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Evaluation The Performance Geodetic of the Receivers Using Static Positioning Technique

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ABSTRACT

Global Navigation Satellite System (GNSS) is considered to be one of the most crucial tools for different applications, i.e. transportation, geographic information systems, mobile satellite communications, and others. Without a doubt, the GNSS has been widely employed for different scientific applications, such as land surveying, mapping, and precise monitoring for huge structures, etc. Thus, an intense competitive has appeared between companies which produce geodetic GNSS hardware devices to meet all the requirements of GNSS communities. This study aims to assess the performance of different GNSS receivers to provide reliable positions. In this study, three different receivers, which are produced by different manufacturers, were fixed to form a triangle. Simultaneous observations were made in static mode (2.5 to 3 hours). This observation technique was carried out three times by changing the location of receivers in each time to ensure that three receivers observed each station three times. To evaluate the performance of each receiver, OPUS web-based processing software and TOPCON TOOLS were used to process the raw GNSS observations. The distances between adjacent stations were computed for each observation and compared to standard distances, which were measured using a total station. Furthermore, the internal angles were also computed and compared to those measured by Total Stations. The results showed that some calculated distances are closer to the corresponding distances measured by the total station. This indicates that the receivers involved in the composition of these distances are the most accurate.

Key Words: GNSS, GPS, receivers, Static Survey, Accuracy Evaluation

تقييم اداء متسلمات النظام العالمي للملاحة بالأقمار الاصطناعية المختلفة باستخدام أجهزة وتقنيات مختلفة

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الخلاصة

يعد النظام الملاحي العالمي من الانظمة المهمة في العديد من التطبيقات الجيودسية الواسعة والمختلفة، فقد استخدم في مجالات تحديد مواقع ووسائل النقل المختلفة مثل السيارات والطائرات والسفن. ومن ناحية اخرى يستخدم في العديد من التطبيقات العملية والعلمية كأنتاج الخرائط والمسح الارضي والرصد المستمر للإنشاءات الضخمة. لقد تنافست مؤسسات وشركات ضخمة في انتاج المتسلمات التي تستخدم النظام الملاحي العالمي لمعرفة وتحديد المواقع والاحداثيات الارضية. الا ان السؤال

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المطروح الان هو كيف يتم التأكد من ان هذه المواقع او الاحداثيات التي تزودنا بها تلك المتسلمات بمختلف انواعها هي احداثيات دقيقة وغير مخطوءة ؟ وهذا ما سيتم ايضاحه في هذه الدراسة.

حيث استخدمت ثلاث متسلمات مختلفة النوع ومن منشئين مختلفين لرصد ثلاث نقاط (تكون على شكل مثلث) في نفس الوقت بطريقة الرصد الثابت وبفترة زمنية للرصد تتراوح بين ساعتين ونصف الى ثلاث ساعات. تم اتباع اسلوب معين للرصد مبني على اساس التبادل بين مواقع المتسلمات في كل عملية رصد لكي يتم رصد كل نقطة بثلاث متسلمات من خلال ثلاث مجاميع للرصد. وللحصول على دقة عالية تتراوح من 3-5 ملم تم اجراء عمليات التصحيح على النقاط المرصودة بإرسالها الى موقع معين على الشبكة العنكبوتية (OPUS) اضافة الى تصحيح خط القاعدة الاساس باستخدام برنامج (TOPCON TOOLS). وبعدها يتم استخراج المسافات بين تلك النقاط في كل عملية رصد وهي تمثل اطوال اضلاع المثلث. ومن ثم قياس المسافات بين النقاط الثلاث (التي تمثل اطوال اضلاع المثلث) بأسلوب اخر عن طريق استخدام جهاز المحطة المتكاملة واجراء عملية التحقق من هذه المسافات عن طريق حساب الزوايا الداخلية للمثلث بقانون (COSINE). اظهرت النتائج ان المسافات المحسوبة بالأسلوب الاول تتباعد وتتقارب من المسافات المقيسة بالأسلوب الثاني وبعد تحليل النتائج نستنتج ان المسافات التي تتقارب تكون متأتية دائما من نفس المتسلمات وهي الادق.

