Comparison of DOP of GPS and Galileo in the South Asian Region

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***Abstract*—Dilution of precision is one of the most important parameter to consider for satellite navigation. With the existent full operational US operated GPS system the position can be calculated anywhere in the world. The upcoming European Galileo system is also a strong contender for the efficient calculation of position determination. Comparing both the GPS and Galileo in terms of GDOP and PDOP and also number of visible satellites the Galileo system has been proved a better version between the two. Simulation with the help of MATLAB GUI the overall comparison has been carried out for the three countries of South Asian region.**

Keywords—DOP; GDOP; PDOP; Number of satellites; GPS; Galileo

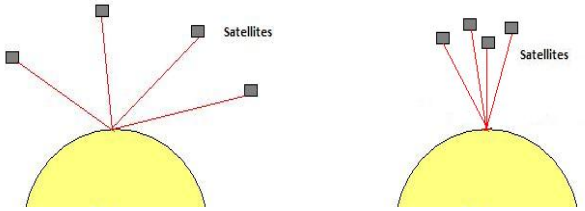
I. INTRODUCTION

A satellite navigation or Sat Nav system is a system of satellites that provide autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude) to high precision (within a few meters) using time signals transmitted along a line of sight by radio from satellites. As of February 2014, only the United States NAVSTAR Global Positioning System (GPS) and the Russian GLONASS are global operational GNSSs. The European Union's Galileo positioning system is a GNSS in initial deployment phase, scheduled to be complete operational with 30 satellites by 2020 at the earliest. China is in the process of expanding its regional Beidou navigation system into the global Compass navigation system by 2020. France, India and Japan are in the process of developing regional navigation systems.

Now for evaluating the performance of these systems there are certain parameters. One of them is geometry of the system. DOP (Dilution of Precision) is a dimensionless parameter to describe the effect of geometry on position accuracy. In this paper an analysis has been done on DOP values and also the availability of satellites on a specific coordinate and epoch over the region of South Asia. The places considered for analysis are - Dhaka, Delhi and Islamabad. Two system GPS and Galileo is considered in this aspect. The result has shown the best system which gives a lower DOP hence provide improved geometry and also the improved satellite availability.

II. DILUTION OF PRECISION

The satellite geometry, which represents the geometric locations of the satellites as seen by the receiver(s), plays a very important role in the total positioning accuracy. The better the satellite geometry strength, the better is the positioning accuracy. Good satellite geometry is obtained when the satellites are spread out in the sky. In general, the more spread out the satellites are in the sky, the better is the satellite geometry, and vice versa. The satellite geometry effect can be measured by a single dimensionless number called the dilution of precision (DOP).



(a) Good geometry, lower DOP (b) Bad geometry, higher DOP

Figure 1: DOP overview

The lower the value of the DOP number, the better is the geometric strength. The DOP number is computed based on the relative receiver-satellite geometry at any instance, that is, it requires the availability of both the receiver and the satellite coordinates. Approximate values for the coordinates are generally sufficient though, which means that the DOP value can be determined without making any measurements. As a result of the relative motion of the satellites and the receiver(s), the value of the DOP will change over time. In practice, various DOP forms are used. The analysis is carried out for position dilution of precision (PDOP) and geometric dilution of precision (GDOP). For examining the effect of the satellite geometry on the quality of the resulting three-dimensional (3-D) position (latitude, longitude, and height) can be done by examining the value of the position dilution of precision (PDOP). In other words, PDOP represents the contribution of the satellite geometry to the 3-D positioning accuracy. PDOP can be broken into two components: horizontal dilution of

precision (HDOP) which represent the satellite geometry effect on the horizontal component of the positioning accuracy and vertical dilution of precision (VDOP) represents the satellite geometry effect on the vertical component of the positioning accuracy.

III. MATHEMATICAL REPRESENTATION

The idea of Geometric DOP is to state how errors in the measurement will affect the final state estimation. The DOP values depend on cofactor matrix $Q_{\hat{x}}$. It is defined as:

$$Q_{\hat{x}} = [G\ e_m]^T [G\ e_m] \quad (1)$$

Here, e_m= m vector having all ones as its entries, m= number of satellites, G= design matrix that captures the single difference (SD) receiver satellite geometry.

$$PDOP = \sqrt{trace\ (Q_{\hat{x}})}$$

$$\Rightarrow PDOP = \sqrt{Q_{XX} + Q_{YY} + Q_{ZZ}} \quad (2)$$

Here, (X,Y,Z) is the receiver position.

$$TDOP = \sqrt{Q_{TT}} \quad (3)$$

$$GDOP = \sqrt{TDOP^2 + PDOP^2} \quad (4)$$

IV. SIMULATION AND ANALYSIS

A. Simulation

A Matlab® software Graphical User Interface (GUI), VISUAL, is used to analyze the result. The input parameters chosen for the simulations are -

- System: GPS and GALILEO.
- Almanac: a Yuma almanac file for current GPS and GALILEO ;
- Time and date: 06-02-2014 0:00-0:24h (temporal variation);
- Number of epochs: 1-300s;
- Cutoff elevation: 15° ;
- Ionospheric model: fixed ;
- Tropospheric model: fixed;
- Receiver type: Stationary;
- Baseline model: Geometry Free;
- Locations: Dhaka 23.7000° N, 90.3833° E, Delhi 28.6100° N, 77.2300° E, Islamabad 33.7167° N, 73.0667° E (temporal variations).
- Outputs: GDOP, PDOP, Number of satellites.

