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REVIEW ARTICLE

A Panacea for Defence Sector in Global Navigation System: IRNSS

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ABSTRACT

India is a developing country with developing reliable technology. Indian Space Research Organisation (ISRO) is developing a satellite technology called Indian Regional Navigation Satellite System (IRNSS), which will make India independent of foreign location tracking system such as American GPS. Developing of such an indigenous satellite system is important for India in defence sector. This technology plays an important role particularly in military operation because foreign government controlled global navigation system is not reliable in hostile situation as it happened to Indian military depending on American GPS during kargil war. This paper proposes how IRNSS can be used in defence sector and reduce dependence on foreign global navigation system.

Keywords: ISRO, IRNSS, GPS, Satellite navigation, Defence sector.

1. INTRODUCTION

1.1. Satellite navigation system

A satellite navigation or satnav system is a system of satellites that provide position of an object at a particular point on earth with accuracy. It allows small electronic receivers to determine their location, including longitude, latitude and altitude with great accuracy (of few meters) using time signals along the line of sight by the use of radio signals from satellites. A satellite system with global coverage may be termed as a global navigation satellite system.

1.2. Types of available navigational systems

There are currently five available satellite systems. The satellite systems are given as follows

1.2.1. Global Positioning System (GPS)

The global positioning system is under United States of America government and it is operational worldwide. The system provide critical capabilities to military, civil and commercial users around the world. The US government makes it freely accessible to anyone around the world with GPS receivers. It currently has 31 satellites and for operation of system it requires minimum 21 satellites by design.

1.2.2. Global Navigation Satellite System (GLONASS)

GLONASS is a space based navigation system, which is operated by Russian aerospace defence forces. GLONASS provide an alternate system to GPS and is operational worldwide with comparable accuracy with GPS. It requires 24 satellites for its operation by design.

1.2.3. BeiDou navigation satellite system

BeiDou is a Chinese satellite navigational system. It currently offers its service to customers in Asia Pacific region only. It has 5 Geostationary Orbit (GEO) satellites and 30 Medium Earth Orbit (MEO) satellites. Currently 15 satellites are operational and 20 more satellites are planned to be launched.

1.2.4. Galileo

Galileo is a global satellite navigation system, which is currently being made by European union and European Space Agency (ESA). Galileo was created to give a system alternate to GPS and GLONASS, which

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European countries can rely on. It has currently 8 test bed satellites in orbit.

1.2.5. Indian Regional Navigation Satellite System (IRNSS)

IRNSS is an indigenously made satellite system by Indian Space Research Organisation (ISRO), which is under complete control of Government of India. IRNSS would provide two service, with standard positioning service open for civilian and restricted service for authorised user only (including military). IRNSS is supposed to have 7 satellites for its working, out of which 4 satellites are already launched into orbit. It is expected to be operational by 2016.

