Yanbu Journal of Engineering and Science

Volume 4 | Issue 1 Article 7

2012

PRELIMINARY EVALUATION OF EGNOS PERFORMANCE FOR GIS APPLICATIONS

Y. A. Aina
Yanbu Industrial College, Saudi Arabia, yaina@yic.edu.sa

M. M. Hasan
Yanbu Industrial College, Saudi Arabia

K. Kheder
Salman bin Abdulaziz Univeristy, Saudi Arabia

Follow this and additional works at: https://yjes.researchcommons.org/yjes

The journal in which this article appears is hosted on Digital Commons, an Elsevier platform.

Recommended Citation
Aina, Y. A.; Hasan, M. M.; and Kheder, K. (2012), PRELIMINARY EVALUATION OF EGNOS PERFORMANCE FOR GIS APPLICATIONS, *Yanbu Journal of Engineering and Science*: Vol. 4: Iss. 1, 57-64.
DOI: https://doi.org/10.53370/001c.24047
Available at: https://yjes.researchcommons.org/yjes/vol4/iss1/7

This Research Article is brought to you for free and open access by Yanbu Journal of Engineering and Science. It has been accepted for inclusion in Yanbu Journal of Engineering and Science by an authorized editor of Yanbu Journal of Engineering and Science.

Yanbu Journal
of
Engineering
and Science
ISSN: 1658-5321

Vol. 4, April 2012 (1433H)
www.yjes.org.sa

PRELIMINARY EVALUATION OF EGNOS PERFORMANCE FOR GIS APPLICATIONS

Y. A. Aina[1], M. M. Hasan[1], K. Kheder[2]

1 Geomatics Engineering Technologies Department, Yanbu Industrial College, P. O. Box 30436, Yanbu. Saudi Arabia - yaina@yic.edu.sa

2 Civil Engineering Department, College of Engineering, Salman Bin Abdulaziz University, Alkharj, Saudi Arabia

ABSTRACT

European Geostationary Navigation Overlay Service (EGNOS) is a Satellite Based Augmentation System (SBAS) being developed by European Space Agency (ESA) to make GPS and GLONASS suitable for civil aviation and other applications. It improves the accuracy of the GPS and GLONASS signals to about 1 to 2 meters. Though corrected signals from EGNOS are receivable in Saudi Arabia, the accuracy of the signals might be degraded due to the far distance between Saudi Arabia and the ground monitoring stations. The precision and availability of the signals are also expected to be reduced. This paper assessed the EGNOS signal receivable in Saudi Arabia by using handheld GPS (Trimble GeoXH 2005) with GPS software (Trimble GPS Controller 2.3 and ArcPad 7). The GPS data was collected in selected Saudi cities that included Jeddah, Khobar, Madinah and Yanbu. This study also examined the possibility of using EGNOS signals for GIS applications. The results indicate that EGNOS correction improved the accuracy of the signals to about 1.5m and lowest precision of about 5m (mean distance). The results show variations from one city to the other. The drawbacks were availability and precision. So, it cannot be used for time-critical projects unless the availability and precision are improved.

Keywords: *GNSS, EGNOS, Mobile GIS, SBAS, GPS, Differential GPS*

1. INTRODUCTION

European Geostationary Navigation Overlay Service (EGNOS) is similar to Wide Area Augmentation System (WAAS) of the United States, MTSAT Augmentation System (MSAS) of Japan and GPS Aided Geo Augmented Navigation (GAGAN) of India. It is a precursor to GALILEO, the European satellite navigation system. It is a type of satellite-based wide area differential GPS being developed by European Space Agency. The systems are called SBAS (Satellite Based Augmentation Systems) as they are meant to augment and improve the accuracy of signals provided by Global Navigation Satellite System (GNSS). The systems provide a global coverage that could widen the regions of applications of augmented satellite navigation Fig. 1.

