. Position quality increases based on the number and health of satellites active on the orbit. Currently besides GPS, also GLONASS (transliteration from Russian is GLObalnaya NAvigatsionnaya Sputnikovaya Sistema or Global Navigation Satellite System) is fully operable, next to them partly operable are Chinese BeiDou and European Galileo. Now, there are more than 80 GNSS satellites available (Maciuk et al., 2018).

Theoretically many potentials achieved from a more significant number of simultaneously visible satellites over the observation area. First, signals from multiple navigation systems help to reduce the observation duration; increases the quality and accuracy performance, especially in real-time positioning (RTK) (Li et al., 2015). Signals form sick (less accurate) satellites may be illuminated or take a certain weight to be proportional to its strength and quality. Shorten the duration of a session with a greater number of GNSS satellites are possible, especially for measurements that require accuracy and speed in delivery. There are also defects associated with the usage of GNSS measurements. The main defects include different datum or reference frames, GPS based on WGS48 while GLONASS based on Pz-90, so users need proper transformation parameters to complete the processing operation. The time also scales a significant difference in GNSS constellation; finally, the inter-channel is also biased (Píriz et al., 2009). Several sources of noise and errors affect the range measured by the GNSS receiver signals, and this is because they have very low power. So, the range measured by GNSS called pseudo-range because it is contaminated by these errors. The general pseudo-range observation equation is expressed as follows:

$$P^s{}_{\mathbf{r}} = \boldsymbol{\rho}_{\mathbf{r}} s + c(dt_{\mathbf{r}} - dT^s) + I^s{}_{\mathbf{r}} + T^s{}_{\mathbf{r}} + \varepsilon^s{}_{\mathbf{r}}$$

Where $P^s{}_r$ is the pseudo-range between the satellite and the receiver$r$. $\rho_r s$ Is the true geometric range, c is the light speed, and dt_r dT^s are the clock errors in seconds for the receiver and satellite. The symbol I and T denotes the ionosphere and tropospheric delay in meters, while ε combines the multipath and receiver noise errors

Relative and absolute positioning techniques are two types of satellite observation in use. Since the beginning of GNSS, relative positioning is the most accurate and common in use. Relative positioning based on information from a reference station or group of reference stations with known coordinates, they transmit corrections to the unknown's stations. In relativity techniques, most of the errors are reduced. Therefore, the relative positioning technique method is more precise than absolute positioning, and this is after taking into consideration the error of the reference stations. RTK (Real-Time Kinematic) technique is the most used differential positioning method based on relative positioning. Vertical component accuracy is three times smaller than horizontal ones regarding the construction and principle of GNSS operation (Li et al., 2015). With the Static measurements, a millimeter's accuracy can be achieved for respectively long session's length and short vectors. For the short baselines within a hundred meters, the accuracy could be less than a millimeter in 24-hours sessions (Tian et al., 2015). On the other hand, using a single vector baseline of 500-600 km with a one-hour observation session allows us to achieve 3D results better than 10 cm (Bae et al., 2006).

METHODOLOGY

Leica Geo-office software (LGO) was adapted and used for data processing in this paper. Data over two points form a single vector baseline were collected, the distance between them nearly 205 km. One of them is the master (S1) lies in Cairo- Egypt and has its coordinates in WGS 84 system; the other is the slave (S2) lies at 205km south of Cairo (near Wahat oasis). S1 and s2 were observed in static mode for nearly 3-hours of observation session with Leica dual-frequency GNSS receivers (GS 15-Model). In the combined GPS/GLONASS processing, the inter-frequency bias (IFB) in a receiver was estimated as a constant for each GLONASS frequency (Håkansson, Martin, *et al*., 2006). Raw data logging option in the static model used to collect raw data over the two stations S1 and S2 for nearly 3-hours using two Leica GNSS receivers, then the following strategy was followed: Coordinates of S2 (slave station) were obtained using S1 as a reference depending on broadcast ephemeris from GNSS and GPS only one time, and using precise ephemeris from GNSS and GPS only another time. Therefore, four conditions of process strategy were illustrated as following to get the processed coordinates of station S2:

- Using GPS broadcast ephemeris over processing session (0.5, 1, 2, 3 hours).
- Using GPS precise ephemeris over processing session (0.5, 1, 2, 3 hours).
- Using GNSS broadcast ephemeris, over the same processing session (0.5, 1, 2, 3 hours).
- Finally, using GNSS precise ephemeris, over the same processing session (0.5, 1, 2, 3 hours).