2. LITERATURE SURVEY

[1] The improvements in satellite visibility and the dilution of precision are analysed under GNSS compatibility and interoperation conditions. [2] The simulated microstrip patch antenna operates at the frequency of L5 band (1176.45 MHz) which is used for positioning services. Its parameters are enhanced by making 2x8 array with teflon substrate, increasing gain, directivity and efficiency to 17.3dB, 18.1dBi and 95.58% respectively. [3] GNSS mainly offer two types of services: an open service, available to anyone, and an authorized service, available only to authorized users and which provides better performance. The authorized services already support defense military operations of the USA and Russia, while the open services have become instrumental in civil security operations of any state for police and civil protection for instance. [4] The technology, the applications and the economic forces that have driven the design, functionality and performance of ground systems for satellite communications have been very closely mirrored in the other major application satellite services. [5] This paper charts the history of Global Satellite Navigation Systems (GNSS) from the earliest days of the 'Space Race' in the 1960s and 1970s to the latest plans for modernisation of existing systems and the development of new systems yet to be deployed or become operational. [6] In this paper different approaches were studied to develop a highly precise solar radiation pressure model for IRNSS satellites using IRNSS-1A and IRNSS-1B observation data. Since IRNSS satellite's shape, optical properties, physical properties as well as the attitude information are different from other Indian communication satellites, a novel approach has been adopted here for precise modelling of SRP. [7] This paper describes the techniques of kinematic absolute and relative velocity estimation of geostationary satellites in formation. The Doppler range measurements are used to estimate the absolute velocity. The relative velocity estimation is carried out using the between-receiver single-difference carrier phase measurement. The receiver clock bias drift modelling and estimation is also carried out in a highly dynamic environment along with simulation results. [8] The Signal In Space (SIS) broadcasts satellite ephemeris in quasi keplarian elements and satellite clock coefficients which forms the primary navigation parameters generated from navigation software located at INC (ISRO Navigation Centre), Bylalu, India. The determination of these parameters is performed by two types of techniques, Batch Least Square (BLS) and Extended Kalman Filter (EKF). [9] This paper presents the 1.IRNSS time offset generation with respect to other GNSS timescales such as GPS, GLONASS system and traceability to UTC, UTC(NPLI)/UTC(K) and validation of predicted time offsets with actual offsets. The IRNSS time offsets are derived from GNSS navigation message using UTC offsets to validate the predicted IRNSS time offsets. [10, 11] India has successfully stepped into satellite navigation system with the launch of its first three IRNSS satellites IRNSS 1A, 1B and 1C. IRNSS provides two types of services, Standard Posting Service (SPS), which is open for civilian use and the Restricted Service (RS), for authorized users. [12] In this paper, a simple self-similar multi fractal cantor antenna is designed for IRNSS and GAGAN applications in India. A new navigational system which is developed and controlled by Indian government is called Indian Regional Navigational Satellite System (IRNSS). IRNSS simply replaces the role of Global Positioning System in India by which it provides integrity, availability, continuity and selectivity requirements. [13,14,15] illustrates the need for a probabilistic security model in the context of authenticating a timing signal as opposed to the traditionally non-probabilistic security models of message authentication and cryptography. The primary contribution is establishing the necessary conditions for

timing assurance in the context of security-enhanced GNSS signals. This work can be extended by considering the IRNSS satellite positions along with GPS satellite locations.

3. ARCHITECTURE OF IRNSS

IRNSS architecture mainly consist of three parts: 1)Space segment 2)Ground segment and 3)User segment

3.1. Space segment

The space segment consists of minimum 7 satellites (3 GSO and 4 IGSO). Currently 4 satellites are placed in orbit and remaining 3 satellites is proposed to be placed by 2016. The satellites which are supposed to be in the operation of IRNSS are: IRNSS-1A, IRNSS-1B, IRNSS-1C, IRNSS-1D, IRNSS-1E, IRNSS-1F, IRNSS-1G. The IRNSS standard positioning service is transmitted on L5 and S bands. Figure B1 gives the actual working of space segment. The 3 GSO are stationary and fixed in location to focus on particular region.

The four IGSO rotate in its orbital path, so as to get latitude, longitude, altitude and time.

3.2. Ground segment

Ground segment is responsible for maintenance and operation of IRNSS. Ground segment mainly consist of,

1. ISRO navigation centre
2. IRNSS spacecraft control facility
3. IRNSS range and integrity monitoring station
4. IRNSS network timing centre
5. IRNSS CDMA ranging centre
6. Laser ranging station
7. Dual communication Network

3.3. User segment

The user segment mainly consist of

1. Single frequency IRNSS receiver capable of receiving standard positioning service signal at L5 or S band frequency.
2. A dual frequency IRNSS receiver capable of receiving L5 and S band frequency.
3. A receiver compactible to IRNSS.

Figure B2 shows the space segment interface with user segment.

3.4. IRNSS frequency band

The IRNSS SPS service is transmitted on L5 (1164.45 – 1188.45 MHz) and S 2483.5-2500MHz) bands. The frequency in L5 band has been selected in the allocated spectrum of radio navigation satellite services.

3.5. IRNSS carrier frequency

The IRNSS carrier frequencies and the bandwidths of transmission for the SPS service is shown in table A1.

3.6. Modulation scheme

3.6.1. Standard positioning service

The SPS signal is BPSK modulated on L5 and S bands. The navigation data at a data rate of 50 sps (1/2 rate FEC encoded) is modulo 2 added to PRN code chipped at 1.023 Mcps identified for SPS service. The CDMA modulated code, modulates the L5 and S carriers at 1176.45MHz and 2492.028MHz respectively.

