Indian Regional Navigation Satellite System (IRNSS):
A Leap into the Final Frontier

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About a decade back, the Indian Space Research Organisation (ISRO) started pondering over the possibility of establishing India's indigenous regional navigation satellite system, thereby reducing its dependence on the United States' Global Positioning System (GPS) and to enhance its national security and development. The dream is closer to reality with the launch of the first independent satellite out of a cluster of seven named IRNSS-1A on 01 July 2013 from Satish Dhawan Space Centre, Sriharikota. It will usher in a new era of indigenous terrestrial, aerial and marine navigation. The navigation satellite system will consist of seven satellites – IRNSS 1A to IRNSS 1G; three of them in geostationary orbit and the remaining four in geosynchronous orbit at approximately 36,000 km above the earth's surface.

India is expected to invest INR 1,600 crore in the project which is planned to be completed by 2015-16 allowing India to be a part of an elite league including US, Russia and China which have a domestic satellite system for navigation. India has been relentlessly augmenting its space, communication and military technologies by launching dual use military and civil satellites like Cartosat-2A, Cartosat-2B, Oceansat-2 and Risat-2 in the past. ISRO has used its workhorse the Polar Satellite Vehicle (PSLV C-22) to launch the IRNSS 1A, which will be used for surveying and mapping, telecommunications, terrestrial, aerial and marine navigation, transportation, disaster and fleet management among other crucial activities.

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IRNSS 1A satellite consists of two payloads – navigation payload and ranging payload, generating navigation signals in the L5 band (1176.45 MHz) and S band (2492.028 MHz) respectively. Three highly accurate Rubidium atomic clocks are part of the system along with corner cube retro reflectors for laser ranging. Although the clocks are currently being imported, research is being carried out to develop/produce them indigenously. The design of the payload makes the system interoperable and compatible with the US' GPS and European Union's Galileo systems. The technical details of the satellite system are given below:

Lift off Mass: 1425kg

Power: Two solar panels generating 1660 W, one lithium ion battery and 90 Ampere-Hour capacity

Mission Life: 10-12 years

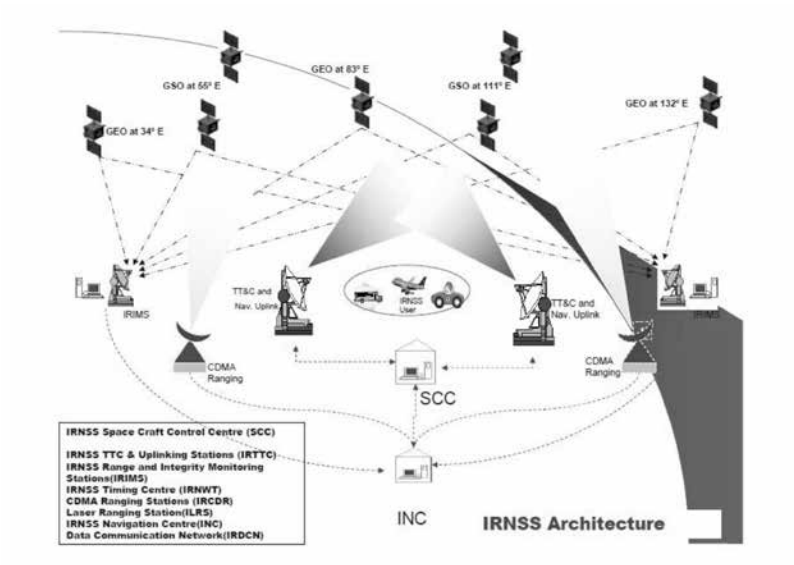
Frequency: C-band: U/L: 6700-6725 MHz (RHCP) D/L: 3400-3425 MHz (LHCP)

L5-band: D/L: 1176.45 MHz (BW- 24 MHz) (RHCP)

S-band: D/L: 2492.028 MHz (BW- 16.5 MHz) (RHCP)

