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Comparative Analysis of Accuracy Using Stand-alone GPS and GAGAN Systems for Indian Region

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Abstract-*The Satellite Navigation System (SNS) is a space-based radio positioning system that includes one or more satellite constellations capable of providing three-dimensional position, velocity and time information continuously to users anywhere on, or, near, and the surface of the earth. The positional accuracy of SNS is limited by several sources of error such as signal propagation delays due to ionosphere and troposphere, multipath, receiver measurement noise, instrumental biases. Several types of receivers and augmentation systems are developed in order to minimize these errors. The aim of the project is to compare and analyze the accuracy in position obtained using a single frequency handheld receiver-with and without Satellite Based Augmentation System (SBAS) corrections-under various conditions. In this work, handheld single frequency GPS/GAGAN Trimble JUNO SA receiver is considered. The analysis of user position is considered under various conditions for low latitude region such as India. The considered station is Hyderabad which is located at (17.415°N, 78.5287°E).*

Indexing terms: SBAS, GAGAN, JUNO SA receiver, Accuracy and PDOP.

I. INTRODUCTION

Satellite Navigation System (SNS) is a navigation system which provides accurate, continuous, all-weather, three-dimensional location of a user (receiver). It includes constellations of earth-orbiting satellites that broadcast their locations in space and time, networks of ground control stations, and receivers that calculate ground positions by trilateration. At present SNS includes two fully operational global systems (Global Navigation Satellite Navigation Systems-GNSS), the United States' Global Positioning System (GPS) and the Russian Federation's GLObal NAvigation Satellite System (GLONASS), as well as the developing Global and Regional Satellite Navigation Systems, namely Europe's European Satellite Navigation System (GALILEO) and China's COMPASS/BeiDou, India's Regional Navigation Satellite System (IRNSS) and Japan's Quasi-Zenith Satellite System (QZSS). All GNSS systems have errors in measurement of the position of the receiver due to various sources. Of these sources, ionospheric time delay is the major source. The errors vary depending on the environmental conditions under which the receiver data is collected and can be reduced to a great extent on the augmentation system used. In this project, a comparative analysis of the positions obtained from the receiver under various conditions (with and without using SBAS- an augmentation system) is carried out. The positional coordinates and satellite parameters are extracted with a single frequency receiver using a) stand-alone GPS system (without applying SBAS/GAGAN corrections and b) Integrated GPS/SBAS system (applying SBAS corrections to the coordinates using GPS). This activity is carried out under five different conditions namely under open sky, under partially open sky, under canopy, amidst buildings and indoors and the data so obtained is analyzed in terms of accuracy. The activity is carried out at the Department of Electronics & Communication Engineering (ECE), University College of Engineering (UCE), Osmania University (OU), Hyderabad (17.4135° N,78.5287° E).

II.THEORETICAL BACKGROUND

The SBAS consists of a Ground Earth Station (GES), ground reference stations, master stations and Geostationary Earth Orbit (GEO) satellites. The ground reference stations of SBAS send satellite

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data to master stations, which then determine the integrity, differential corrections, residual errors and ionospheric information for each monitored satellite and generate Geostationary Earth Orbit (GEO) satellite navigation parameters. This information is sent to a Ground Earth Station (GES) and uplinked along with the GEO navigation message to GEO satellites. The GEO satellites broadcast integrity, correction data and ranging signals to GPS/SBAS receivers worldwide. The GPS Aided Geo-Augmented Navigation (GAGAN) is an implementation of the regional SBAS by the Indian Government by providing reference signals to GNSS receivers to improve the accuracy. The space segment of GAGAN consists of three operational GEO satellites. The ground segment consists of 15 Indian Reference Stations (INRES) and the Indian Master Control Center (INMCC). The GPS data is received and processed in the INRES and the Indian Master Control Center (INMCC) processes the data from the INRESs to compute the differential corrections and the estimate of its level of integrity. The SBAS message generated by the INMCC is uplinked to the GEO satellites through its corresponding INdian Land Uplink Station (INLUS). The SBAS-enabled receiver processes the correction data broadcast by the GEO satellites and applies these corrections to the GPS data thus improving the accuracy.

III. EXPERIMENTAL DATA

The readings of user position are extracted from Trimble JUNO SA GPS/SBAS single-frequency handheld receiver. The Juno SA handheld is a durable, compact field computer with an integrated high-yield GPS receiver. The front panel view of the receiver is shown in Fig.1.