3.6.2. Interplex modulation

Each carrier is modulated by three signals namely, BPSK, data channel BOC and pilot channel. These signals when passed through power amplifier or TWTA operating at saturation conditions will produce a non-constant envelope. Hence additional fourth signal namely, interplex signal is added in order to have a constant envelope at the output of TWTA RF spectrum.

3.7. Polarisation characteristics

All the IRNSS signals are right hand circularly polarized. The antenna axial ratio does not exceed 2.0 dB.

3.7.1. Channel group delay

Channel group delay is defined as the time difference between transmitted RF signal and signal at the output of the on-board frequency source. There are three different delay parameters: Fixed/Bias group delay, differential group delay and group delay uncertainty in bias and differential value. The fixed delay or hardware group delay is a bias term. It is included in the clock correction parameters transmitted in the navigation data and is therefore accounted for by the user computations of system time. Differential group delay is the delay difference between two navigation signals. It consists of random plus bias components.

3.8. Ionospheric Grid Points (IGPs)

The ionospheric grid points that have been identified over Indian subcontinent for tracking position is shown in figure B3.

3.8.1. Selection of Ionospheric Grid Points (IGPs)

After determining the location of the user ionospheric pierce point, the user must select the IGPs to be used to interpolate the ionospheric corrections. This selection is done without regard to whether or not the selected IGPs are monitored, not monitored or with don‘t use status.

3.8.2. Ionospheric pierce point vertical delay and model variance interpolation

Given three or four nodes of a cell of the IGP grid described above that surround the user's ionospheric pierce point to a satellite, the user can interpolate from those nodes to his pierce point using the algorithms such as four point interpolation or three point interpolation. The IGPs as selected must be used for interpolation, with one exception. If four IGPs were selected, and one of the four is identified as not monitored, then the three point interpolation should be used if the user‘s pierce point is within the triangular region covered by the three corrections that are provided. If one of the four is identified as don‘t use, the entire square must not be used.

4. USAGE OF IRNSS

4.1. Military purpose

The IRNSS can be used effectively during military operation to get precise location of each soldier in battle field. This can help army officials sitting in main station to set up strategy and instruct soldiers regarding the location in which they should be in. With the help of IRNSS each soldier can track location of friend soldiers. The IRNSS can give accurate location of soldiers even in complex location involving mountain ranges and deserts. The IRNSS may be proposed to track location of position of enemy camp and send information of their location to main receiver station. The position can be tracked as shown in figure B4.

With the help of 4 IGSO that are rotating in its orbital path, tracking of location of soldier is possible in the same way as GPS. The system of seven satellites helps in determining the latitude, longitude, altitude and time of point location on map. By this way control station receiver comes to know about location of friend soldier. The 3 stationary GSO also enable control station to get live feed of region activities and keep track on enemy movements.

4.2. Navy

IRNSS is proposed to track the position of naval ships patrolling Indian waters. The IRNSS may be proposed to track intruding (unauthorised) ships in Indian water and raise alarm in main patrolling station.

4.3. Air force

IRNSS can help the pilot of aircraft to know his current location with accurate time synchronised with atomic clock in satellite. This reduces dependence on foreign based navigational systems. Even if RADAR is not working, IRNSS can help track location of aircraft. It can also track location of unauthorised aircraft (with 5G technology) entering Indian sub-continent, which even RADAR are not capable of tracking.

5. CONCLUSION

Thus IRNSS prove to be a boon to Indian defence sector, which will reduce risk of dependence on foreign made navigational systems. Currently IRNSS is proposed to track position within Indian sub-continent and top of Indian Ocean with 7 satellites, which can further be upgraded to cover the whole world. IRNSS will definitely improve efficiency of Indian defence sector and will make it par with world’s powerful countries.