الكلمات الرئيسية: الرصد الثابت، المتسلمات، خط القاعدة الاساس، النظام الملاحي العالمي.

1. INTRODUCTION

Global Navigation Satellite System (GNSS) is defined as satellite navigation systems, which prepare independent geospatial positioning with worldwide coverage. Currently, GNSS includes Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), Galileo, Beidou and other regional systems. The term GNSS is used widely everywhere in the world with the benefit to access various satellites with precision and redundant measurements at any time, **Wallner, et al., 2006.**

The central standard of navigation satellite system is the establishment of a trilateration network from any station on the ground to the navigation satellites. However, at least three navigation satellites must be available to define the 3D position. The ranges to the satellites are computed using the time of arrival of the radio signal that passes with the speed of light to the receiver. The range to the navigation satellite can easily be calculated by multiplying the travel time by the light's speed in a vacuum. The positions of the satellites are observed by the ground stations and this is compulsory for post process, **Lechner** and **Baumann, 2000.**

One of the most important points to state in this respect is that surveying applications require different of level accuracies, which range between centimeters to millimeters. This implies that phase measurements have to be assessed and each of the ambiguity estimates has to be resolved. This can be authenticated with a minimum of 4 satellites which have to be tracked instantaneously at each receiver to gain accurate position at each epoch. Positioning with GNSS can be carried out using two ways: stand-alone positioning and relative positioning, and GNSS stand-alone positioning uses one GNSS receiver that measures the code pseudo-ranges to determine the user's position instantaneously, **DiBiase** and **Dutton, 2017.**

Static surveying positioning technique is a differential positioning technique that relies on the carrier-phase observations. It employs two receivers at the same time tracking the same navigation satellites. One receiver that called the static receiver is installed on a station with known coordinates of high precision. However, the other receiver that called rover receiver is installed at a station whose coordinates are unknown. It is important to mention that the static receiver can be connected with any number of rover receivers if and only if a minimum of four common navigation satellites is available within the static and the rover sites. The static surveying technique depends on collecting simultaneous measurements for individual receivers within a certain period of time. This can deliver the coordinates of the unknown point following post-processing. Thereafter, the collected data is transferred from the receivers to the personal computer for processing. Various processing options could be selected based on the user requirements, such as the baseline length, etc, **EL-Rabbany, 2002**.

The rapid static surveying mode is ideal for many surveyors. It is considered to be intermediate mode between static and kinematic measurements. In this kind of measurements the procedure is similar to static surveying, however, the receivers should always be on a control station while the others should move between unknown stations. Therefore, observations are made for individual points but time exerted for individual sessions is much shorter than static technique. The rapid static technique is appropriate for observing baselines up to twenty km in length under good conditions. It can produce accuracies on the order of ± (3-5mm +1 ppm), however, to reach these accuracies, best satellite structures (good PDOP) and favorable ionospheric conditions must exist which is ideal for small control surveys. Particularly with static surveys, all receivers must be designed to set data at the same epoch rate, where epoch rate is set to 5 sec, **Ghilani** and **Wolf, 2012.**

On the other hand, the real-time kinematic (RTK) surveying technique needs the relative position technique to be fixed as the roving receiver occupies a certain position in the field. However, in this respect, it is important to keep the data transmitted from the main point to the rover point. A static period of initialization will be required before work can commence. Therefore, the engineering survey should attempt to avoid working close to main obstacles to the line of sight to the navigation satellites. In this kind of surveying, the base station transfers code and carrier phase observations to the mobile receiver. However, onboard data processing resolves the ambiguity estimates and resolves the change in position differences between mobile and reference receivers. This positioning technique can be used for single and/or dual frequency receivers. Loss of lock can also be regained using remaining static for a short period of time over a known station. The significant advantage of this technique is that GPS can be employed for the setting-out in the field, which is a very significant point to be gained by the user. The setting-out coordinates can be uploaded into the moving receiver and the graphical output can show the distance and direction and distance through which the pole of the antenna must be moved. The locations of the point to be setting-out and the antenna are shown. When both coincide, the center of the antenna is over the setting-out location, **Schofield** and **Beach, 2007.**

Therefore, the aim of this study is to evaluate the performance of GNSS receivers used by the Department of Surveying Engineering – College of Engineering – the University of Baghdad using a simple geometrical test based on the static GNSS observation technique and Total station measurement (distances with angles).