Figure 1 show the processing strategy followed in this paper

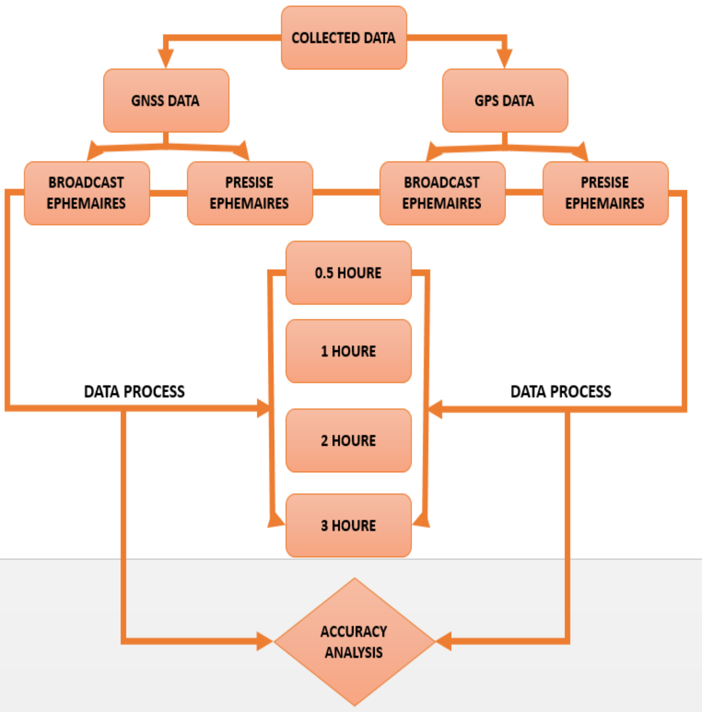

Fig1: processing strategy flowchart

During the process using LGO, some parameters were fixed for all cases; the options of fixed processing parameters in the paper are listed in Table 1. According to table 1, seven items for processing were fixed during this research: (1) LEICA Geo Office 8.4 software (LGO) is the used software (2) WGS84 is the selected coordinates system (3) Cut-off angle (4) Fix ambiguities up to (5) Solution (6) Ionosphere model (7) Troposphere model. In the following lines, some general notes were introduced for these parameters, also Explain why certain values are chosen for some of these parameters in this paper.

Table 1, Fixed Proceeding parameters

Item	**Condition**
Application software:	LEICA Geo Office 8.4
Coordinate system name:	WGS 1984
Cut-off angle:	15°
Fix ambiguities up to:	300 km
Solution (L1-L2-L3)	Automatic
Ionosphere model:	Klobuchar
Troposphere model:	Hopfield

As the used GPS instrument was Leica GNSS dual-frequency receiver, GS 15, so the desired software is Leica Geo Office 8.4, LGO work with files have DBX format, it also has the capability of RINEX conversion. The coordinates of point S1 were obtained in the horizontal datum WGS84, so no transformation parameters need for any conversions.

15° Cut-off angle was used and fixed during data process in this paper as observations to satellites having low elevation angle can sometimes cause problems and data loss may occur. For this reason, the recommended procedure is to increase the satellite cut–off angle for elevation. Sometimes the resolution of ambiguities, may have problems, the solution may be in increase by increasing the cut–off angle; this also might improve final processing results over selected stations, S1 and S2. This is due to when cutting off the noisier has low elevation, the overall phase noise of the satellite can be reduced. As 205 km is the baseline length between the observed points S1 and S2 (the master and slave), so fix ambiguities up to 300 km is the selected value as fixed processing parameters instead off its default value (80km). The default value notable us to resolve the ambiguities as the baseline longer than 80km. The selected value (300 or 80 km) determined the maximum baseline distance supported by LGO software and should try to for ambiguities resolve. But when the limitation of this value becomes higher take care should be doing because in this case, float solution may be computed for baselines above this limit.

Regarding to frequency and solution type, frequency parameter defines which the data will be processed in terms of L1 and L2 or L3. The following options are introduced in LGO : (1) Automatic (2) L1 (3) L2 (4) L1+L2 (5) Iono-free (L3). If dual-frequency receivers used, as in this case, both frequencies (L1 + L2) will typically be used. If data in the form of dual-frequency is available and longer than 15 km baseline observed, as in this case (205 km is the baseline distance), L3 solution will be used by LGO software. At this extent, two cases will happen: (1) ambiguities resolved previously and LGO introduced ionosphere-free solution or (2) ambiguities have not been resolved and LGO introduced L3 float solution. Choosing L1+L2 directly will force LGO to use L1 and L2 frequencies without using iono-free processing, not considering the baseline length. Choosing Iono free (L3) will aid the LGO to compute an L3 solution not considering of the baseline length between S1 and S2.

