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THE INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM 1E: ANOTHER KEYSTONE FOR MAKE IN INDIA

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It is widely believed that the term 'Navigation' derives from the Sanskrit "*Navgatih*". Many don't believe so. Regardless of the disputes on the etymology of the word, there is no disputing the fact that navigation per se is very important to nation building, development and to day-to-day living. The benefits accruing from space based navigation are too varied and common place to be recounted. Most nations covet the capability and the more indigenous the capability, the greater the freedom of operation and the greater the benefits. However, the significant issue is that less than a handful of countries have indigenous capability of Satellite Navigation (SatNav) and these include the US with its NAVSTAR GPS, Russia with its GLONASS, Japan's QZSS, China with its *Beidou*/*Kompass*that went through a vast set of challenges and Europe's Galileo that continues to be entangled in a variety of issues. This pushes into significance the fact that India and its space agency ISRO had the dedication, confidence and vision to go ahead with an indigenous endeavour that would enable India to have unbridled access to all space based positioning, navigation and timing can provide. It was in recognition of the above requirement that the Indian Government approved in May 2006, a project to implement an Indian Regional Navigation Satellite System (IRNSS) of seven satellites in the next six years. The total cost of the project was then placed at Rs 1420 Crores. On the 20th of January 2016, the fifth satellite the IRNSS-1E was successfully launched.

Architecture and Configuration of the Constellation

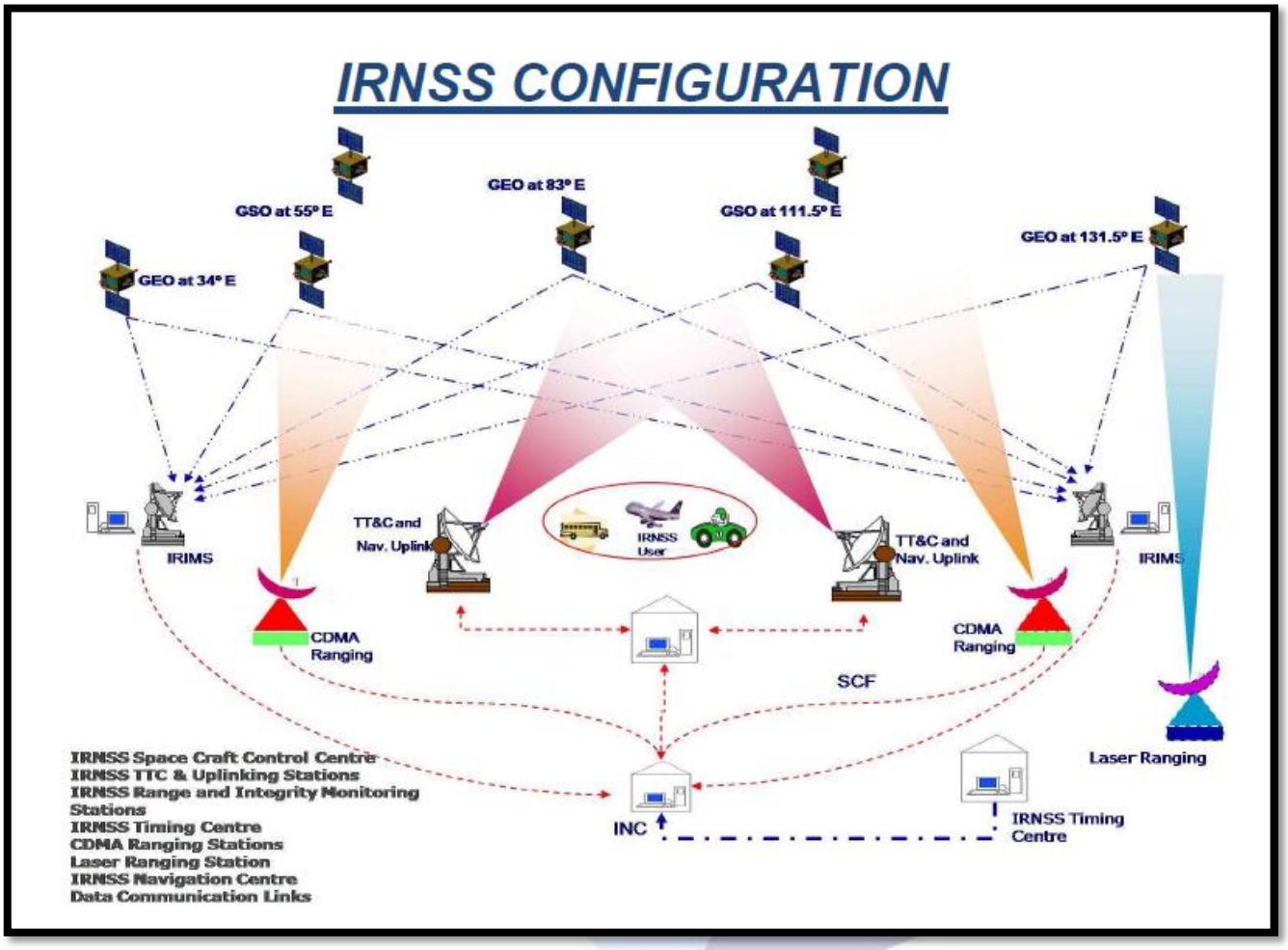
Descriptively speaking the IRNSS consists of a constellation of seven satellites and a large ground segment. In addition to the seven original satellites, ISRO announced in January 2016, that