The EGNOS system is originally developed to serve as a means of complementing and improving the accuracy of GPS to extend its fields of applications to include civil aviation [1]. It is also meant to be part of the plan to fulfil the need for civilian global navigation system [2]. EGNOS consists of ground stations called Ranging and Integrity

Received: April 2011 Accepted: December 2011

Monitoring Stations (RIMS) and Geostationary satellites.

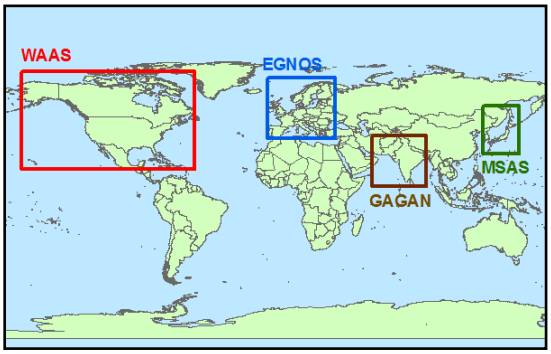

Fig. 1. Global coverage of SBAS programs

The RIMS are for monitoring and correcting GPS signal while the satellites are used in broadcasting EGNOS corrections. The RIMS are mainly located in Europe while the broadcasting satellite cover larger area extending to regions outside Europe. The area covered by the system is determined by the coverage of the ground stations and not by the area covered by the satellites [3]. There is a plan to extend the coverage areas beyond Europe [1].

EGNOS has been documented to achieve average monthly accuracies ranging from 0.57m to 1.80m [1], while the accuracy of an autonomous receiver is around 5m to 15m [4]. That is, EGNOS can improve GPS accuracy to about 1 to 2 meters. Though nearly all the monitoring stations are based in Europe, the satellite signals cover Africa and Middle East. Thus, the corrected signals are receivable in Saudi Arabia but the accuracy of the signal might be degraded [5]. The availability of the signals is also expected to be reduced.

The availability of accurate augmentation system in Saudi Arabia could increase the areas of applications of GPS especially applications related to mobile GIS data collection such as facilities/asset management, cadastre mapping and disaster management. The accuracy of uncorrected GPS data might be low for these applications while local correction methods such as Real Time Kinematics (RTK) might not be cost-effective. EGNOS signal might serve as cost-effective alternative to commercial global DGPS (such as OmniSTAR and StarFire) for these mobile GIS applications.

Al-Ghamdi [5] noted that it might not be economically feasible to have a national RTK/DGPS augmentation service in Saudi Arabia. EGNOS could provide free real-time corrected data without the need for hardware or software upgrade. Thus, the global augmentation services could be adopted for improving GPS accuracy across the country. The aim of this study is to assess the corrected signals being received in Saudi Arabia from EGNOS system. The assessment criteria are mainly accuracy and availability. This assessment will indicate the applicability of EGNOS signals in mobile GIS data collection and applications.

2. RELATED WORKS

The evaluation of GPS and DGPS data has been very crucial to making decisions on the most cost-effective method of collecting data for different GPS applications. The required level of accuracy varies from one application to the other. As accuracy tends to be inversely related to cost, the challenge is to achieve the minimum level of accuracy required at the minimum cost.

Most of the earlier works on GPS assessment had focused on comparing the accuracy and usability of different GPS receivers and software. Al-Ghamdi [6] assessed GIS data collection software on accuracy and precision in collecting DGPS data. They highlighted the need to improve the compatibility of software with DGPS formats and the importance of DGPS data in GIS and surveying applications.

Studies by Serr et al. [7], Wieser [8], Zhang [9] and El-Tokhey [10] compared the accuracies of GPS receivers especially high sensitivity receivers. Serr et al. [7] assessed the accuracies of five GPS receivers including Trimble GeoXT with WAAS, Trimble GeoXT without WAAS, Trimble GeoExplorer, Trimble ProXR and HP iPaq. They concluded that the costlier receivers were more accurate and the accuracies were close to manufacturers' specifications. They were unable to report the accuracy of the receiver with WAAS because the closest WAAS station was off during the period. However, they noted reduced accuracy with WAAS enabled GPS.