The ionosphere formed of tenuous electrically of charged gas named plasma that exists in altitudes between 100-1000 km around the Earth. As both the troposphere and a signal path delay cases by the ionosphere, which reaches to several tens of meters in some cases. The Ionosphere model parameter defines which model is used to solve the problem and reduce the impact of the ionosphere. This is important if ambiguities tried to be resolved. The Klobuchar model used in LGO reflects solar activity during the 11-year cycle; it is particularly well and can be advantageous during high solar activity periods **(LGO HELP)**. The LGO Klobuchar ionosphere model should only be used if Leica receiver's observation data is being used for processing as in this case since this type of data included the necessary files of the almanac. Because of the missing almanac, the processing parameters automatically switch to No model, this is in the case of the observation data has been imported via RINEX and the Klobuchar model is selected,

The troposphere which is one of the selected fixed parameters during the process is the atmosphere part is up to altitudes of about 30 kilometers which reflect a delay in the propagation of the electromagnetic waves as those used in GPS or GLONASS. For computing this delay in GNSS signals, one must know the behavior of the refractive index for the troposphere. Many of troposphere models are available. These models are based on data for temperature, pressure, and relative humidity around the station on the ground. Analyses of these parameters allow this path delay in the signals to be computed. A few millimeters are the differences that result from using different models of the troposphere. It is recommended that locally model adopted for computations for a country area. But for lack of troposphere model, Hopfield was used as the system default model in this paper.

RESULTS AND DISCUSSION

After the process, seven items are taken into consideration for the evaluation process. (1) Ambiguity status; (2) solution type; (3) frequency; (4) position quality; (5) height quality; (6) position and height quality; (7) The baseline length; and (8) stranded deviation for the measured distance. Regarding to ambiguity, all possible combinations of ambiguities searches by LGO. Most probably the correct solution and the second most probably correct solution determine using rigorous statistical techniques by LGO. The most probable solutions are then analyzed and compared, if the probability of the first solution is likely to be correct than the second solution, in this case, the first solution is taken as the correct answer (LGO HELP).

In this paper, the solution fixed, and ambiguity was solved in all cases except 3 cases in the small observation time (0.5 hours). These three cases are: precise GNSS; broadcast GPS; and precise GPS as in table 2.

Table 2: Ambiguity statues for all observation session

Ephemeris Type	0.5H	1H	2H	3H
Ambiguity Statues				
Broadcast GNSS	✓	✓	✓	✓
Precise GNSS	☒	✓	✓	✓
Broadcast GPS	☒	✓	✓	✓
Precise GPS	☒	✓	✓	✓

✓ Fixed all

☒ Float

The explanation of the float solution is that half-hour observation was not enough to fix the ambiguity for a baseline has 205 km. Raw data logging in half-hour observation time was able to fix the ambiguity in the case of GNSS Broadcast solution as there was a potential of combination GPS and GLONASS satellites data over the sky of S1 and S2. The combination of GPS and GNSS Gives the opportunity the great number of common satellites to observe from S1 and S2. There was no problem with the ambiguity solution for other cases. Regarding position accuracy, the best case was broadcast GNSS over 2 and 3-hours, Table 3. Half hour observation was the best case among the four cases in the same session (0.5 Hour).

Slightly improvement in all cases for position performance starting from 2-hour observation to 3- hours occurred. Broadcast GNSS not precise was not the best case of position performance; this may be due to errors due to using not accurate precise orbits data in the processing operation at least in this paper. Height quality of position performance also achieved in the same case of broadcast GNSS overall case of time observation and process except for half an hour case. Half an hour case was the worst case among the four cases. Also, slight improvement noted starting from 2-hours to 3-hours of observations. Therefore, the same pattern of the results realized in the case of position and height quality.