four more will be built as spares. Three of the seven satellites in IRNSS constellation are planned in GEO (Geostationary Orbit) at 32.5°, 83° and 131.5° East, while the other four satellites are in an inclined geosynchronous orbit with an inclination of 29° with longitude crossing at 55° and 111.75° East[1]. All the seven satellites would have continuous radio visibility with Indian control stations. The IRNSS is expected to provide positional accuracies similar to the Global Positioning System (10 m over Indian landmass and 20 m over the Indian Ocean) in a region centered around the country with a coverage extending up to 1,500 km from India between longitude 40° E to 140° E and between latitude ± 40°. Thus while the system is conceptually similar in broad terms to other navigation systems like the NAVSTAR system of the US, Russia's GLONASS etc, it is quite different from these global navigational systems that are capable of locating any point on planet earth. It is distinct in that the design has been tweaked to provide a greater regional visibility and accuracy. Each satellite has two payloads: a navigation payload and CDMA ranging payload in addition with a laser retro-reflector. The payload generates navigation signals at L5 and S-band. The design of the payload makes the IRNSS system inter-operable and compatible with GPS and Galileo. The satellites are based on the I-1K (I-1000) bus. Both GEO and GSO satellites have the same configuration. Overall, the status of the system is as below.

PRESENT STATUS OF IRNSS

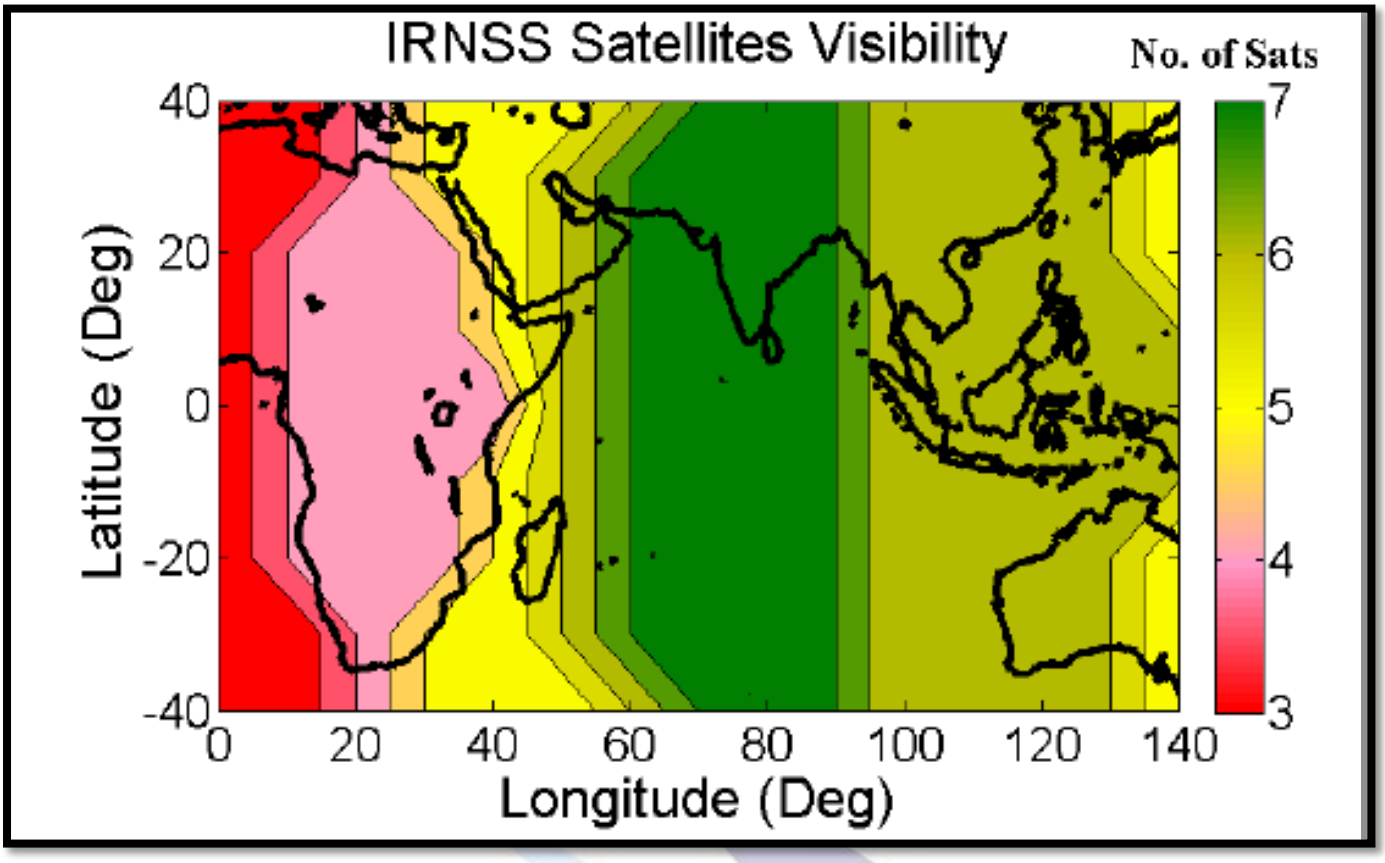
NAME	INTERNATIONAL CODE	LAUNCH DATE	OPERATIONAL STATUS
IRNSS-1E	2016-003A	2016-01-20	**IN ORBIT**
IRNSS-1A	2013-034A	2013-07-01	**IN ORBIT**
IRNSS 1B	2014-017A	2014-04-04	**IN ORBIT**
IRNSS 1C	2014-061A	2014-10-15	**IN ORBIT**
IRNSS 1D	2015-018A	2015-03-28	**IN ORBIT**