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APPENDIX A

Table A1.Carrier frequency and bandwidth

Signal	Carrier frequency	Bandwidth
SPS-L5	1176.45 MHz	24 MHz (1164.45 -1188.45 MHz)
SPS-S	2492.028 MHz	16.5MHz (2483.50 – 2500.00MHz)

APPENDIX B

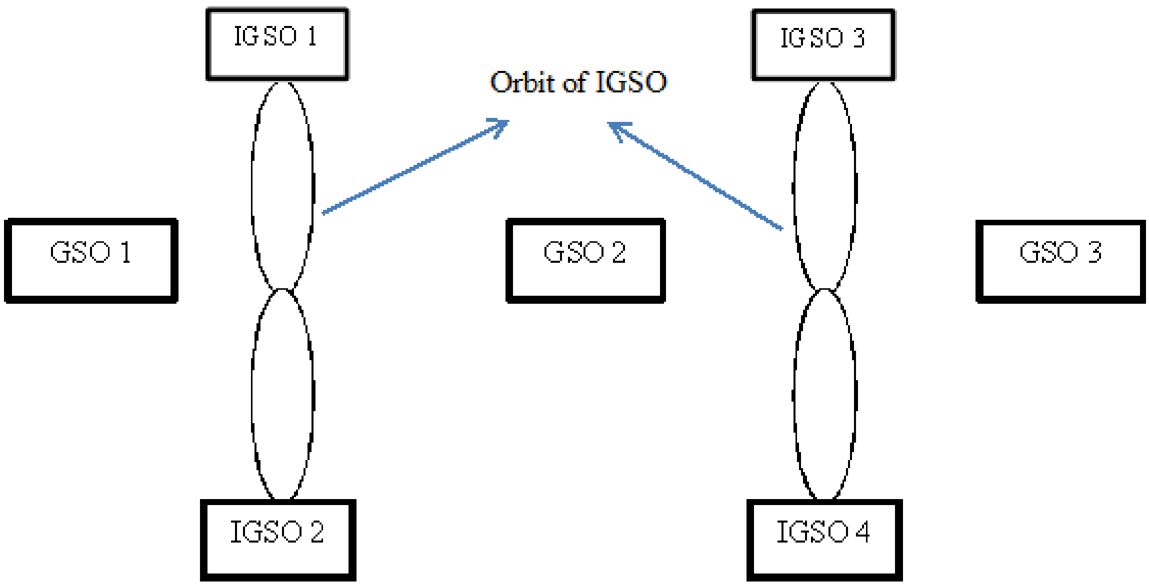

Figure B1.Position of GSO'S and IGSO'S for IRNSS