It has a high-sensitivity GPS receiver, which is capable of yielding positions in difficult environments such as under forest canopy and up against buildings. The system features a 533MHz processor with 128MB RAM, 128MB of non-volatile flash storage, a micro SD memory card, internally rechargeable and removable Li-Ion battery. The Juno SA handheld is equipped with an integrated high-sensitivity GPS/SBAS receiver and antenna which can achieve 2 to 5 meter positional accuracy after real time differential correction and 1 to 3 meter accuracy after post processing. It can support NMEA and SiRF protocol.

Fig 1. Front panel view of the JUNO SA Handheld Single-frequency Receiver

There are various optional softwares available for the handheld namely Trimble TerraSync software, Trimble GPS Pathfinder Office software, etc. that can be used to collect and maintain GIS and GPS data. The number of channels available, data update rate and data protocols are mentioned in Table 1.

Table 1 GPS Specifications of single frequency receiver

S.No	Parameter	Specification
1	Channels	12 (L1 code only)
2	Integrated Real Time	SBAS1
3	Update rate	1 Hz
4	Time To first Fix	30 seconds
5	Protocols	SiRF, NMEA-0183

The accuracy of code-processed GPS data is 1-3m whereas the accuracy of Real-time SBAS system is 2-5m as given in Table 2.

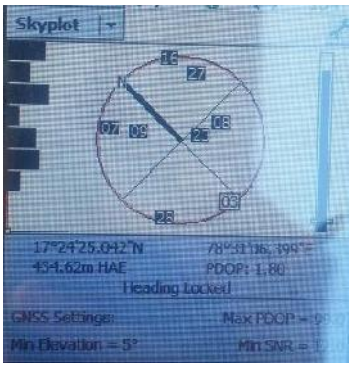
Table 2 Accuracy Specifications of single frequency receiver

S.No	Processing type	Accuracy
1	Code Post Processed	1-3m
2	Real-time (SBAS)	2-5m

In this work, the positional coordinates and satellite parameters i.e. latitude, longitude, Height Above Ellipsoid (HAE), Positional Dilution of Precision (PDOP) and accuracy are extracted with a single frequency receiver. PDOP is a measure of the strength of the satellite geometry. A lower value of PDOP (ideally 1) indicates a good satellite geometry i.e. the satellites are evenly spread out in the space hence giving a good coverage. This activity is carried out in the following five different case. (a)Under open sky (on the terrace of ECE building, UCE, OU), (b) Under Partially Open Sky (In the portico of ECE building, UCE, OU) (c)Under heavy canopy (In the garden of ECE Department) (d)Amidst Buildings (In front of Principal Office Building, OU) (e)Indoors (inside the classroom). In each case, the parameters are extracted using stand-alone GPS first and then by enabling SBAS corrections. The Fig 2 shows the skyplot of the satellites available and other parameters in each case.

(a)

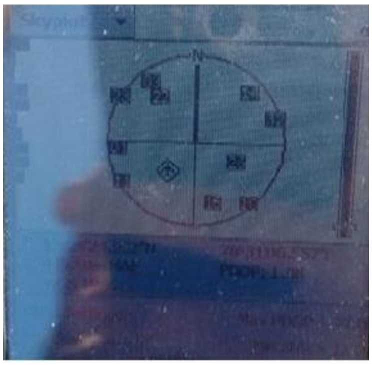
(b)



(c)

(d)

(e)



(f)

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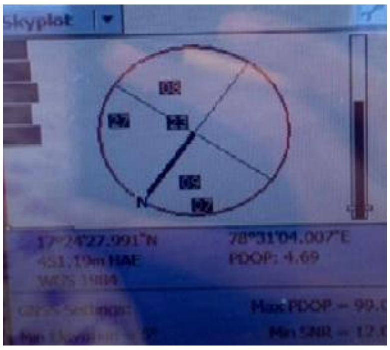
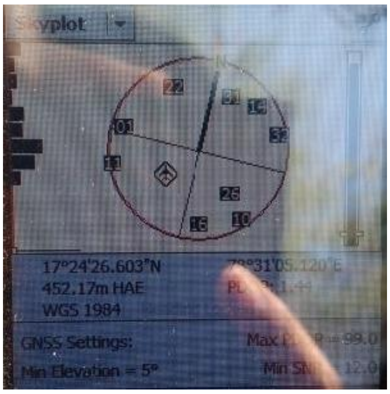
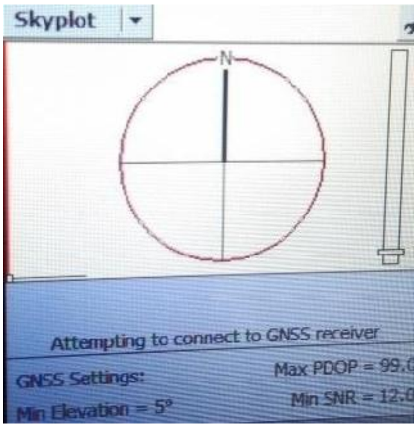