Wieser [8] noted that high sensitivity receiver can track weak signals but the accuracy is sometimes degraded. This factor has to be considered in processing and using data collected by high sensitivity receivers. In the same vein, Zhang et al. [9] after assessing eight high sensitivity receivers concluded that the performance of the receivers varied in different aspects and newer receivers were more accurate. They also noted that receivers that tracked SBAS (MTSAT) performed better than those that did not receive SBAS. El-Tokhey [10] noted that receivers using mainly C/A code are not as accurate as receivers using L1 frequency and accuracy could be improved by using cycle slip detection algorithm. They achieved relative baseline accuracy in the range of 2cm to 13cm with a cycle slip detection algorithm.

Arnold and Zandbergen [11] in their evaluation of accuracy of WAAS in consumer-grade GPS units collected data for 30-min over each control point. They found no significant difference between WAAS-enabled and autonomous positions. Witte and Wilson [12] showed that there was a significant improvement in the accuracies of position and speed measured by using WAAS-enabled receivers over autonomous measurements.

European Commission [1] and Nevalainen [13] examined the performance of EGNOS signals in Europe. European Commission [1] observed that GPS performance was enhanced by EGNOS signals. Nevalainen [13] in the study of Finland, recorded an improvement in accuracy to 2 to 3m due to EGNOS signals. However, the availability reported was 51% due to the fact that the EGNOS satellites are located below elevation of 22 degrees at the study area. The previous studies, as highlighted above, showed that the assessment of EGNOS signals had given mixed results that depended on the coverage of the monitoring stations and the elevation angle of the satellites.

3. METHODOLOGY

3.1 STUDY AREA

The study was conducted in four cities in Saudi Arabia. The cities were Jeddah, Khobar, Madinah and Yanbu. Khobar lies at the eastern coast of the country while Jeddah, Madinah and Yanbu are at the western coast. All the stations can receive signals from EGNOS satellites. However, the nearest operational monitoring station to Saudi Arabia is the station at Turkey (there are closer stations that are not yet operational) which is about at least 2000km away from the cities Fig. 2.



Fig. 2. Selected Cities and EGNOS RIMS

3.2 MATERIALS AND METHODS

The equipment used for this study is Trimble GeoXH 2005. It is a 12-channel receiver that has integrated SBAS and can achieve sub-meter accuracy with SBAS (without post processing) [14]. The equipment was complemented by the in-built GPS software (GPS Controller 2.3) and ESRI ArcPad 7. The GPS Controller has an interface that shows computed accuracy for the signal and also PDOP and satellite information. However, the Controller cannot log signal data. Additional software is needed to log the signals. ArcPad is one of the major software for mobile GIS data collection and application and has data logging function. Locations with clear visibility and accessibility were chosen within the cities as data collection points.

The data collection for the study was carried out by logging GPS signal at each point (one point in each city) for a period of 1 to 2 hours. About 2500 data sets were collected at each point. Accuracies of the data were also recorded from the GPS Controller (controller cannot log the data) at ten-minute interval and at least 30 data sets were recorded for each point. Data sets were collected in WGS 84 reference system. Position Dilution of Precision (PDOP) less than or equal to 6 was ensured throughout the data logging exercises. PDOP values greater than 6 were not logged. The accuracy data sets recorded from the Controller were used for accuracy assessment while the logged data sets were used for availability and precision assessment.

In this study, accuracy means the accuracy computed by the in-built GPS Data Controller. Availability means the number of times EGONS signals were used out of the available logged data. Availability was computed in percentage. Precision means the repeatability of the collection of position estimates. That is, how close or far apart are the estimated points to each other. ArcGIS software was used to compute the precision of the logged data. After data collection, the logged data sets were transferred to ArcGIS and the spatial reference was transformed to UTM (WGS 84 Datum) using appropriate zones. Zone 37 North was used for Jeddah, Madinah and Yanbu while Zone 39 North was used for Khobar. An ArcGIS tool, called Point Distance, was used to calculate the distances between a point and other points. Then, the statistics (such as minimum, maximum and standard deviation) of the distances were computed. The standard deviation indicated the precision.