B. Result Analysis

The analysis has been carried out for three different locations as – Dhaka, Delhi, and Islamabad in terms of GDOP, PDOP and Number of satellites.

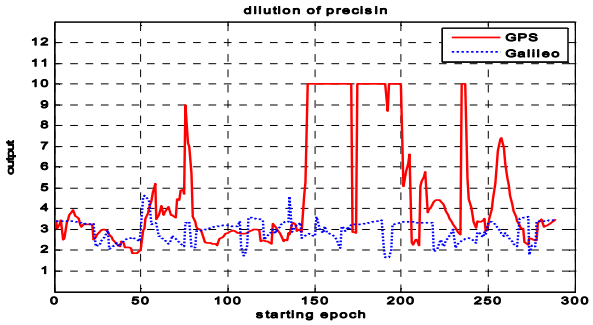


Figure 2: GDOP for Dhaka

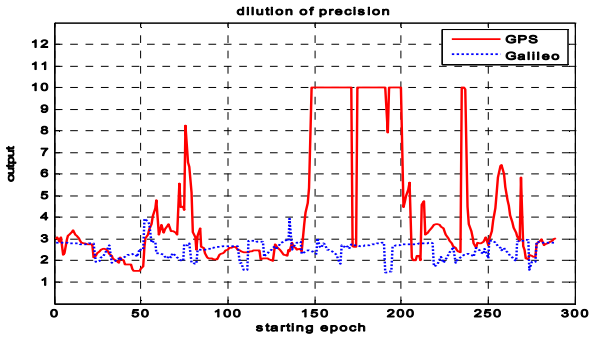


Figure 3: PDOP for Dhaka

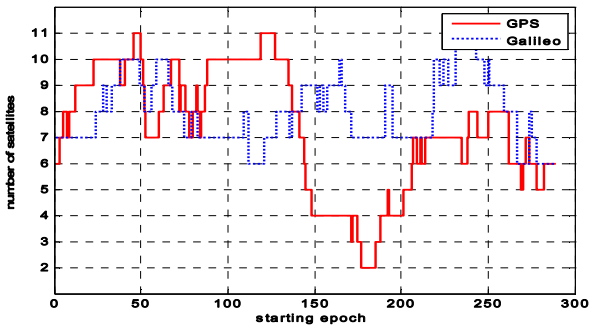


Figure 4: Number of satellites of Dhaka

From the figures it has been inferred that for a specific location selected as Dhaka, the GDOP, PDOP and Number of visible satellites has been compared with respect of GPS and Galileo. As we know the lower the DOP value the better. In GDOP analysis, for GPS the magnitude varies from 10 to 1.855 where for Galileo it varies from 4.579 to 1.665. So Galileo GDOP is 54% better than GPS. In PDOP analysis, values of GPS lies between 10 and 1.538 where for Galileo it lies between 3.93 and 1.467. So in terms of maximum PDOP the Galileo is 60 % better than GPS. Number of visible satellites is a very important parameter in position determination and other calculations. Here for GPS the maximum number of visible satellites at a time is 11 and minimum is 2. For Galileo maximum number remains as 11 but the minimum number improves to 6.