The IRNSS will have two types of signals in L5 (1176.45 MHz) & S (2492.028 MHz) band. Both L5 and S-band consists of two downlinks. IRNSS provides two basic services such as Standard Positioning Service (SPS) for common civilian users and Restricted Service (RS) for special authorized users. The system can be augmented with local area augmentation for higher accuracy. Going by ISRO reports[2] the overall configuration is as pictorially depicted below:



Coverage, Visibility and Accuracy over the Indian Sub-Continent

Based on the publicly available description of the IRNSS, it would be possible to arrive at a broad inference of its coverage, accuracy and visibility. Earth coverage is primarily a measure of the number and geometry of satellites available. In this case, since the design primarily comprises of three satellites in the Geostationary Earth Orbit (GEO) that typically covers 1/3 rd of the earth, the Indian subcontinent is well covered and the satellites in will always be visible to users on Indian subcontinent. Simply put, these satellites tend to revolve around the earth in a heavily synchronized manner so that for the observer in India below, these satellites are just stationary objects in the sky. The other 4 satellites are geosynchronous satellites that are in orbits inclined with the earth's equator. For an accurate positioning on earth, at least 4 satellites are required. The inclination of the geosynchronous satellite orbits is 30º and hence these satellites create an 8-shaped loop that extends up to30º on either side of the equator. Thus broadly the coverage would be over India and to a certain extent beyond. Going by a 2008 ISRO report, the coverage is in the the region of -40º to 60º latitude and 0º to 140º longitude. Accordingly, the IRNSS satellite coverage[3] for a full seven satellite configuration would be as below:



The obvious inference from the above figure is that with five satellites, the IRNSS has reached the half way mark and that full visibility would be possible once the constellation is in place. Secondly, the coverage reduces beyond the Indian subcontinent indicating reducing positional accuracy. The same can be augmented by augmentation systems like the Gps Aided Geo Augmentation and Navigation (GAGAN) for civil uses. Thus, the constellation while useable with reasonable accuracy at present has enormous potential for use once the constellation is complete. Accuracy would also be enhanced once the balance satellites are launched. With 3 geostationary and 4 geosynchronous, the constellation cannot afford to have any satellite system/sub-system failure. Losing one satellite means losing precise tracking in one region of the IRNSS target area. Hence, to include the element of redundancy and reliability, the IRNSS would have four spare satellites.

Challenges and Opportunities

Thus, while the system is yet incomplete, it is usable to a certain extent and would become increasingly refined as it progresses. The pace of progress may be slow but possessing an indigenous system does come with its own set of costs, complexities and opportunities. While it would be too premature to exult that the IRNSS-1E has taken us on par with the US GPS[4], it would be essential to put in equal effort in indigenous support products like compatible and cheap receivers, software etc.

Increased usage would lead to increased refinement and for that the system would have to be user-friendly and common place. It would have a variety of uses from town planning to road, rail and air mapping, coordination of activities to more common place activities like fishing, hiking etc. The market for indigenous products increases exponentially, particularly, in view of the fact that IRNSS is designed to be compatible with both the US and the Russian system. Put together, the opportunities far outweigh the challenges and hence it makes sense to purposefully progress on completing the system at the earliest.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

Notes

[1] S Sayeenathan, ISRO, Asso Director (SATNAV) to United Nations Office of Outer Space Affairs (UNOOSA) at http://www.unoosa.org/pdf/icg/2013/icg-8/5.pdf accessed on 19 Nov 16.

[2] Ibid.

[3] Figure sourced from VG Rao, et.al "Analysis of IRNSS over Indian Subcontinent" available at plan.geomatics.ucalgary.ca/papers/ion_itm11_rao%20et%20al_jan11.pdf accessed on 20 Jan 2016.

[4] Press Trust of India, "India launches 5thNavsat IRNSS 1E"20 Jan 2016 at http://www.hindustantimes.com/india/india-launches-5th-navigation-satellite-irnss-1e-powered-by-psl-rocket/story-iQcSrv7tV5sL3nfU49kLII.html