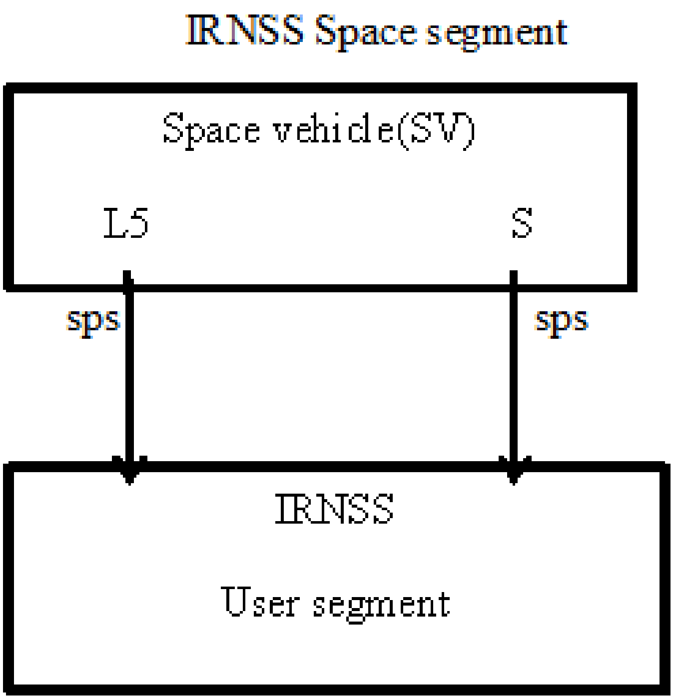

Figure B2.Space segment interface with user segment

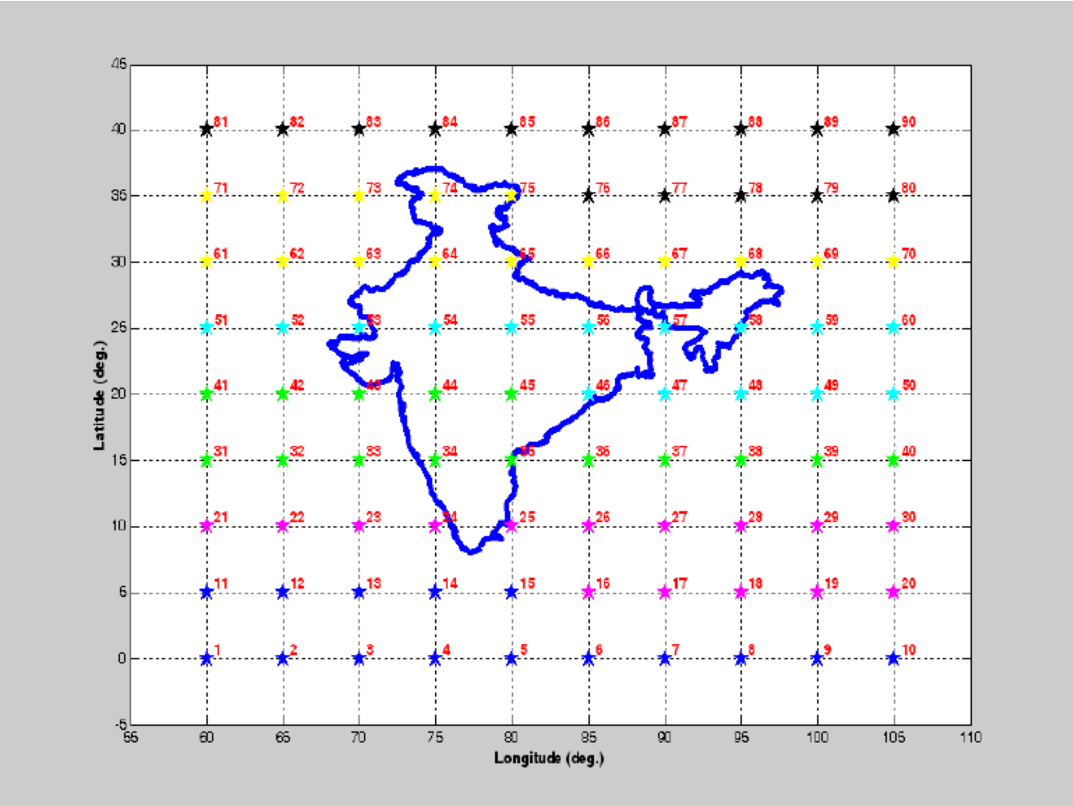

Figure B3.Identified IGP (Ionospheric Grid Points) for grid based corrections over Indian region

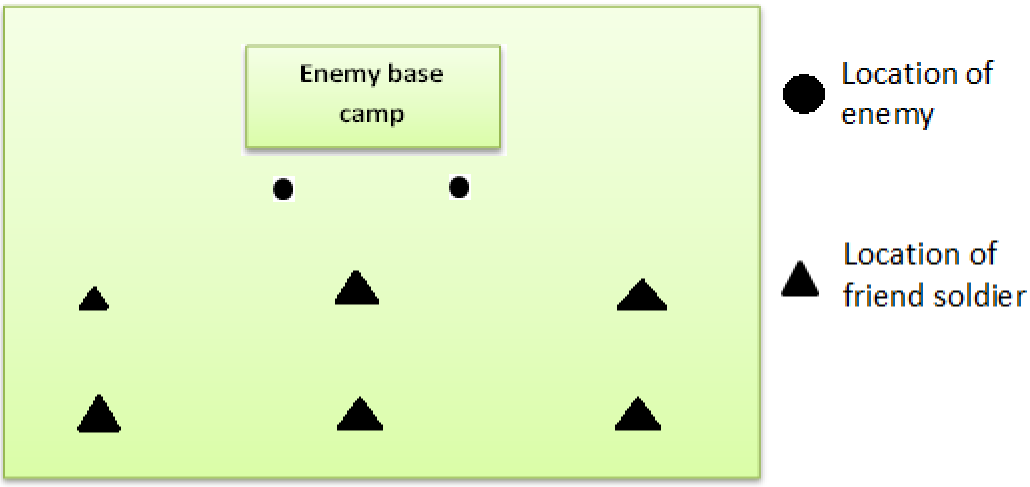

Figure B4.Representational image of receiver screen of IRNSS