INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM

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Abstract- **The IRNSS is an indigenously developing satellite based Navigation System that will offer an independent positioning & time services of Indian Subcontinent. IRNSS is developing under the auspices of the Govt. of India to ensure a sufficient Navigation system in hostile situations. Having own eyes in sky meant that government through IRNSS will provide two services, with Standard Positioning Service which will be open to the civilian use and, the high end restricted service meant only for highly authorized users such as Army .**

***Index Terms*— GNSS, India, IRNSS, Navigation, Surveillance**

I. INTRODUCTION

IRNSS is an indigenously developing Navigational Satellite System that will be use to provide real time positioning & timing services over India & region extending to 1500 Km. IRNSS will be armed with a constellation of 7 satellites. However the full system comprises nine satellites, two on ground as standby. The IRNSS system was planned to be operational by end of 2016. The IRNSS was conceived in 2006 by the government for both Space & Ground infrastructure with an allocation of about Rs. 1420 crore . The requirement of such a navigation system was driven because access to foreign government controlled GNSS isn't guaranteed in hostile situation as happened with Indian Military on depending on American GPS during Kargil war .

The IRNSS is expected to provide better positioning accuracy than GPS in the region centered around the country with the coverage extending to 1500 km around India between Longitude 40 E to 140 E and between Latitudes +40 to -40. A much larger secondary service is extended from 30 to 130 east Longitude & 30 S to 50 N Latitude.

Launched onboard PSLV C-22 on 1 July 2013, IRNSS 1A became the first navigational satellite in the IRNSS Series of satellites to be placed in the geosynchronous orbit. Built in ISRO's satellite centre with a cost of 125 crore, it weighs 1380Kg & carries a navigational payload . The satellite is configured with an I-1K bus structure with a power Handling capacity of around 1600 watts & is designated for a ten year mission. IRNSS 1B, a 1432 Kg satellite, was launched on 4 April 2014 aboard the PSLV C-24 rocket which will help augmenting the satellite based navigation system of India . Satellite has two payloads : a navigational payload & aCDMA Ranging Payload in addition with a LASER retro reflector. IRNSS 1C is the third of the seven satellite cluster. The payloads in the satellite generate the navigation signals at L5 & S band. IRNSS1D,a 1435Kg satellite, was launched on 26 March 2015 with an expected mission duration of 12 years and carried same payloads as its siblings. IRNSS1E , another 1425 Kg satellite, was launched on 20 Jan 2016 with an expected duration of 12 years. The satellite is powered by the solar arrays which generate power up to 1660 Watts with 1300 watt as the operational need of the spacecraft. IRNSS1F , is the 6th satellite of the IRNSS series which was launched on 10 March 2016with a life expectation of 12 years. The navigation payload transmit navigation service signals to users & ranging payload consist of C-Band Transponder that facilitate accurate determination of the range of satellite. IRNSS1G is the 7th satellite of IRNSS series & is targeted for launch on April 28 2016 using India's PSLV.

IRNSS consist of three segments: The space segment, The Control Segment & the User Segment. The Control Segment tracks the satellite & then provides

them with corrected orbital & time information. The Control Segment of the IRNSS constellation consist of a Master Control Station(MCS) stationed in Karnataka and several other ground control stations. The Ground Station receives data from the satellites & then sends that information to the MCC where it makes necessary ionospheric clock corrections & run the Navigation software. In pursuit of an independent system, an Indian Standard Time infrastructure would also be established. The satellite service will provide SPS for civilian uses & RS with encryption for armed forces.

The navigation signals would be transmitted in the S-Band frequency (2-4Ghz) and broadcast through a phased array antenna to maintain the requisite coverage and signal strength .the system expected to provide an absolute position accuracy of about 10 metres over India as well as the region extending 1500 km around India. The system will provide accurate Position, Navigation & Time (PNT) services on various platforms with all the time availability under all environmental conditions.