2. CASE STUDY AREA AND DATASET

Al-Jadriya Campus - the University of Baghdad was selected as a study area for this research because the aim of this paper is to evaluate the GNSS devices as well as it contains local control points which are distributed in a geometrical force shape. Three stations were selected depend on: **1)** the visibility between them for distances measurement purpose. **2)** The positions avoiding any obstruction and reflective surfaces as shown in **Fig. 1**.These points form a triangle shape with two acute angles and short distances that can be easily defined and calculated its elements.

Each of these three stations was observed by different manufacturers GNSS devices (Topcon, Leica) using static GNSS Positioning Technique and compute the distance between them by two methods. The first method is carried out by Topcon tools software based on the GNSS observations where the distance in the second method is observed by Topcon total station device.

The comparison between the distances comes from these two methods was employed to evaluate the accuracy of GNSS receivers.

3. METHODOLOGY

Regarding fieldwork, the three points (SUR, KHW, SCI) selected in the University of Baghdad Al-Jadirya campus were observed using different manufacturers GNSS device by three sets as shown below:-

Set 1: The three devices (Leica AS 10, Leica GS 15 and Topcon GR5) were installed simultaneously on the station (SUR, KHW, SCI) respectively, using static GNSS survey technique with observed period about 2.5-3 hours.

Set 2: At this set the receivers positions were switched in clockwise direction over the same three points, the sequence would be as follow: the three devices (Topcon GR5, Leica as 10 and Leica GS 15) were installed simultaneously on the points (SUR, KHW, SCI), respectively, also using static GNSS survey technique with observed period about 2.5-3 hours.

Set 3: Following the same procedures in set 2, the sequence would be as follows: The three devices (Leica GS 15, Topcon GR5 and Leica GS 10) were installed simultaneously on the points (SUR, KHW, SCI) respectively, also using Static GNSS survey technique with observed period about 2.5-3 hours.

Then the distances between these points in three sets computed by Topcon tools software. on the other way, the Topcon Total Station was used to observe the distances between the main three stations and verified that the geometric shape was correct and that there were no errors by using cosine rule to calculate the internal angles of the triangle, where it was found to be 180°. Finally, the comparison of the distances from the two methods above led to known the accurate receiver.

4. THE RESULTS AND DISCUSSION

The three stations selected have been named depending on the buildings nearby, point SUR near to the Surveying Department building, point KHW near to the Al-khwarizmi Engineering building, point SCI near to college of science sector. The first set of observation was done on 25 Jan. 2016, the second set of observation was done on 4 Feb. 2016 and the third set observation was done on 24 Feb.2016. Then the raw GNSS file was collected from the three receivers to the PC and send to OPUS web-based processing software to fix ambiguities and mitigate multipath error and provides easy access to high-accuracy National Spatial Reference System (NSRS) coordinates, the coordinates were averaged from three independent, single-baseline solutions, each computed by double-differenced, carrier-phase measurements from one of three nearby CORS, and send back via email. as shown in **Fig. 2**. The result of these sets for each point was observed by three receivers listed in **Table 1**. Then the distances between these points in three sets computed by the Topcon tools software after applying the baseline process as listed in **Table 2.**

Generally, a total station measures a slop distance, and the microprocessor uses the vertical angle recorded by theodolite along the line of sight to calculate the horizontal distance. As well as the height distance between the trunnion axis and the center of the prism is also calculated and shown. So, the distances between the main three points were observed using Topcon Total Station as a list in **Table 3.** Then it was verified that the geometric shape was correct and that there were no errors through using cosine rule to calculate the internal angles of the triangle, where it was found to be 180°.