Results in the same context for position and height quality compared with position only and height quality only. In the case of the base line length, the superiority for base line length performance indicates in the smallest stander deviation value, which is in GNSS broadcasts ephemeris. It is remarkable that, in all cases of the GNSS and GPS ephemeris, superiority in accuracy performance was achieved in the case of GNSS broadcast. In GNSS case, the position quality was 0.0006, 0.0004, 0.0003 and 0.0003 m in 0.5 H, 1 H, 2 H, and 3 H respectively of all session using broadcast ephemeris, table 3 and figure 2. GPS broadcast was in the second rank, while the two other cases were in the final rank. Height quality was 0.0011, 0.0008, 0.0007 and 0.0006 m in 0.5 H, 1 H, 2 H, and 3 H respectively of all session using GNSS broadcast. Also, GPS broadcast was in the second rank, table 4 and figure 3. Regarding position and Height quality, the accuracy was 0.0013, 0.0009, and 0.0008 and 0.0007 m in 0.5 H, 1 H, 2 H, and 3 H respectively of all session using GNSS broadcast, GPS broadcast was in the second rank, while the two other cases were in the same rank, table 5 and figure 4.

The change in the base line length was dramatically after 0.5-hour observation time in all case except using ephemeris from broadcast GNSS. The standard deviation value was 0.0005, 0.0003, 0.0003 and 0.0002 m in 0.5 H, 1 H, 2 H, and 3 H respectively of all session using GNSS broadcast, while all other 3 cases were in the same rank. Using ephemeris from broadcast GNSS, the baseline length was stable to some extent starting from half-hour observation to 3-hours observation, and this means that, using broadcast ephemeris, the solution was close to the Absolute results in this case, table 6 and figure 5. Overall, GNSS has good potential in a small session for a slightly longer baseline at least in this paper. Broadcast ephemeris shows superiority in position performance quality better than precise ephemeris, thus may be due to Problems with precision orbit calculations at the time of the observation.

Table 3: Position quality for an observation session

Ephemeris Type	**0.5h**	**1H**	**2H**	**3H**
Position Accuracy [M]				
Broadcast GNSS	0.0006	0.0004	0.0003	0.0003
Precise GNSS	0.0075	0.0006	0.0004	0.0005
Broadcast GPS	0.0075	0.0005	0.0006	0.0006
Precise GPS	0.0075	0.0006	0.0004	0.0005

Table 4: Height quality for all observation session

Ephemeris Type	0.5h	1H	2H	3H
Height Accuracy [M]				
Broadcast GNSS	0.0011	0.0008	0.0007	0.0006
Precise GNSS	0.0038	0.0011	0.0008	0.001
Broadcast GPS	0.0038	0.0011	0.0012	0.0012
Precise GPS	0.0038	0.0011	0.0008	0.001

Table 5: Position and Height quality for station for all observation session

Ephemeris Type	0.5h	1H	2H	3H
Position And Height Accuracy[M]				
Broadcast GNSS	0.0013	0.0009	0.0008	0.0007
Precise GNSS	0.0084	0.0012	0.0009	0.0011
Broadcast GPS	0.0084	0.0012	0.0013	0.0013
Precise GPS	0.0084	0.0012	0.0009	0.0011

Table 6: Baseline length for all observation session

Ephemeris Type	0.5H	1H	2H	3H
Base Line Length (205580.000) [M]				
Broadcast GNSS	0.035	0.033	0.0476	0.0647
Precise GNSS	0.201	0.031	0.0517	0.04
Broadcast GPS	0.242	0.025	0.0211	0.0282
Precise GPS	0.227	0.032	0.0517	0.04

Table 7: Baseline St. Dev for all observation session

Ephemeris Type	0.5h	1H	2H	3H
Base Line St. Dev[M]				
Broadcast GNSS	0.0005	0.0003	0.0003	0.0002
Precise GNSS	0.0055	0.0004	0.0003	0.0003
Broadcast GPS	0.0056	0.0003	0.0004	0.0004
Precise GPS	0.0056	0.0004	0.0003	0.0003