(g)



(h)



(i)

Figure 2 (a) Under open sky (GPS) (b) Under open sky (GPS+SBAS) (c)Under partially open sky (GPS) (d) Under partially open sky (GPS+SBAS) (e) Under heavy canopy (GPS) (f) Under heavy canopy (GPS+SBAS) (g) Amidst Buildings (GPS) (h) Amidst Buildings (GPS+SBAS) (i)Indoors

IV. RESULTS AND DISCUSSION

A comparative analysis of the experimental data obtained is carried out and the results obtained are described in this section.

Case I: Comparison of user position using GPS and GAGAN for accuracy under open sky.

Table 3 shows the positional coordinates obtained under open sky. The PDOP value obtained using GAGAN is much better than that obtained using Stand-Alone GPS. It has improved from a value of 1.8 to 1.44. It can also be seen that the accuracy improved from 6.4m to 3m and the number of satellites visible increased from 7 to 11. It can be inferred that there is a 53% an improvement in accuracy by using GAGAN.

Table 3 Positional coordinates obtained under open sky

Parameter	GPS	GPS+SBAS
Latitude	17°24'26.901"N	17°24'26.839"N
Longitude	78°31'5.161"E	78°31'4.454"E
HAE	438.42m	430.96m
PDOP	1.8	1.44
Accuracy	6.4m	3m
No. of Satellites	7	11

Case II: Comparison of user position using GPS and GAGAN for accuracy under partially open sky.

Table 4 shows the positional coordinates obtained under partially open sky. The PDOP value obtained using GAGAN is much better than that obtained using Stand-Alone GPS. PDOP has improved from 6.13 to 2.52. It can also be seen that the accuracy improved from 6.6m to 3.3m. Also the number of satellites visible increased from 7 to 8. It can be inferred that there is a 50% an improvement in accuracy by using GAGAN.

Table 4 Positional coordinates obtained under partially open sky

Parameter	GPS	GPS+SBAS
Latitude	17°24'25.042"N	17°24'28.349"N
Longitude	78°31'6.399"E	78°31'4.088"E
HAE	434.62m	454.96m
PDOP	6.13	2.52
Accuracy	6.6m	3.3m
No. of Satellites	7	8

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Case III: Comparison of user position using GPS and GAGAN for accuracy under heavy canopy.

Table 5 shows the positional coordinates obtained under heavy canopy. The PDOP value obtained using GAGAN is much better than that obtained using Stand-Alone GPS. It can also be seen that the accuracy improved from 8m to 3.8m. Also the number of satellites visible increased from 7 to 11. It can be inferred that there is a 52.5% an improvement in accuracy by using GAGAN.

Table 5 Positional coordinates obtained under canopy

Parameter	GPS	GPS+SBAS
Latitude	17°24'26.775"N	17°24'24.952"N
Longitude	78°31'5.218"E	78°31'6.557"E
HAE	465.05m	445.59m
PDOP	1.8	1.08
Accuracy	8m	3.8m
No. of Satellites	7	11

Case IV: Comparison of user position using GPS and GAGAN for accuracy amidst buildings

Table 6 shows the positional coordinates obtained amidst buildings. The PDOP value obtained using GAGAN is much better than that obtained using Stand-Alone GPS. It can also be seen that the accuracy improved from 8.5m to 4m. Also the number of satellites visible increased from 5 to 9. It can be inferred that there is an improvement of 52.9% accuracy using GAGAN.