All the coordinates were transferred to UTM to be more realistic, the comparison in **Table 4** illustrates that some distances calculated from the sets of observation are close to the distances measured by the total station. After analysis, the convergence and divergence founded that the value that deviates from of the total station value always comes from which receivers, which the Topcon receiver more accurate than other because all the distances calculated form Leica GS15 and Leica AS 10 were faults.

5. CONCLUSIONS

- This study showed that the receiver Topcon found to be most accurate, followed by Leica GS 15 and then Leica AS 10
- All GNSS receiver must be tested periodically.
- A simple and new method was introduced and can be applied in the field without any difficulties.
- The basic idea aim of this study is to provide a simple test for the GNSS receiver performance after used for a long time measurement without calibration.

6. RECOMMENDATIONS

- The distances used between the receivers were short because there were many obstacles that prevent the visibility between the points in the study area and it is better to choose large distances to determine the accuracy of the receiver through baseline processing.
- It is preferable to use more GNSS surveying techniques and compare the result.
- It's better to use another processing software (Leica geometrics office, Bernese, Gamit, and Globk) but the software license not available.

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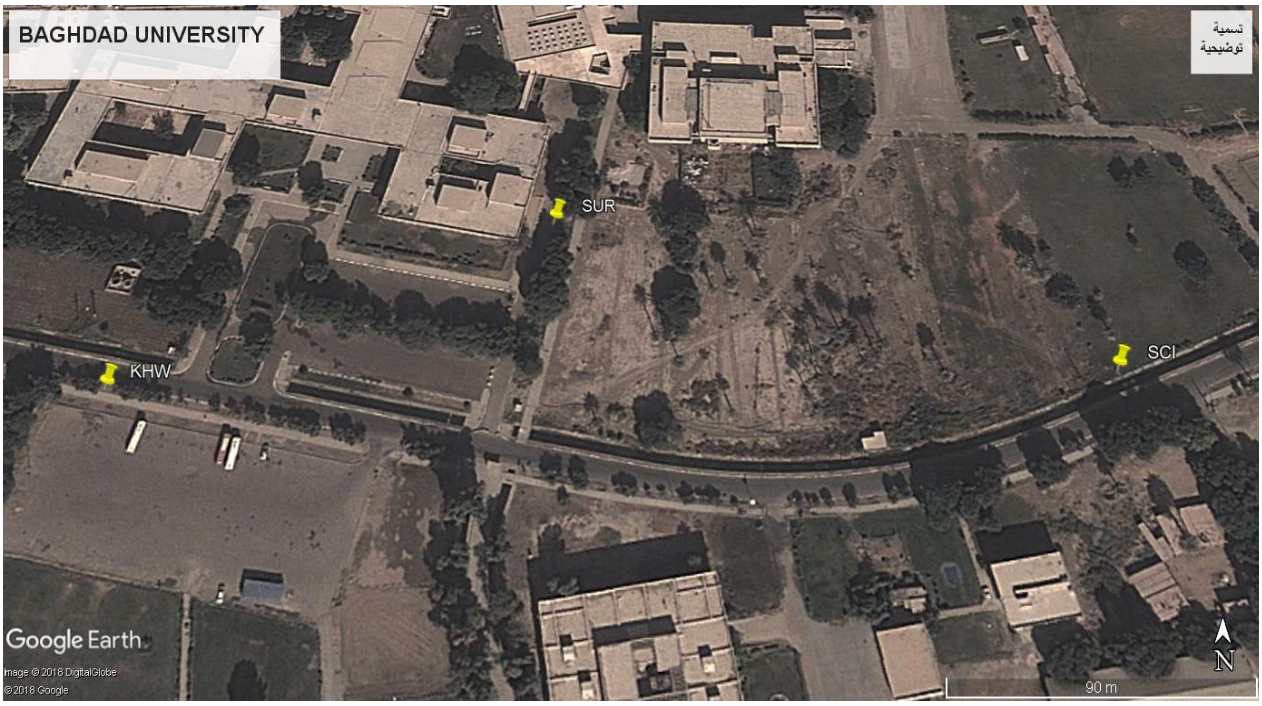

Figure 1. The Position of The Three points (SUR, KHW, SCI).