4. RESULTS AND DISCUSSION

4.1 ACCURACY OF THE OBSERVATIONS

The results of the accuracy assessment highlight the variations in the accuracies at the different cities Table 1.

TABLE 1: ACCURACY ASSESSMENT OF EGNOS SIGNALS

City	Highest Accuracy (meters)	Lowest Accuracy (meters)	Mean Accuracy (meters)	Mean Accuracy (m) (No EGNOS)
Jeddah	0.85	0.97	0.95	5.7
Khobar	1.1	1.4	1.25	6.2
Madinah	0.6	1.3	0.7	6.0
Yanbu	0.59	1.2	0.78	6.0

The western cities; Jeddah, Madinah and Yanbu has better accuracies than the eastern city of Khobar. They had sub-meter accuracies while Khobar has 1.25m mean accuracy. The cities in the north like Yanbu and Madinah also have better accuracy than Jeddah in the south. This might be due to closeness to the monitoring stations. The accuracy without EGNOS is generally about 6m. That indicates that the accuracy is

improved by about 5m with EGNOS correction. There is a direct relationship between the accuracies of data sets with EGNOS and without EGNOS. When the accuracy with EGNOS is low, the accuracy without EGNOS is also low and vice versa Fig. 3.

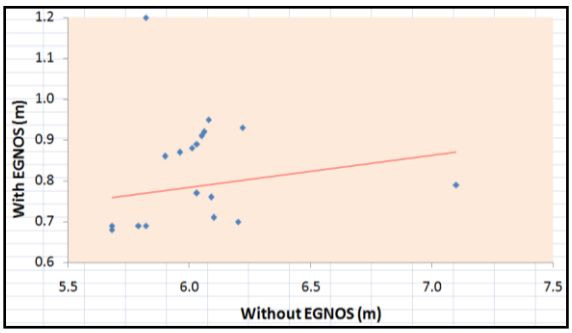

Fig. 3. Correlation between accuracy with EGNOS and without EGNOS

4.2 Availability of EGNOS signals

The availability assessment results show that the availability of EGNOS signals is less than the availability of GPS signals at all the points Table 2.

TABLE 2: AVAILABILITY ASSESSMENT OF EGNOS SIGNAL

City	Availability of Signal EGNOS) (%)	Availability of Signal (No EGNOS) (%)	Mean PDOP	Mean No of Satellites
Jeddah	74	95	3.7	7
Khobar	88	98	2.9	7
Madinah	68	92	3.5	6
Yanbu	65	91	4	6

The availability of the GPS signals might have been affected by the PDOP setting (not greater than 6). Generally, the availability of EGNOS signals was around 70% which might not be usable for a time-critical project. The availability of the signals is expectedly less than the 99% availability computed for Europe [1].

4.3 Precision of the observations

The results in Table 3 below show that the mean distance between the points is generally higher with EGNOS correction than without EGNOS correction. The case is the same for the standard deviation which is a measure of precision of the signals. It means that the points collected without EGNOS correction are more precise than with EGNOS correction Table 3. This is also highlighted by the display of the points for Jeddah and Yanbu in ArcGIS. The points collected with EGNOS are more dispersed than the points collected without EGNOS, Fig. 4 and Fig. 5.

TABLE 3: PRECISION OF EGNOS OBSERVATIONS

City	Mean Distance (EGNOS) (meters)	Precision (Standard Deviation) (EGNOS) (meters)	Mean Distance (No EGNOS) (meters)	Precision (Standard Deviation) (No EGNOS) (m)
Jeddah	2.62	1.84	0.87	0.78
Khobar	3.25	2.35	1.43	1.24
Madinah	1.33	0.8	3.74	2.30
Yanbu	4.46	3.14	1.68	1.13