Table 6 Positional coordinates obtained amidst buildings

Parameter	GPS	GPS+SBAS
Latitude	17°24'27.991"N	17°24'26.603"N
Longitude	78°31'4.007"E	78°31'5.120"E
HAE	451.19m	452.17m
PDOP	4.69	1.44
Accuracy	8.5m	4m
No. of Satellites	5	9

Case V. Indoors

It has been observed that no satellites were visible indoors and hence no data.

Table 7 compares the accuracy of the receiver in the various conditions discussed above. Fig 3 brings out the comparison in the form of a bar chart. It can be seen that the accuracy of readings obtained under open sky is much better than in any other case because there is a clear view of satellites with no hindrance. Further, in each case, integrated SBAS feature (GPS+GAGAN) resulted in roughly 50% improvement in accuracy.

Table 7 Comparison of Accuracy of Single-Frequency Receiver under various conditions

S.No	Location	Stand-Alone GPS	GPS/SBAS
1	Open Sky	6.4m	3m
2	Partially Open Sky	6.6m	3.3m
3	Canopy	8m	3.8m
4	Buildings	8.5m	4m

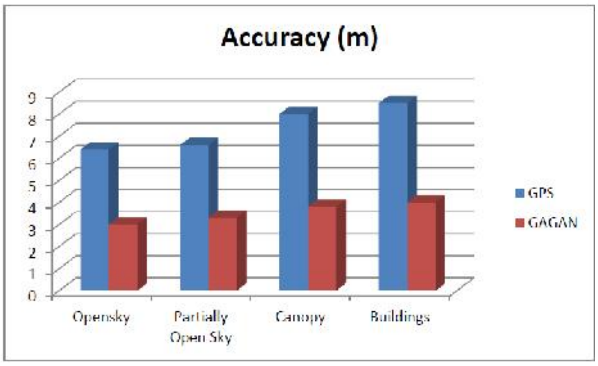

Fig 3 Comparison of Accuracy of Single-Frequency Receiver under various conditions

Following is the order of quality of data (in terms of accuracy) obtained under various conditions starting with the condition of best quality:

1. Under open sky using single frequency receiver (GPAS+SBAS)
2. Under open sky using single frequency receiver (Stand-alone GPS)
3. Under partially open sky using single frequency receiver (GPAS+SBAS)
4. Under partially open sky using single frequency receiver (Stand-alone GPS)
5. Under canopy using single frequency receiver (GPAS+SBAS)

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6. Under canopy using single frequency receiver (Stand-alone GPS)
7. Amidst buildings using single frequency receiver (GPAS+SBAS)
8. Amidst buildings using single frequency receiver (Stand-alone GPS)

V. CONCLUSIONS

The analysis of the results mentioned in the above sections using single frequency handheld receiver show that the accuracy and PDOP values of those taken under open sky are better than the ones obtained under the other conditions. In each case, the accuracy improved to a large extent, with SBAS (GAGAN) corrections applied to GPS system, when compared to the stand-alone GPS system. Land survey, map-making and area calculation are some of the fields which could benefit by the use of this device. Many experiments are in progress using single and dual frequency GNSS/SBAS receivers.

VI. REFERENCES

1. B. Hoffman-Wellenhof, H. Lichtenegger and J. Collins, GPS Theory and Practice, 1997.

2. Christopher J. Hegarty, Evolution of the Global Navigation Satellite System (GNSS), Senior Member IEEE, and Eric Chatre, Proceedings of the IEEE | Vol. 96, No. 12, December 2008.

3. Srinivas,R., Naveen Kumar,P. and Subba Rao,P.V.V., "Design and Validation of Online BER Measurement of Satellite Data Channel for IRS Series Satellites" The Biennial IEEE Applied Electromagnetics Conference, Karnataka, 2009.

4. Elsobeiey, M.E., "Stochastic Analysis of Low-Cost Single-Frequency GPS Receivers Positioning", Scientific Research Publishing Inc., 2016.

5. Willy Hereman and William S. Murphy Jr., Determination of a Position in Three Dimensions Using Trilateration and Approximate Distances, October 1995.

6. trl.trimble.com/docushare/dsweb/Get/Document-524676/JunoSeries_UserGuide_Rev B.pdf.

7. Perumalla Naveen Kumar, Achanta D. Sarma, AmmanaSupraja Reddy, Modelling of ionospheric time delay of Global Positioning System (GPS) signals using Taylor series expansion for GPS Aided Geo Augmented Navigation applications, 26 February 2015, IET Radar, Sonar and Navigation.