Navigating Satellite: -A Review

Shivangi Barthwal, Anurag Vidyarthi, Vivek Chamoli, Shubham Negi
Electronics & Communication, Graphic Era (Deemed to be University)
Dehradun, Uttarakhand
shivangi.ddn@gmail.com

Abstract— Navigation satellites are an important part of our day to day life even though one may not realize it. In the present scenario wherever one goes he uses the navigation satellite with the help of his smartphone and accesses a lot of data from them for their day to day tasks. However, the use of these satellites is not restricted to just smartphones and other known purposes like for military uses and every day a new application of these satellites comes up, for example, their use in soil moisture sensing etc. to name a few. Thus it becomes important to have knowledge of these satellites. Hence, this article covers a brief review of working of navigation satellites and different satellites systems that are present around the world. Along with this, a comparison of these satellite systems has also been provided. The comparison between the satellite systems gives the basic idea about the better technology used by different countries such as BeiDou Navigating Satellite System (BDS), Galileo , Global Navigation Satellite System(GLONASS), IRNSS /Navigation Indian Constellation (NavIC), Quasi-Zenith Satellite System (QZSS), Global Positioning System(GPS), and this information can be used to develop accuracy in navigating systems.

Keywords— Global Satellite Navigation System; Navigation Satellite; GPS; IRNSS; NAVIC; Galileo; BeiDou, QZSS; GLONASS

I. INTRODUCTION

Navigation is defined by the monitoring and controlling the movement of any moving object. Navigation can be referring study that involves the determination of position and direction. [1-2] .Global navigation satellite system (GNSS), its provides PNT (positioning, navigation, and timing) services on a global or regional basis. The main ones are named below.

1. BeiDou Navigating Satellite System (BDS)
2. Galileo
3. Global Navigation Satellite System(GLONASS)
4. IRNSS /Navigation Indian Constellation (NavIC)
5. Quasi-Zenith Satellite System (QZSS)
6. Global Positioning System(GPS)

This paper is divided into five sections including the current introductory section. Section II discusses the basic working ideology for navigational satellites. In section III details of different navigation satellites around the world has been discussed. This is followed by a comparison of these different satellites in a tabular method. At last in section five concluding remarks have been given.

II. WORKING IDEOLOGY

In satellite system the reference co-ordinate structure is consist of [3-5]:

1. Global
2. Earth orbit

Two reference structure are required:

1. Space-fixed (description of motion of the satellites) .
2. Earth-fixed(positioning of the observation stations).

Satellite Navigation Systems are divided into three section:-

1. Space section (generate radio navigational signals transferring a huge information content simultaneously)

2. Ground section (composed of site for launching CMC (Command Measuring Complex) and Control Centre.

   a. CMC serves satellites information supply.

   b. Control Centre operatrates all the satellites systems.

3. User section (composed of UE (user's equipment). The navigation signals for the end users are served in the user section.

Fig.1 Satellite Navigation System's Segments

Earth-fixed (Terrestrial reference system) is defined by three axes as shown in fig.2:

X-axis: Greenwich meridian

Z-axis: CIO (Conventional International Origin)

Y-axis: orthogonal to both Z and X axis

Fig 2. ECEF coordinate system and ellipsoidal coordinates. Earth Centered, Earth Fixed (ECEF).

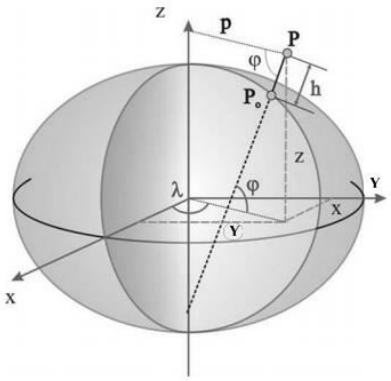

Fig.2 ECEF coordinates system and ellipsoidal coordinates

III. DIFFERENT NAVIGATING SATELLITE

A. *BeiDou Navigation Satellite System (BDS)* [7]

BeiDOU Navigation Satellite System components

1. Space section
2. Ground section
3. User section

Target:

1. Expanding range of application in china's economic and social sector.
2. Maintenance independence and initiative.
3. Global services with open, stable and reliable technology.
4. Strengthening foundation of navigation satellite industrial chain.

