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An Overview on the Indian Regional Navigation Satellite System – GAGAN

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ABSTRACT –

satellite based augmented system (SBAS) and Global positioning system (GPS) is a type of navigation system based on satellite which is used to provide the geographical, positioning and the timing data to the various application. GPS is owned by the US government so for providing the crucial data the GPS cannot satisfy the various necessary requirement such as accuracy, continuity, availability, integrity and safety application concerns so the Indian space research organization , Raytheon and the airport authority of India (AAI) have worked and implemented GPS aided geo augmented navigation (GAGAN) the satellite based augmented system (SBAS) for the Indian space region and this project is known as the GAGAN and certified from Directorate General of Civil Aviation, Government of India. this paper gives an overview about the augmentation system along with that satellite based augmented system, geo augmented navigation system and brief about Indian regional navigation satellite system along with that the error we get from the receiver and the satellite side and methods available for reduction of this error.

Keywords– GPS (global positioning system), SBAS (satellite based augmented system), ISRO (Indian space research organization), AAI (Airport Authority of India)

1. INRODUCTION

GAGAN project is implementation of satellite-based augmentation system by the Indian space research organization and the airport authority of India we have used the GPS which is US based satellite system so for providing the additional factor such as precision, accuracy and the availability so by keeping all that factor in mind they have launched the project GAGAN. it is very first satellite based navigation system it assists in the bestride of equatorial region area of earth the main objective of this project is to locate the satellite based augmentation system for the civil aviation authority application for the safe operation it this is meant only for the Indian space region along with that the constellation is designed to provide a better accuracy and this project established around the 15 reference station, 3 land uplink station and the 3 control mission center and the GAGAN satellite provide the non- precision approach service with the radius of the 185.2 meter the GAGAN project will help in redefining the satellite navigation system over Indian airspace region it will provide the self-sustaining satellite system and by doing India become the third nation in the world to have such accuracy approach toward the satellite system.

2. AUGUMENTATION SYSTEM

Augmentation is a type of method which we used for providing the accuracy, availability and the reliability for the enhancement in the satellite navigation system. there is various augmentation system developed by different countries and they used their argumentation system only such as -

1.1. Wide Area Augmentation System (WAAS) this system is used by north America and this is operated by the FAA (Federal Aviation Authority)

1.2. Continuously Operating Reference Station (CORS) this is US core network and this system is managed by the National Oceanic and Atmospheric Administration.

1.3. Global Differential GPS (GDGPS) this augmentation system is managed and developed by jet propulsion laboratory NASA for the determination of the positioning and the timing of the missions.

1.4. International GNSS service (IGS) the main objective of this augmentation system is to provide the high accuracy and quality data and this is used by 80 countries and 200 organization is contributing in more than 350 GPS monitoring stations

1.5. Nationwide Differential GPS system (NDGPS) this augmentation system is ground based system which is used to increase the accuracy of the GPS.

3. SATELLITE BASED AGUMENTATION SYSTEM (SBAS)

Satellite based augmentation system is a type of augmentation system which is used to increase the accuracy, precision of the existing GPS system as GPS is alone not sufficient to provide the accuracy and the satellite-based augmentation system is primarily the GNSS constellation. In case of SABS, we are having the differential ground station for receiving the signals from the various GNSS system like, GPS, Navic …. Etc. then by using these signals error can be evaluated and this error will transmit back to the satellite system and then the geostationary satellite will transmit these signals back. the main objective of SBAS has to provide the integrity assurance and it can be improving the estimation of the position even by using a single receiver but it is not easy for operator to have the different type of GNSS system as in that case we required a lot of arrangement and the receiver are also very expensive but with that we can get the accuracy only after the post process and implementation. If the satellite station is spreaded over a large area then the satellite-based augmentation system will be more appropriate for improving the accuracy and precision and all the satellite-based augmentation system must fall the standards and recommended practice which is specified by the ICAO for providing the flawless navigation.
As we can see new innovation happening in the field of science there are many applications and upcoming application which required the very high accuracy, precision and positioning. Country even launched the driverless car which require the high accuracy so in that case the satellite-based augmentation system will help to get the desire accuracy where the implementation in GNSS will be required.

HOW DOES IT SBAS WORK?

Satellite based augmentation system use the GNSS monitoring system for calculating the GNSS error which is caused due to the atmospheric disturbance and satellite and receiver error. So due to that the position, precision error be creating due to time error between the satellite and the error.
So, for calculating the GNSS error the GNSS data will be compared with the documentation of each land-based detector if there any dispersancy found we determined to be an error and that disprency data will be sent to the GSS and will broadcast it from the region these satellite-based augmentation system correction is known as deviation correction and we have to allow GNSS receivers to more accurate to determine the precision and the position.
There are many regions which have satellite-based augmentation system coverage even some are still in development phase.

Regions that have their satellite-based augmentation system coverage are –

GAGAN – This is known as the GAGAN (GPS aided geo augmentation navigation system) and developed by the ISRO and AAI
MSAS – It is Multi-Functional Satellite Augmentation system and operated by Japan civil aviation bureau.
ENGOS – This is known as European Geostationary Navigation Overlay Service and developed by the ESA.

