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Improving the Positioning Performance of GPS Through Differential GPS – An Overview

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ABSTRACT:- *The advent of GPS and its exceptional capability of providing continuous Position, Velocity and Time (PVT) information to the users worldwide proved to be a great technological success of 20th century. The PVT solution provided by standalone GPS is degraded by various error sources such as atmosphere based errors, satellite based errors and receiver based errors. The errors that are correlated in time and space can be mitigated or reduced using Differential GPS (DGPS) technique. Thus DGPS enhances the accuracy of stand-alone GPS. This is achieved by employing reference stations that transmit the corrections to the users in its service area. This paper presents an outline of the salient features of DGPS, while throwing light on the DGPS types and error corrections in DGPS.*

Keywords:- *GPS, DGPS corrections, error mitigation.*

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I. INTRODUCTION

Designed, developed and operated by USA, GPS is a satellite-based navigation system. GPS satellites in space and control segments on the ground, continuously work together to provide user segment with Position, Velocity and Time (PVT) estimates. The position solution is computed based on the range measurements (satellite-to-user distance).There are a number of error sources that corrupt the GPS range measurements (Fig.1). The error sources can be categorized into three major sources namely satellite based errors, atmospheric errors and receiver based errors. Satellite based errors include satellite clock offset, satellite ephemeris error, instrumental bias error, relativistic effects etc. Receiver errors include multipath and receiver noise, receiver clock offset, receiver instrumental bias, the receiver antenna phase center variation etc. Besides these errors, the satellite signal experiences delays as it propagates through the ionosphere and troposphere parts of the atmosphere. Typical values of pseudorange errors for a single frequency (L1) user are shown in Table 1.

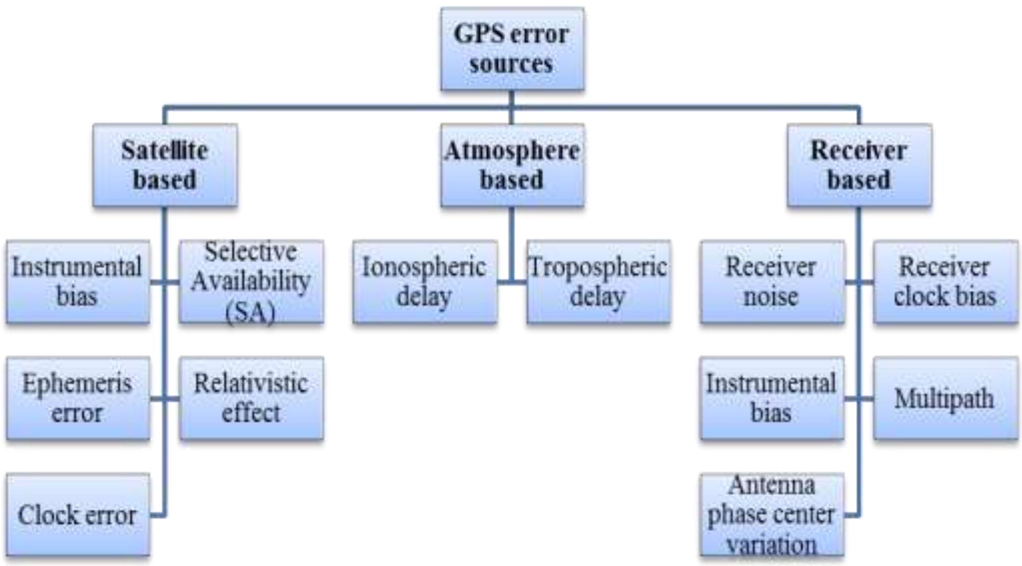

Fig.1: Prominent error sources affecting GPS range measurements

Table 1 Pseudorange errors for a single frequency (L1) user [1]

Error Sources	RMS Range Error (1σ) (m)
Satellite based	
Satellite clock	3
Predictability of SV parameters	1
Ephemeris prediction	4.2
Others	2
Medium based	
Tropospheric delay	2.0
Ionospheric delay	2.3
Receiver based	
Receiver noise	1.5
Multipath	1.2
Other	0.5

There are two types of services offered by GPS. They are - the Precise Positioning Service (PPS) to military and Standard Positioning Service (SPS) to civilian users. Because of these errors, GPS SPS offers a position accuracy of 10m and 15m (with 95% confidence) in the horizontal and vertical directions respectively (without Selective Availability) [2]. However, there are many applications that demand higher accuracies. For such applications, Differential GPS (DGPS) is required.

II. DIFFERENTIAL GPS (DGPS)

DGPS improves the positioning performance of GPS. This technique is based on the principle - spatially correlated errors such as satellite clock error, ephemeris error and atmospheric propagation errors are same for all the GPS users separated by certain distances (tens of kilometers) and also exhibit less variations with time (temporally correlated). This basic idea is realized by setting up a reference station that employs a dual frequency GPS receiver at a known (well surveyed) location (Fig. 2).