The IRNSS mainly consists of three components: space segment, ground segment and user segment. The ground segment of the IRNSS constellation would consist of a Master Control Centre (MCC) (stationed at Karnataka) and ground stations to track and control the satellites. The MCC would predict the position of all satellites, calculate integrity, make necessary ionospheric and clock corrections and run the navigation software. The navigation software has been indigenously developed at ISRO Satellite Centre. The software modules interface with various subsystems of the ground segment and generate navigation parameters required for broadcast from the spacecraft. The satellite system will provide two basic services – Standard Positioning Service (SPS) for civil users and Restricted Service (RS) with encryption for special authorised users like the armed forces. The navigation signals would be transmitted in the S-band frequency (2-4 GHz) and broadcast through a phased array antenna to maintain the requisite coverage and signal strength. The system is intended to provide an absolute position accuracy of about 10 metres over India as well as the region extending 1,500 km around India. The system will provide accurate Position, Navigation and Time (PNT) services on various platforms with all time availability under all weather conditions. The architecture of the satellite system can be best described by the figure shown below.

Figure 1.1 (Architecture of IRNSS)



"As of now, the IRNSS is a regional system with seven satellites, which would be further expanded into eleven satellites in the coming years," said Dr. K. Radhakrishnan, Chairman ISRO. Civil aviation is one of the sectors that will benefit from the IRNSS and satellite based augmentation system. "We currently have 456 airfields and 85 operational airports in the country. ISRO has also developed a GPS supported geo-augmented navigation system (GAGAN) to assist the navigation of civilian air traffic over Indian airspace. Once the IRNSS and GAGAN are fully functional, they will help us with precise navigation, provide data on mountainous, oceanic areas and enhance security tremendously", said Mr. VP Agrawal, Chairman Airports Authority of India. The vast spectrum of services that would be provided by the network will be significant to the growth of the nation in the field of science and space technology which would propel our economic growth in the years to come.

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Apart from monitoring, precision agriculture, disaster warning, aviation, maritime and other research areas, missile targeting would be an important military application of the IRNSS project. In addition, critical network centric military operations would be dependent on the IRNSS. The success of the independent IRNSS programme would make India self sufficient and in full control of its space based assets. In adverse scenarios or conflicts, India will not have to rely on GPS or GLONASS as far as military operations are concerned and will be independent of critical foreign technologies and would help in overcoming technology denial regimes. The significance of the programme for maintaining internal and external security of the nation can be gauged from the remark of Mr. Rajesh Kochhar, former Director National Institute of Science, Technology and Development Studies, "The IRNSS will be a major advancement for the country. It will enhance the country's image in the international arena of space sciences. I see it as very useful for national security and defence besides its civilian use. The network will cover India and 1,500 km around the country. I feel it would enable the government to view disturbed areas within the country like the Red belt and also areas around like Pakistan, Nepal, Tibet, Afghanistan and even parts of China".

However, some issues that could pose challenges to the performance of the navigation system relate to low signal to noise ratio (SNR), spectrum competition, radio frequency interference, ionospheric influence, jamming, spoofing and satellite segment malfunction. Some of these problems can be sorted by utilising the services provided by GPS and GLONASS in addition to IRNSS. The IRNSS is a regional system so it can use other Global Navigation Satellite System (GNSS) such as GPS and GLONASS as leverage. A study conducted by the Department of Geomatics Engineering, University of Calgary highlights the improvement in availability, accuracy and reliability of the navigation satellite system due to a combined constellation approach. Hence, the need for interoperability and compatibility with GNSS especially with regard to civil applications cannot be ignored. The commercial viability of the IRNSS system is another economic factor that needs to be looked at. China has exported its system to many Asian countries like Thailand, Laos, Brunei, Pakistan and Sri Lanka. China plans to capture 70-80 per cent of the domestic market by 2020 and create strategic industries around the navigation system for enhanced investments to spur economic growth. The European

Union is also in talks with Africa for collaborating on the implementation of satellite navigation technologies with an aim towards rapid economic development. A decision by ISRO to involve Indian industry in developing communication satellites and PSLVs will not only lighten the burden on ISRO but also lead to greater economic activity and exports, which is the need of the hour to support our faltering economy in the recent times.

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