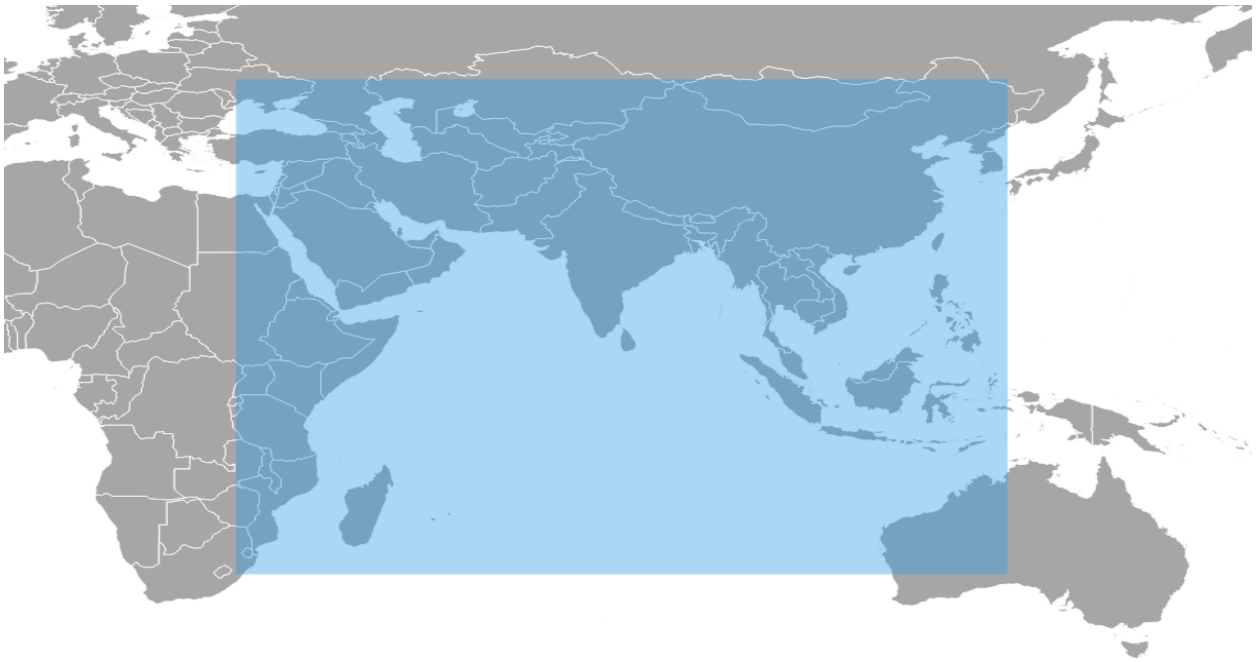

Fig. 1: Illustration of the IRNSS coverage which includes an area of ~1500 km around the Indian land mass
(Image Credit : ISRO)

ISRO had also developed a Geo Augmented Navigation System called GAGAN which is currently supported by GPS to assist the navigation of Civilian air traffic within Indian Airspace. Once the IRNSS & GAGAN are fully operational , they will help with precise navigation, provide data on mountainous, oceanic areas & enhance security tremendously .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. The more satellites that the Receiver can ‘ see ‘, the better the accuracy ,Signal reception can be blocked by building ,terrains, electronic interference & sometimes dense foliage a cluster of 7 satellites could be seen by the receiver giving more accuracy than GPS.

The objective of the IRNSS is to implement an independent and indigenous regional space bore navigation system for national applications. The IRNSS design requirement call for a position accuracy of <20 m throughout India and within the region of coverage extending about 1500 km beyond. The system is expected to provide accurate real-time

position, velocity & time observables for users on a variety of platforms with 24 hours x 7 days service availability under all weather conditions. The IRNSS was being developed parallel to the GAGAN program, the ISRO SBAS(Satellite Based Augmentation System) version of an overlay system for GNSS signal corrections.

II. IRNSS ARCHITECTURE

THE SPACE SEGMENT consist of a constellation of seven satellites: three Geostationary Orbit (GEOs) located at 32.5 East , 83 East & 131 East Longitude & four Satellites(GSO) in Geostationary Satellites(GSO)in orbit of 24000km apogee & 250 Km perigee inclined at 29 degrees .Two of the GSOs will cross the equator at 55 East & other two at 111.75 East (two satellites in each plane).

The constellation design consideration have been mainly :

a) Minimum number of satellites
b) Orbital slots for India for a continuous visibility with the control station.

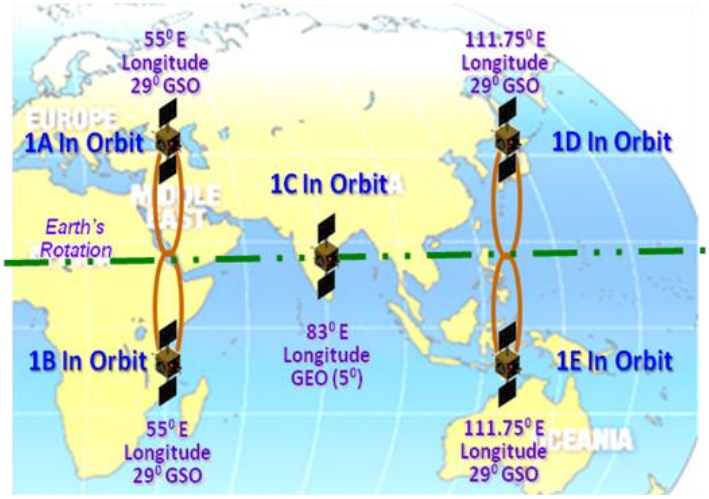

Fig 2: IRNSS Constellation after IRNSS 1-E (Image Credit : ISRO)

Major role played by IRNSS payload are:

a) Transmission of the navigational timing information in the L5 bands
b) Transmission of navigation, timing information in S-band.
c) Generation of navigation data on-board
d) CDMA ranging transponder for precise ranging