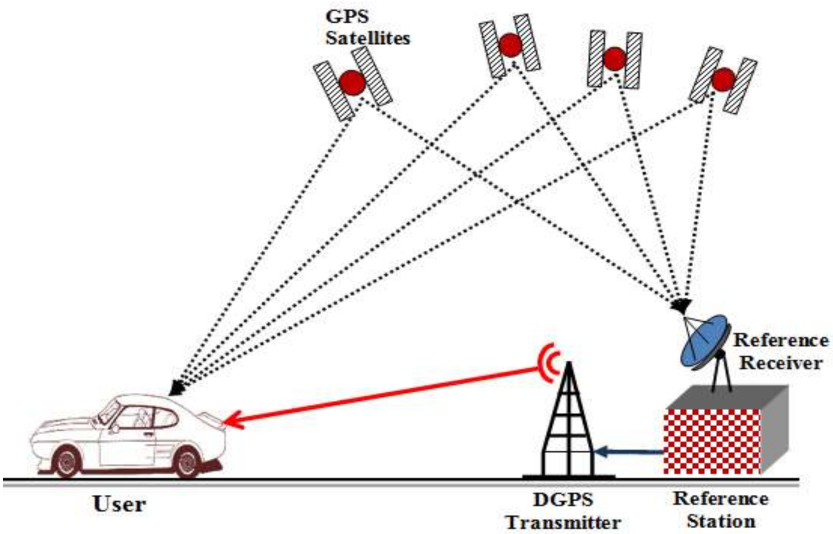

Fig. 2: Illustration of the concept of DGPS

As the position of reference station is known a prior, the combined effect of the errors for each SV can be estimated. These error estimates are made available to the user in the form of differential corrections. User receivers within the coverage range of the reference station apply the differential corrections to their measurements to improve their navigation accuracy.

A. Types of DGPS

Based on the geographic area to be covered, DGPS systems may be categorized as Local Area DGPS (LADGPS) and Wide area DGPS (WADGPS) [3]. LADGPS systems are designed to function only over a small geographic area with the separation between user and reference station of about 10–100 km. WADGPS systems effectively cover larger geographic regions by employing multiple reference stations and transmitting vector corrections valid over large geographic area. Geostationary communication satellites are used to broadcast the corrections. Another categorization of DGPS systems is based on the type of GPS range measurements used to compute differential corrections. Code-based DGPS systems rely on GPS code measurements (pseudoranges) and provide decimeter-level position accuracies whereas carrier-based DGPS systems use GPS carrier measurements to compute the corrections [4]. Carrier phase measurements are more precise and provide millimeter-level performance, but contain integer ambiguity that must be resolved.

B. DGPS corrections

In DGPS, the corrections can be estimated in three domains namely, position domain, measurement domain and state space domain [5]. In position domain, well-known position of the reference receiver is compared with its GPS computed position. The difference in the position estimates is transmitted to the user to correct its position. This technique is efficient only when same set of satellites are visible to the reference station and user i.e over short distances. In the measurement domain, the pseudorange of each visible satellite is compared with the geometric range. The difference is transmitted to the user to correct its observed pseudorange. This technique works well for user to reference receiver separations of about hundred kilometers. In the state space domain, state vector of the errors within the working area are assessed based on the observations from several reference stations. Vector corrections work well even for user-reference station separation of several thousands of kilometers. Depending on the type of application, corrections can be generated in any of the three modes. But, as the distance between the reference receiver and the user increases (spatial de-correlation) and as the time passes (temporal decorrelation), the validity of transmitted pseudorange corrections is reduced. Hence, the errors affecting DGPS performance are classified into three major categories - temporally decorrelated errors, spatially decorrelated errors and uncorrelated errors.

C. Error mitigation in DGPS

Satellite clock and ephemeris errors are spatially correlated but temporally decorrelated. Clock error varies slowly over hours and is completely eliminated with differential corrections transmitted every hour. Ephemeris error changes slowly over minutes. Even after applying differential corrections, a residual error of 0.1 m (rms) still remains. Ionospheric error shows significant variability both spatially and temporally. For a satellite at zenith, post-differential-correction residual error would be 0.1-0.2 m for receivers separated by 100 km. Under active ionospheric conditions, the errors can be 1 m or more [2]. Tropospheric delay depends on water vapour content in the atmosphere, which varies both spatially and temporally. Residual error can be 0.1-0.2 m for two receivers separated by 10 km and increases for low elevation satellites. Errors such as receiver noise and multipath are not correlated between the reference station and user receivers and DGPS cannot correct such errors.

III. CONCLUSIONS

By employing DGPS, some of the GPS errors are completely mitigated and some are partially mitigated leaving a residual error, while few errors cannot be eliminated. Hence DGPS offers an improved accuracy when compared to standalone GPS. Several DGPS services are now in use worldwide and are offering meter-level positioning accuracies. Though the accuracy is improved, major drawback with DGPS is that the corrections that are broadcast are valid for the users in a limited area in the vicinity of the reference station. To serve a vast geographic area, networks of reference receivers, each with its own communication link with the user are required.

REFERENCES

[1]. Parkinson, B.W., and J.J. Spilker, "Global Positioning System: Theory and Applications", Vol.1, American Institute of Aeronautics and Astronautics, Washington, 1996.

[2]. Misra, P., and Per Enge, "Global Positioning System: Signals, Measurements, and Performance", Ganga-Jamuna press, 1st Edition, New York, 2001.

[3]. Groves Paul, D., "Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems", GNSS Technology and Application Series, Artech House, Boston, London, 2008.

[4]. Prasad, R., and Marina Ruggieri, "Applied Satellite Navigation using GPS, Galileo, and Augmentation systems", Artech House, Boston and London, 2005.

[5]. Seeber, G., "Satellite Geodesy", Walter de Gruyter, Berlin, New York, 2nd Edition, 2003.

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