B. *Galileo*

Global Satellite Navigation System (GNSS) of Europe is Galileo[6], [11-12]

Application of Galileo:

1. Location-based services (LBS)
2. IOT
3. Emergency, security and humanitarian services
4. Science, environment, weather
5. Transport
6. Agriculture
7. Fisheries
8. Civil engineering
9. A crucial time-reference function

C. *Indian Regional Navigation Satellite System (IRNSS)/ NavIC*

IRNSS is developed by India ,is an independent regional navigation satellite system IRNSS will provide two types of services.[14-19].

1. Standard Positioning Service (SPS): for all the users
2. Restricted Service (RS): use by only specific person.

Some applications of IRNSS are:

1. Ground base and Marine based Navigation
2. Disaster Management
3. Object tracking(any moving object like cars ,humans ,aeroplances etc.)
4. Accurate position (position accuracy= upto 20 m) .

D. *Quasi-Zenith Satellite System (QZSS)*

QZSS is a Japanese satellite positioning system composed mainly of satellites in quasi-zenith orbits (QZO). The QZSS is known as the "Japanese GPS." [20].

Some plus point of QZSS:

1. highly compatible with GPS
2. Low cost receiver
3. Highly precise, stable positioning possible
4. Lesser the positioning errors

E. *Global Positioning system (GPS)*

The Global Positioning System (GPS) owned by the US government and operated by the US Air Force. The GPS provides précised positioning capabilities to military, civil, and commercial users around the world. [21-22].

Application of GPS:

1. Aviation.
2. Marine.
3. Farming.
4. Science.
5. Surveying.
6. Military.

F. *GLONASS*

GLONASS or "Global Navigation Satellite System" is a space-based satellite navigation system operating in the radio navigation-satellite service. Its owned by the Russia[23].

Advantages of GPS/GLONASS use:

1. Double warranty of positioning when a satellite of one system does not work
2. Allow to catch the signal even in buildings near windows and in city
3. In northern hemisphere GPS may work worse than GLONASS;
4. Low price of GPS/GLONASS in future
5. Power consumption in GPS mode and in GLONASS mode is equally low.

Application of GLONASS is

1. Providing real time position .
2. Surveying, mapping and GIS.
3. Transport

4. Agriculture

5. Fisheries

IV. COMPARISTION OF DIFFERENT NAVIGATION SATELLITE

TABLE I. **COMPARISON OF NAVIGATION SATELLITE**

Navigation satellite	GPS	BeiDou	GLONASS	NAVIC	Galileo	QZSS
Country	United States	China	Russia	India	EUROPE	Japan
Channel Access Method	Code- DMA*	Code- DMA*	Frequency-DMA*	Code- DMA*	Code- DMA*	Code- DMA*
Satellite's numbers	31	GEO*(5)+ MEO*(30)	28	GEO*(3)+ GSO*(4)	14	4
Accurateness	Civil (15m)	Civil (10m)	4.5m – 7.4m	Civil (10m)	Civil (1m)	Civil (1m)

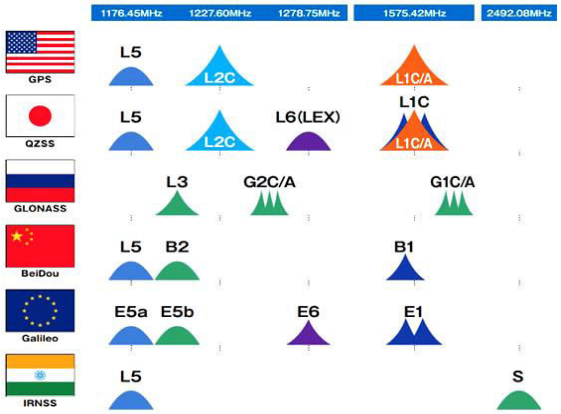

Fig.3 . The frequency band for different navigation satellite

***NOTE:** Geostationary Orbit (GEO) Satellites, Medium Earth Orbit (MEO) Satellites, Geosynchronous (GSO), DMA (division multiple access)

V. CONCLUSION & RECOMENDATIONS

This article reviews different navigation satellites which are being used all around the world. It provides an overview of different satellites, including their specifications and their purpose. GPS, IRNSS, GLONASS etc. satellite systems have been discussed which includes their working, specifications and purpose. It further highlights that apart from being used for the navigation purpose, what other onus these satellites are given for example disaster management, science and technologies, GIS etc. to name a few.