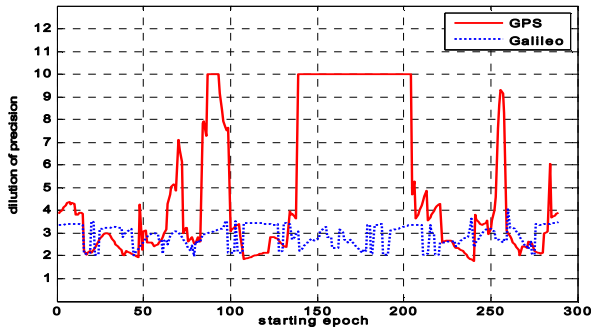


Figure 5: GDOP for Delhi

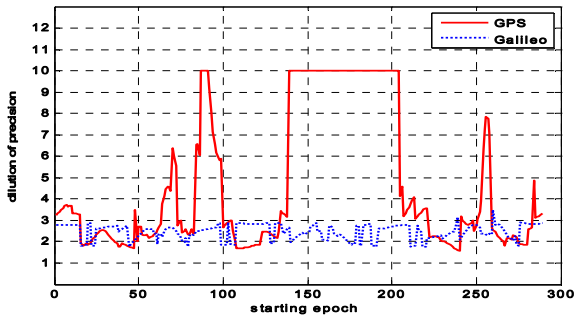


Figure 6: PDOP for Delhi

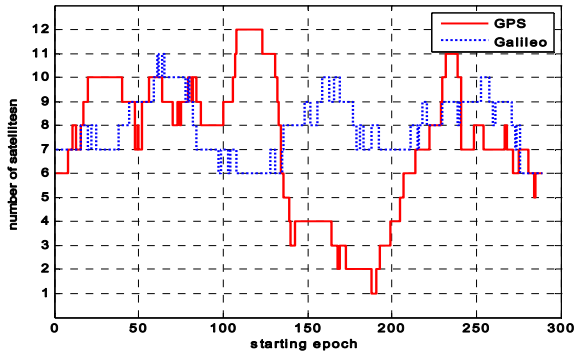


Figure 7: Number of satellites for Delhi

For a specific location selected as Delhi, the GDOP, PDOP and Number of visible satellites has been compared with respect of GPS and Galileo. In GDOP analysis, for GPS the magnitude varies from 10 to 1.783 where for Galileo it varies from 4.056 to 1.993. So Galileo GDOP is 59% better than GPS. In PDOP analysis, values of GPS lies between 10 and 1.564 where for Galileo it lies between 3.49 and 1.785. So in terms of maximum PDOP the Galileo is 65 % better than GPS. Number of visible satellites is a very important parameter in position determination and other calculations. Here for GPS the maximum number of visible satellites at a time is 12 and minimum is 1. For Galileo maximum number remains as 11 but the minimum number improves to 6.

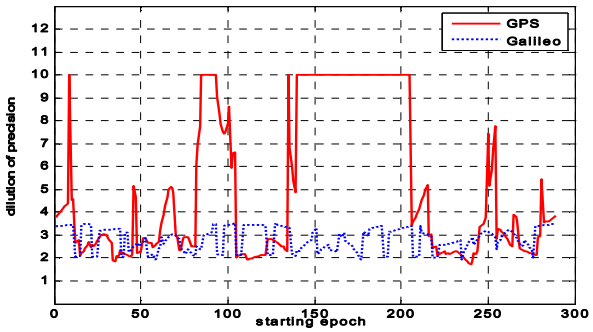


Figure 8: GDOP for Islamabad

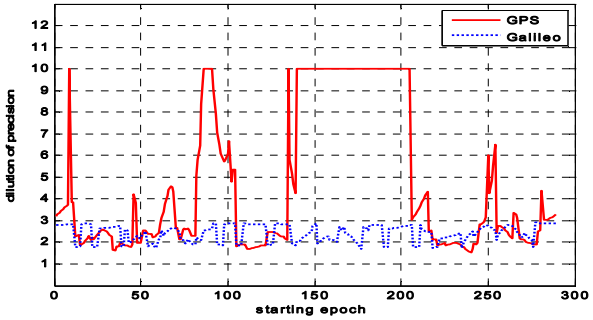


Figure 9: PDOP for Islamabad

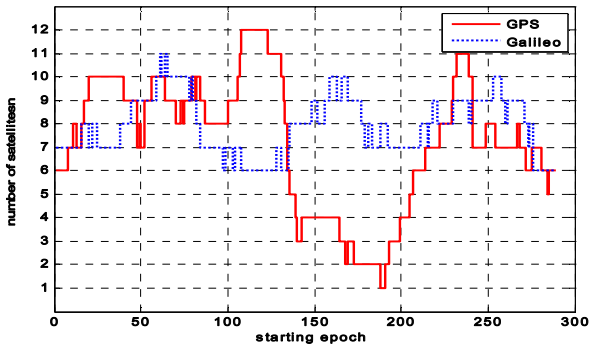


Figure 10: Number of satellites for Islamabad

Coordinates selected as Islamabad to calculate the parameters – GDOP, PDOP and number of satellites. In GDOP analysis, for GPS the magnitude varies from 10 to 1.712 where for Galileo it varies from 3.505 to 1.921. So Galileo GDOP is 59% better than GPS. In PDOP analysis, values of GPS lies between 10 and 1.51 where for Galileo it lies between 2.912 and 1.712. So in terms of maximum PDOP the Galileo is 65 % better than GPS. Number of visible satellites is a very important parameter in position determination and other calculations. Here for GPS the maximum number of visible satellites at a time is 12 and minimum is 1. For Galileo maximum number remains as 11 but the minimum number changes to 6.

V. CONCLUSION

From the analysis and simulation it has been observed that in comparison with the unevenly distributed GPS system, the modern Galileo system is much more improved and will give more accurate result. DOP value is less for the Galileo system which indicates better geometry for the satellites. In terms of visible satellites it also gives a constant result as at any moment the number does not fall below 6. For that reason it can be said that in terms of DOP and number of satellites visible the Galileo system is much more efficient than GPS.

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