Regions that have their satellite-based augmentation system still in development phase –

SNAS – Satellite Navigation Augmentation System it is China based augmentation system and still in deployment phase.
SDCM – System for Differential Correction and Monitoring is still in development phase and Russian agencies working on it after completion it will offer correction to GPS and Russian satellite navigation system.
WADGPS - Wide Area Differential Global Positioning System this is South Korea based augmentation system and still in development phase.

4. GPS AIDED GEO AUGMENTED NAVIGATION(GAGAN)

GAGAN is an autonomous Satellite Based augmentation system it (GPS aided geo augmentation navigation system) is developed by the ISRO and AAI. GAGAN is a system which is used to increase the accuracy, integrity and the position by providing the signal as the reference to the GNSS receiver. The effort of Government Of India to implementing the augmentation system is the first step to modernize the communication and the navigation system of the Indian region for the implementation of the satellite based augmentation system the L1 and L2 frequency were obtained from the united states the GAGAN project has the two major architecture the one is the ground segment and the second one is the space segment along with that the GAGAN system is also contain the fifteen reference station which is available in the different part of India along with that two master control system is operation and the one control system is in the shadow mode and the for the first inspection of GAGAN project was held in four major cities airport such as Bengaluru, Hyderabad, Nagpur, Kozhikode and the result from these inspection was good and the accuracy was satisfactory .
The main essential project of GAGAN is to study the ionosphere atmospheric layer behaviors over the Indian airspace for the study of the same some Indian universities and the research and development centers suggested nine more TEC station.
So, as all the reference station getting the GPS information which is forwarded to the Indian mission control center and after all the information being processed whatever the error, we get it displays the correction messages and after that these correction message sent to the Indian land uplink station and it further uplink them with the three satellite communication GSAT – 8, GSAT – 10 and GSAT -15.

4.1. DEVELOPMENT

The GSAT-4 geostationary satellite gets integrated from the GAGAN transmitter and had expected to be launched and operational in the 2008 but due to some delays it was launched in April 2010 but after the third stage it failed and can't able to get the desired orbit.

In 2009 Raytheon had won the contract for modernize the Indian navigation system after that in 2012 the DRDO got the demised version of the instrument which exhibit all the attribute from the GNSS and the GPS.
On 30 December the GAGAN get certified by the directorate general of civil aviation to required navigate performance 0.1.

4.2. SATELLITES

GSAT – 8 - Geostationary -8 is the communication satellite from India it is launched on 21 may 2011 and launched from the kourou by using the European space launch vehicle placed in the geosynchronous 55-degree E mass at lift off was 3093 kg and the dry mass was 1426 kg along with that the satellite getting power from the solar array which is providing the 6242 watts lithium ion batteries and the physical dimension of 2.0 *1.77*3.1 m cuboid and the life span of this satellite is more than 12 year . GSAT – 8 is the first satellite which carried the GPS Aided Geo augmented system satellite payload and provided the navigation service from the orbit.

GSAT – 10- It is also a high power and advance communication satellite and it is inducted into the Indian national satellite system and launched on 29 September 2012 from the Kourou, French by using the European space launch vehicle Ariana – 5 ECA rocket carrier and placed in geostationary orbit 83-degree East and co – located with the INSS -4A along with GSAT-12. The mass at lift was by 3400 KG and dry mass was 1498 KG and the solar array providing the 6474 Watts power and two 128 AH lithium – ion battery and the physical dimension was 2.0 M * 1.77 M * 3.1 M cuboid.
In normal C- band the 30-communication transponder was configured to carry by the GSAT – 10 and GAGAN payload provide the SBAS accuracy and positioning information obtained from GPS as well the GPS aided Geo Augmented navigation pay operation in the L5 and the L1 along with that it also carries a KU – band beacon it helps in getting the accurate point ground of antennas towards the particular satellite.

GSAT – 15– It is also an advance Indian communication satellite it is similar to the GSAT- 10 which is used to augment for providing the more bandwidth and increasing the capacity of transponder for the very small aperture terminal services it is launched on 10 November 2015 from the kourou by using the European launch vehicle Ariane 5 ECA mass during the launch was around 3164 KG and dry mass was about 1440 KG placed at the geostationary orbit (93.5 degree E) and it is manufactured by the Indian satellite center space application center Ahmedabad it carries transponder bond 24 * Ku band also carries 2 Ku band with bandwidth around 36 MHz and satellite payload is operating in the L5 and L1 band the expected lifespan of the GSAT – 15 is around 12 year .

5. INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM (IRNSS)

5.1 IRNSS

IRNSS is an autonomous and unrestrained navigation satellite system also known as the NavIC (Navigation with Indian Constellation) and developed by the Indian space research organization. On May 2016 the NavIC satellite become fully operational. It is used for the navigation between the Indian order and space exceeding range of 1500 KM beyond the Indian borders as well it is useful in providing the precision, mapping, voice navigation and the terrestrial navigation for the national application.