The Navigation payload carried in the Satellite is in redundant configuration & has following subsystems:

a) NSGU(Navigation Signal Generation Unit)
b) Atomic Clock Unit (Rubidium atomic clocks)
c) Clock management & control unit
d) Frequency generation unit
e) Modulation Unit
f) High Power Amplifier Unit
g) Power combing unit
h) Navigation Antenna

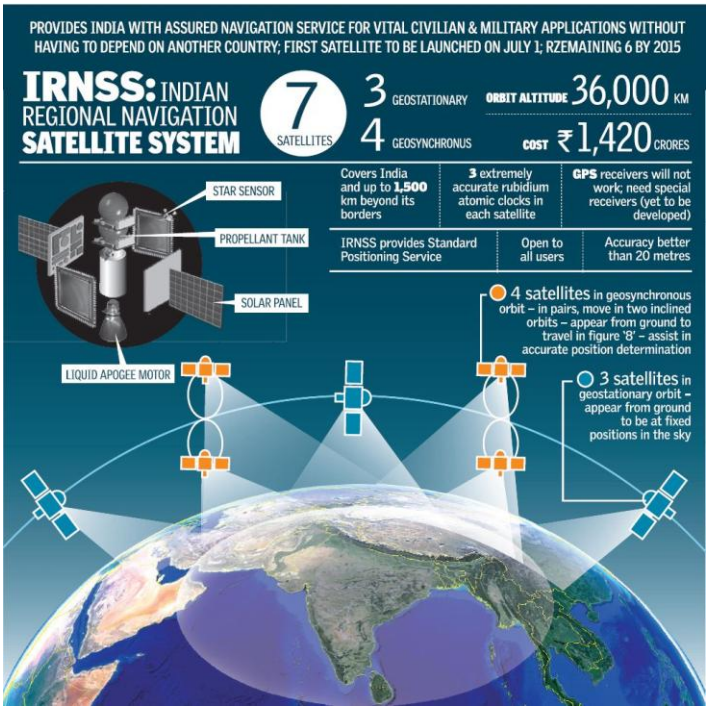

Fig 3 : The picture shows how the Indian Regional Navigation Satellite System provides assured navigation services to every individual on the street. (Image Credit: ISRO)

THE GROUND SEGMENT of the IRNSS consist of :

a) IRNSS Spacecraft Control Centre (SCC)
b) IRNSS Navigation Centre (INC)
c) IRNSS TTC & station Uplink Station (IRTTC)
d) IRNSS Range & Integrity Monitoring Stations (IRIMS)
e) IRNSS Timing Centre
f) Laser Ranging Station (LRS)
g) Data Communication Network (IRDCN)

The SSC & the INC will be the core of the ground segment & they're in charge of estimating & predicting IRNSS Satellite position; ionospheric & clock correction & running the navigation software. 17 IRNSS sites will be distributed across the country for orbit determination & ionospheric models. The IRNSS timing will consist of two widely stable clocks.

THE IRNSS USER SEGMENT is made of the IRNSS users & the IRNSS Receivers. There will be dual frequency (L5 or S Band frequency) with capability to receive ionospheric connection. They'll be able to receive and process navigation data from other GNSS(Global Navigation Satellite System) constellation & the seven IRNSS satellites will be tracked by the user receiver. The user receiver will have a minimum gain, G/T, of -27 db/k.

IRNSS Signals will consist of a SPS (Special Positioning Service) & a Precision Services. Both will be carried on L5 (1176.45 MHz) & the S Band (2492.028 MHz) . The SPS signal will be modulated by a 1 MHz BPSK Signal. The Precision Services will use BOC (Binary Offset Carrier) Modulation. An additional BOC plot signal is provided for the RS

(Restricted Services) in order to help provide better acquisition & performance. As each L5 band & S Band contains three signals, the IRNSS design adds an interplex signal in order to maintain the constant envelope characteristic of the composite signal. The transmission is done using the L-Band and S-band helix array antenna to provide global control in right-hand circularly polarized (RHCP) signals. Thus, user receivers can operate in single/dual-frequency mode.

Potential Errors possible in IRNSS Receiver may due to following sources :

a) Orbit Errors: Satellite Orbit (referred to as ' Satellite Ephemeris ') pertains the altitude , position & speed of the satellite. Satellite orbits vary due to gravitational pull & solar pressure fluctuations. Orbital Errors will be monitored & corrected by the Master Control Station.
b) User Mistakes account: Incorrect datum & typographic errors when inputting coordinates into a IRNSS receiver can result in errors up to many kilometers.
c) Satellite Clock Errors: Cause by slight discrepancies in satellite's automatic clocks. Errors will be monitored & corrected by the Master Control Centre,
d) Ionospheric Interference : The Ionosphere is the layer of atmosphere from 50 to 500 km altitude that consist primarily of ionized air. Ionospheric interference may causes the satellite radio signals to refract as they pass through the earth's atmosphere-causing the signals to go up or down.

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