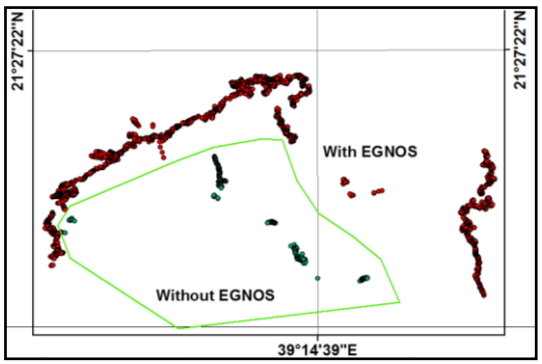

Fig. 4. Data sets with EGNOS and without EGNOS for Jeddah city

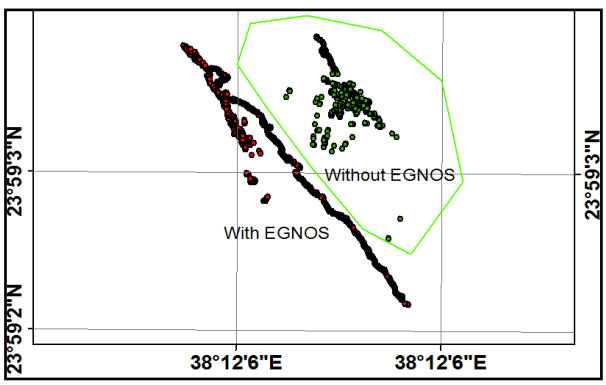

Fig. 5. Data sets with EGNOS and without EGNOS for Yanbu city

As highlighted by Serr et al. [7], GPS data can be used for mapping at a scale of 1:1100 if the precision and accuracy are about 1m. And this also applies to most GIS mobile applications such as facilities management, natural disaster management and cadastral mapping. The EGNOS correction is able to achieve one aspect, that is, accuracy. The aspect of precision is below the required standard for the job. This might be solved by using algorithms that can filter the outliers and extreme values to improve the precision.

This study has two limitations. The study analyzed only the accuracy recorded by GPS Controller and the values might be different if the logged points are compared with known control points. Also, the study carried out only static data collection for the assessment. Kinematics data collection is also relevant to GIS mobile mapping and applications.

5. CONCLUSION

The study has shown that the EGNOS signal receivable in Saudi Arabia led to the improvement of GPS data accuracy by about 5m and this might make it useful to more applications. However, the precision and availability of the signal are below the requirement. Further data collection and analysis might help in confirming the reported accuracies and determining suitable application areas for the correction data. The planned RIMS could boost the accuracy and precision of EGNOS signals in Saudi Arabia when they become operational.

ACKNOWLEDGEMENTS

The paper is based on the study presented at the First Geomatics Conference in Saudi Arabia, Jeddah 2011. The authors acknowledge the assistance of the following colleagues; Hatem Al-Ghamdi and Kamorudeen Aleem, and students; Adel Al-Ghamdi and Khaled Alofei, in collecting the required data for this paper.

REFERENCES

[1] European Commission, EGNOS service definition document open service, 2009. http://www.essp-sas.eu/downloads/telgiowl/egnos_os_sdd_in_force.pdf

[2] Lechner, W. and Baumann, S., Global Navigation Satellite Systems, Computers and Electronics in Agriculture, Vol.26, 2000, pp 67 – 85.

[3] Samama, N., Global positioning: technologies and performance, Wiley, New Jersey, 2008.

[4] Oliveira, J. M. V. and Tiberius, C. C. J. M., EGNOS performance for landing, European Journal of Navigation, Vol.6 (2) , 2008, pp 2 – 7.

[5] Al-Ghamdi, Y., Bowhay, M. and Abulleif, T., GPS for GIS: what is really involved? In: Proceedings of Second National GIS Symposium in Saudi Arabia, 2007. http://www.saudigis.org/FCKFiles/File/SaudiGISArchive/2ndGIS/Papers/43_E_YousifAlghamdi_KSA_F.pdf

[6] Al-Ghamdi, Y. and Bowhay, M., Assessment of GIS data collection software for high precision DGPS in surveying and engineering mapping applications, In: Proceedings of First National GIS Symposium in Saudi Arabia, 2005. http://www.saudigis.org/FCKFiles/File/SaudiGISArchive/1stGIS/Papers/8.pdf

[7] Serr, K., Windholz, T. and Weber, K., Comparing GPS receivers: a field study, URISA Journal, Vol.18 (2) , 2006, pp 19 – 23.