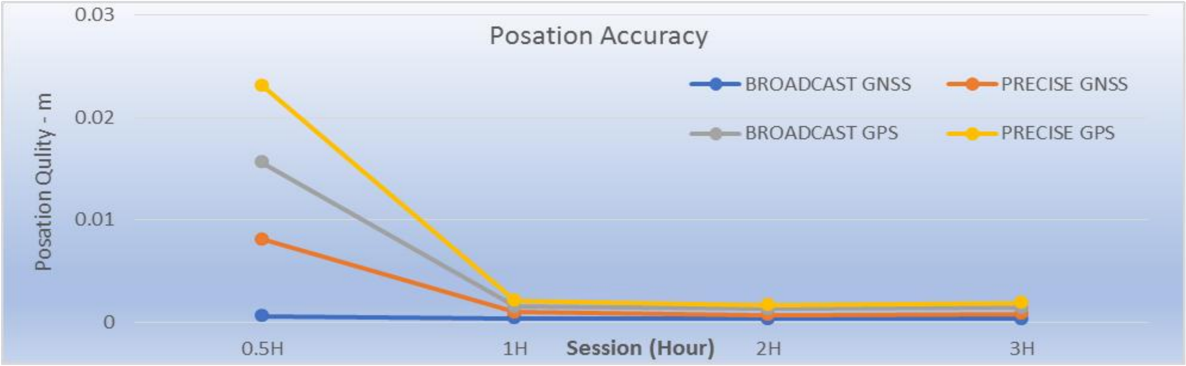

Fig 2: Position quality for all observation session

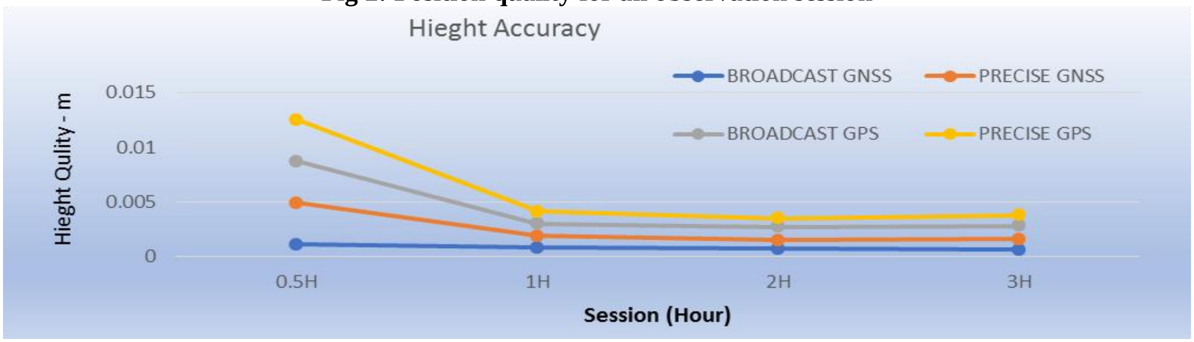

Fig 3: Height quality for all observation session

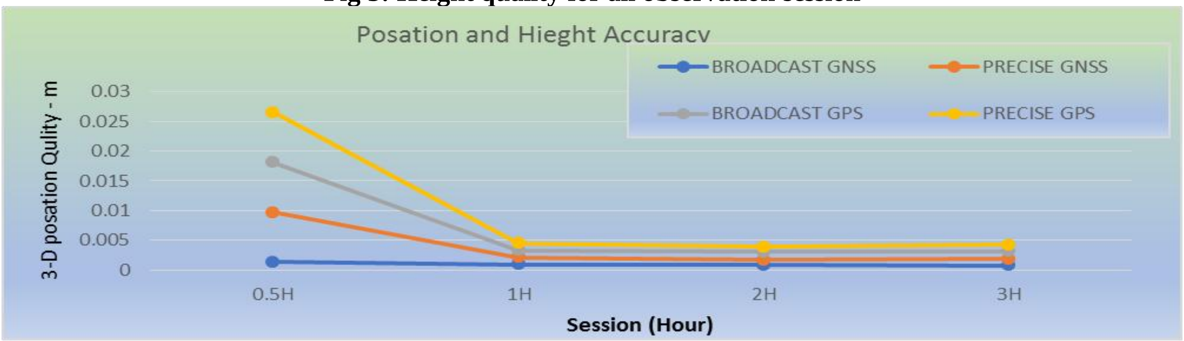

Fig 4:3-D Position quality for all observation session

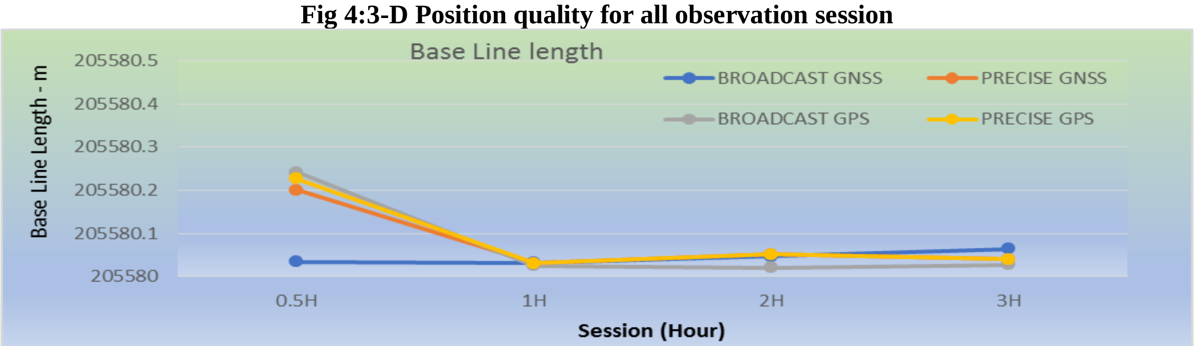

Fig 5: Base line length for all observation session

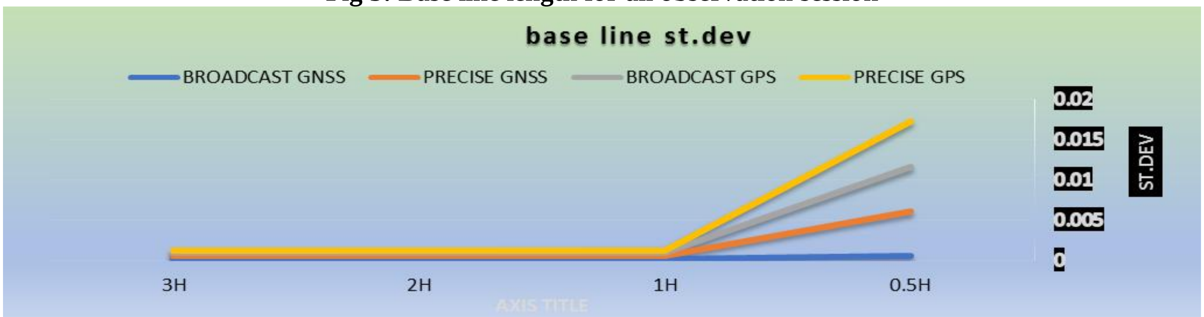

Fig 6: Standard deviation of the base line length for all observation session

CONCLUSION

With the availability of receivers work with the GNSS signal, new standards in satellite techniques were added. These new signals which combined to the existing GPS signal has a potential for the position accuracy and quality performance. The development of global navigation satellite signals requires also progress in solutions algorithms to be able to deal with this variety of signals. In this paper, GPS-only and GNSS (GPS and GLONASS) static observations mode for a baseline has a 205 km length was done. The baseline observed nearly for a 3-hour session of time. The process made using LGO software over 0.5,1,2, and 3-hours. Seven parameters were calculated, 1-D position quality, 2-D position quality, 3-D position quality, baseline length, standard deviation for the baseline length, this beside the ambiguity status. The paper shows a few millimeters improvement in position quality solutions using the combination of GPS and GLONASS compared with GPS only over the full-time session(3-hours). Adding GLONASS signals to GPS reduced the time of the observation to one over six getting nearly the same results performance, ambiguity was solved in the half-hour sessions only in the GNSS case.