Currently, GPS is at the helm of navigation technologies and is being used world over because it was the primary system of its kind and possessed good level of accuracy. But it is to be highlighted that being a project developed by a government organization there were a lot of politically motivated issues surrounding the use of GPS, an example of which can be taken form Kargil war for India where it was denied the use of this particular facility for military purpose. Thus, finally IRNNS has been discussed which is India's independent venture in this domain. And even though it is in nascent phase, it has begin to show good results not only for navigation purposes nut other research related fields as well.

References

[1] Cutler, Thomas J. (December 2003). Dutton's Nautical Navigation (15th ed.). Annapolis, MD: Naval Institute Press. ISBN 978-1-55750-248-3.

[2] Department of the Air Force (March 2001). Air Navigation (PDF). Department of the Air Force. Archived from the original (PDF) on 2007-03-25. Retrieved 2007-04-17.

[3] Seeber G. (2003). Satellite Geodesy: Foundation, Methods, and applications. Walter de Gruyter, Berlin New York.

[4] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[5] Hofmann-Wellenhof B., Lichtenegger H., and Collins J. (2001), Global Positioning System: Theory and Practice, 5th ed. New York: Springer VerlagWien

[6] "Galileo goes live!". europa.eu. 2016-12-14.

[7] "Beidou satellite navigation system to cover whole world in 2020". Eng.chinamil.com.cn. Retrieved 2011-12-30.

[8] "A Beginner's Guide to GNSS in Europe" (PDF). IFATCA. Retrieved 20 May 2015.

[9] https://www.broadcom.com/company/news/product-releases/2302120

[10] Jury, H, 1973, Application of the Kalman Filter to Real-time Navigation using Synchronous Satellites, Proceedings of the 10th International Symposium on Space Technology and Science, Tokyo, 945-952.

[11] "Boost to Galileo sat-nav system". BBC News. 25 August 2006. Retrieved 2008-06-10.

[12] "Commission awards major contracts to make Galileo operational early 2014". 2010-01-07. Retrieved 2010-04-19.

[13] "GIOVE-A launch News". 2005-12-28. Retrieved 2015-01-16.

[14] "India to develop its own version of GPS". Rediff.com. Retrieved 2011-12-30.

[15] S. Anandan (2010-04-10). "Launch of first satellite for Indian Regional Navigation Satellite system next year". Beta.thehindu.com. Retrieved 2011-12-30.

[16] "India to build a constellation of 7 navigation satellites by 2012". Livemint.com. 2007-09-05. Retrieved 2011-12-30.

[17] The first satellite IRNSS-1A of the proposed constellation, developed at a cost of 16 billion (US$280 million),[3] was[4] launched on 1 July 2013 from Satish Dhawan Space Centre

[18] "ISRO: All 7 IRNSS Satellites in Orbit by March". gpsworld.com. 2015-10-08. Retrieved 2015-11-12.

[19] Laiqh A. Khan (May 24, 2016). "'NAVIC could be operationalised during July-August this year'". The Hindu. Retrieved September 2, 2017.

[20] "JAXA Quasi-Zenith Satellite System". JAXA. Archived from the original on 2009-03-14. Retrieved 2009-02-22.

[21] Leick A., 2003, GPS Satellite Surveying, 3rd ed. New York: John Wiley and Sons.

[22] "GPS Space Segment". Retrieved 2015-07-24.

[23] "GLONASS status". Archived from the original on 2013-05-04.Retrieved 2015-07-24