[8] Wieser, A., High-sensitivity GNSS: the trade-off between availability and accuracy, In: Proceedings of 3rd IAG/12th FIG Symposium, Baden, Austria, , May 2006, pp 22-24 .

[9] Zhang, J., Li, B., Dempster, A. and Rizos, C., Evaluation of high sensitivity GPS receivers, Coordinates, March, 2011. http://mycoordinates.org/evaluation-of-high-sensitivity-gps-receivers/all/1/

[10] El-Tokhey, M. E., Abd-Elrahman, A. H., Fath-Allah, T. F. and Awad, A. E. I., Preliminary evaluation of baseline relative accuracies using L1 frequency observations of navigation-grade GARMIN receivers, Journal of Surveying Engineering, Vol.137 (1) , 2011, pp 26 – 32.

[11] Arnold, L. L. and Zandbergen, P. A., Positional accuracy of the Wide Area Augmentation System in consumer-grade GPS units, Computers & Geosciences, Vol.37, 2011, pp 883 – 897.

[12] Witte, T. H. and Wilson, A. M., Accuracy of WAAS-enabled GPS for the determination of position and speed over ground, Journal of Biomechanics, Vol.38, 2005, pp 1717 – 1722.

[13] Nevalainen, E., Evaluation of Global Positioning System augmentation options for Finland, Aalto University, Espoo, Finland. MSc Thesis. 2010.

[14] Trimble, GeoXH datasheet, Trimble Navigation Limited, USA, 2007.

تقييم مبدئي لأداء أقمار التصحيح الأوروبية على تطبيقات نظم المعلومات الجغرافية

يوسف عينا[1]، محمود حسن[1]، خالد خضر[2]

1 كلية ينبع الصناعية، المملكة العربية السعودية
2 كلية الهندسة المدنية، جامعة الخبر، المملكة العربية السعودية

الملخص:

إن الأقمار الصناعية ثابتة المكان (EGNOS) والمصنعة بواسطة الاتحاد الأوروبي صنعت بغرض تصحيح أرصاد الأقمار الاصطناعية للنظامين العالميين (GLONASS) (GPS) لقارة أوروبا. في هذا البحث تم دراسة مدى تغطية هذه الأقمار لعدة مدن بالمملكة العربية السعودية ودراسة تأثير التصحيحات المرسلة عن طريق أقمار (EGNOS) في دقة الإحداثيات المستنتجة من النظامين العالميين السابق ذكرهما.

وقد تمت الدراسة باستخدام جهاز محمول باليد لاستقبال أرصاد أقمار أل GPS ماركة (Trimble Geo XH 2005) وباستخدام برامج الحاسب الآلي(Trimble GPS Controller 2.3 and Arc Pad 7) . وقد اختيرت 4 مدن (جدة , الخبر , المدينة المنورة وينبع) للدراسة. وقد أظهرت النتائج إن التصحيحات المرسلة بواسطة أقمار (EGNOS) أن أعلى تحسن بدقة الإحداثيات المأخوذة بمستقبلات ال (GPS) يساوي 1.5 متر وأن أقل دقة للإحداثيات قد تم الحصول عليها هي 5 أمتار. وقد أظهرت النتائج أيضاً أن كلا العاملين الدقة المتحصل عليها ونسبة تواجد الإشارات يختلفا من مدينة إلى أخرى كما هو مذكور بالبحث. وقد استخلص من هذا البحث بأنه يمكن استخدام التصحيحات المرسلة من بواسطة أقمار (EGNOS) في المشاريع التي لاتحتاج إلى أكثر من هذه الدقة كما انه لايمكن استخدامها للمشاريع المرتبطة بوقت زمني معين.