Table 1. The coordinates of the three-point for each set.

Point name	Grid Northing (m)	Grid Easting (m)	Elevation (m)	Receiver Type
SET 1 on 25 January 2016				
SUR	3681645.641	441917.378	34.278	Leica AS 10
KHW	3681596.078	441758.108	34.208	Leica GS 15
SCI	3681606.111	442122.054	34.286	Topcon GR5
SET 2 on 4 February 2016				
SUR	3681645.634	441917.431	33.976	Topcon GR5
KHW	3681596.057	441758.153	34.145	Leica AS 10
SCI	3681606.093	442122.108	34.798	Leica GS 15
SET 3 on 24 February 2016				
SUR	3681645.668	441917.436	34.523	Leica GS 15
KHW	3681596.081	441758.151	33.843	Topcon GR5
SCI	3681606.109	442122.117	33.843	Leica AS 10

NGS OPUS SOLUTION REPORT

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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: eng.omarali@gmail.com DATE: April 04, 2016
RINEX FILE: 1641025h.16o TIME: 07:16:01 UTC

SOFTWARE: page5 1209.04 master53.pl 160321 START: 2016/01/25 07:24:00
EPHEMERIS: igs18811.eph [precise] STOP: 2016/01/25 10:07:00
NAV FILE: brdc0250.16n OBS USED: 5058 / 6055 : 84%
ANT NAME: LEIGS15 NONE # FIXED AMB: 53 / 63 : 84%
ARP HEIGHT: 1.189 OVERALL RMS: 0.020(m)

REF FRAME: IGS08 (EPOCH:2016.0666)

X: 3815526.201(m) 0.080(m)
Y: 3733128.640(m) 0.050(m)
Z: 3479220.728(m) 0.032(m)

LAT: 33 16 18.55526 0.030(m)
E LON: 44 22 28.59994 0.068(m)
W LON: 315 37 31.40006 0.068(m)
EL HGT: 32.607(m) 0.059(m)

UTM COORDINATES
UTM (Zone 38)

Northing (Y) [meters]	3681596.078
Easting (X) [meters]	441758.108
Convergence [degrees]	-0.34310532
Point Scale	0.99964182
Combined Factor	0.99963670

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE (m)
DK4489	ISBA IRAQ SURY BAGHDAD CORS ARP			9740.7
DL5972	ISKU IRAQ SURVEY KUT CORS ARP			159022.2
DL3893	ISER IRAQ SURVY ERBIL CORS ARP			322089.4

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

Figure 2. NGS OPUS solution report.

Table 2. The distance calculated by Topcon tools software.

Line name	Distance (m)
SET 1	
SUR-KHW	166.802
SUR-SCI	208.460
KHW-SCI	364.084
SET 2	
SUR-KHW	166.815
SUR-SCI	208.461
KHW-SCI	364.093
SET3	
SUR-KHW	166.825
SUR-SCI	208.469
KHW-SCI	364.104

Table 3. The distance measured by Topcon total station.

Line name	Distance (m)
SUR-KHW	166.824
SUR-SCI	208.452
KHW-SCI	364.088

Table 4. The convergence and divergence with the distance measured by total station.

Line name	ΔL (m)	Receiver Type
SET 1		
SUR-KHW	0.022	Leica AS 10 - Leica GS 15
SUR-SCI	0.008	Leica AS 10 - Topcon GR5
KHW-SCI	0.004	Topcon GR5 - Leica GS 15
SET 2		
SUR-KHW	0.009	Topcon GR5 - Leica AS 10
SUR-SCI	0.009	Topcon GR5 - Leica GS 15
KHW-SCI	0.005	Leica AS 10 - Leica GS 15
SET3		
SUR-KHW	0.001	Leica GS 15 - Topcon GR5
SUR-SCI	0.017	Leica GS 15 - Leica AS 10
KHW-SCI	0.016	Topcon GR5 - Leica AS 10