References

Bae, Tae-Suk, Near real-time precise orbit determination of low earth orbit satellites using an optimal GPS triple-differencing technique, Diss. The Ohio State University, 2006

Håkansson, Martin, et al, , Review of code and phase biases in multi-GNSS positioning, *GPS Solutions* 21.3 (2017): 849-860.

Li, X., Ge, M., Dai, X., Ren, X., Fritsche, M., Wickert, J., & Schuh, H, Accuracy and reliability of multi-GNSS real-time precise positioning: GPS, GLONASS, BeiDou, and Galileo, *Journal of Geodesy*, *89*(6), 2015, 607-635.

Li, X., Zhang, X., Ren, X., Fritsche, M., Wickert, J., & Schuh, H,Precise positioning with current multi-constellation global navigation satellite systems: GPS, GLONASS, Galileo and BeiDou, *Scientific reports*, 2015, *5*, 8328.

Maciuk, K, GPS-only, GLONASS-only and Combined GPS+ GLONASS Absolute Positioning under Different Sky View Conditions, Tehnički vjesnik, 25(3), 2018, 933-939.

Píriz, R., Calle, D., Mozo, A., Navarro, P., Rodríguez, D., & Tobías, G ,Orbits and clocks for GLONASS precise-point-positioning, In *Proc. ION GNSS* ,2009, pp. 2415-2424.

Tian, Y., Ge, M., & Neitzel, F, Particle filter-based estimation of inter-frequency phase bias for real-time GLONASS integer ambiguity resolution, *Journal of Geodesy, 89*(11), 2015, 1145-1158.