5.2. DEVELOPMENT

For NavIC project Indian space research organization opened new satellite navigation center on the 28 May 2013 in the ISRO campus deep space network in Karnataka along with 21 network ranging station located across the country and this network will provide the data for monitoring the satellite navigation signal along with the orbital determination of the satellite.
On 2014, September the NavIC signal were released for correction of error. On April 2019 the government of India made it compulsory to be install the NavIC the navigation satellite system in all the commercial vehicle in India.
On 20 January 2020 for supporting the navigation with Indian constellation launch three 4G chipset after that on 31 august 2020 launched the 5G chipset.

5.3. SYSTEM DESCRIPTION

This system consists of seven satellite constellation and along with that two additional satellite are standby on ground. NavIC provides the two level of service one is restricted service it is for the authorized user like government bodies along with military and the second is standard positioning service this service can be used by the ordinary and civilian people. The first satellite was launched on the first July 2013 after that the last satellite for NavIC project was launched on 12 April 2018. The height of orbit was 35,786 Km and launched in the geosynchronous orbit. Now government is plans to expand the NavIC satellite project by increasing the constellation size by seven to fourteen.

5.4. GROUND SEGMENT

The ground segment is consisted of –

- IRNSS Spacecraft Control Facility
- Laser Ranging Station
- IRNSS LDMA Ranging Station
- IRNSS Network Timing Center
- IRNSS Data Communication Network
- IRNSS Range and Monitoring Station
- ISRO Navigation Center

5.5. SPACE SEGMENT

The space segment constellation consist of 8 satellite three satellite are located in the geostationary orbit at 32.5-degree East, 83-degree East and 131.5-degree East longitude and remaining satellite incline at the geosynchronous orbit.

5.6. LIST OF SATELLITE IN IRNSS SYSTEM

IRNSS constellation consist of seven satellite – IRNSS – 1A - Launched on 1 July 2013.

IRNSS – 1B - Launched on fourth April 2014
IRNSS – 1C - Launched on 16 October 2014
IRNSS – 1D - Launched on 28 march 2015
IRNSS – 1E - Launched on 20 January 2016
IRNSS – 1F - Launched on 10 march 2016 IRNSS – 1G - Launched on 28 April 016
IRNSS – 1H - Launched on 31 Aug 2017 IRNSS – 1I - Launched on 12 April 018

6. FACTOR AFFECTING SATELLITE SYSTEM

There are several factors which affect the satellite signal and the performance is highly depend upon the receiver and depend on the atmosphere too.

Satellite clock error – The satellite clock error is caused by the satellite oscillator which is not being synchronized and it affect the accuracy as well as the positioning of the GPS system. so, the clock error can be eliminated or avoided in the GPS. the receiver clock error can be eliminated by comparing the arrival of time of the two-given satellite signals.

Ephemeris error - Ephemeris error is the difference between the expected and actual position of the GPS satellite computed by using the GNSS navigation message system, these errors are caused due to the gravitational pull from the natural satellite and also due to the pressure of solar radiation on the individual satellite it decreases the accuracy of the signal as well.

Atmospheric error – Sometime the atmospheric condition can reduce the accuracy as it may weaken the GPS signal such as rain and snow and it's also affected the position of antenna because of the snow coating and thick ice, sometime the accuracy level also drop from the satellite signals travels from space to earth as there are many layers of atmosphere so within the ionosphere it can refract the signal and it cause the positioning error.

7. RESULT AND DISCUSSION

The GAGAN Satellite Based Augmentation system navigate the data by using the L1 and L5 signals. GAGAN is designed to increase the performance level of the. ANP 0.1 and. APV 1.0 over the Indian region. So, the director general of civil aviation has certified the RNP0.1 service of the GAGAN system and on April 2015 it is certified for the vertical guidance, according to this the aircraft which is equipped with the satellite-based navigation system receiver will be able to used the GAGAN navigation system for the en route navigation approach and vertical guidance of the aircraft.
The gap between the MTSAT augmentation system and European geostationary navigation overlay service has been filled by the GAGAN signal along with that the ionosphere effect the accuracy of the signal so in order to cope with that the GAGAN make the use of the Indian Space Research Organization GIVE model – Multi Layer data fusion. It is used for the broadcast of GIVEs to have sufficient high level of integrity in resulting to improve the accuracy and availability.

8. CONCLUSION

In 1999, India requested the United States to provide the global positioning system data but they didn't provide it during the kargil war so after that Indian regional satellite project was approved by the Indian government for the development of the Indian airspace satellite navigation system. For providing the positioning accuracy as well as the integrity information for the Indian application and this can be achieved by sending the correction information, we got from the global positioning satellite so for providing the accuracy along with Indian Space Research Organization, Raytheon and the Airport Authority of India have worked together. In order to facilitate and provide satellite navigation system for India's own satellite navigation system. for this project Indian Space Research Organization has open new satellite navigations centers and also launched the various satellite to provide the desire accuracy. This will boost and redefine the Indian satellite navigation system over Indian airspace and it will also provide the self-reliant and the independent satellite system.

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