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Indian Regional Navigation Satellite System

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Abstract:

The Indian Regional Navigation Satellite System (IRNSS) is an emerging satellite based navigation system offering an independent positioning and timing service over India and neighboring regions. The Indian Regional Navigation Satellite System or IRNSS with an operational name of NAVIC (Sailor or Navigator in Hindi) which stands for navigation with Indian Constellation is an Indian developed Navigation Satellite System that is used to provide accurate real-time positioning and timing services over India and region extending to 1500 km around India. The fully deployed NAVIC system consists of 3 satellites in GEO orbit and 4 satellites in GSO orbit, approximately 36,000 km altitude above earth surface.

1. Introduction:

This is an independent Indian Satellite based positioning system for critical National applications. The main objective is to provide Reliable Position, Navigation and Timing services over India and its neighborhood, to provide fairly good accuracy to the user. The IRNSS will provide basically two types of services Standard Positioning Service (SPS) Restricted Service (RS) Space Segment consists of seven satellites, three satellites in GEO stationary orbit (GEO) and four satellites in Geo Synchronous Orbit (GSO) orbit with inclination of 29° to the equatorial plane.

This constellation of seven satellites was named as "NavIC" (Navigation Indian Constellation) by the Honourable Prime Minister of India, Mr. Narendra Modi and dedicated to the Nation on the occasion of successful launch of IRNSS-1G, the seventh and last satellite of NavIC. All the satellites will be visible at all times in the Indian region. All the seven Satellites of NavIC, namely, IRNSS-1A, 1B, 1C, ID, 1F and 1G were successfully launched on July 02, 2013, Apr 04, 2014, Oct 16, 2014, Mar 28, 2015, Jan 20, 2016, Mar 10, 2016 and Apr 28, 2016 respectively and all are functioning satisfactorily from their designated orbital positions.

2. Spacecraft:

The IRNSS satellites are configured around the spacecraft bus I-1K, which is similar to ISRO's meteorological satellite, Kalpana-1, with a dry mass of ~600 kg and a launch mass of 1,425 kg. The solar panels are generating a power of 1600 W (with a payload power requirement of 900W. The spacecraft are 3-axis stabilized. Attitude control of the satellite is provided with yaw steering, a capability to optimize the use of the solar panels and to support the thermal control of the satellite.

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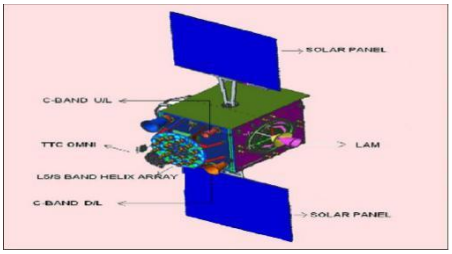
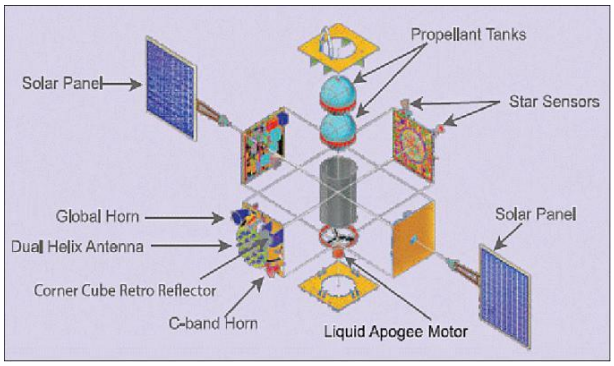


Preliminary view of a deployed IRNSS spacecraft (image credit: ISRO)

Launch mass	1432 kg, dry mass of 614 kg
Spacecraft size (launch configuration)	1.58 m x 1.5 m x 1.5 m
EPS (Electrical Power Subsystem)	Two solar panels generating 1660 W, one lithium-ion battery of 90 Ah capacity
ADCS(Attitude Determination and Control Subsystem)	Zero momentum system, orientation input from sun & star sensors and gyroscopes; reaction wheels, magnetic torquers and 22 Newton thrusters as actuators
Mission design life	10-12 years
Propulsion	440 N LAM (Liquid Apogee Motor) with twelve 22 N thrusters



Blow-up view of the IRNSS spacecraft (image credit: ISRO)

3. SATELLITES :

IRNSS- 1A : The **IRNSS-1A** spacecraft was launched on July 1, 2013 on the PSLV-C22 vehicle from SDSC (Satish Dhawan Space Center) SHAR on the east coast of India. Use of the PSLV 'XL' configuration. After a flight of 20 minutes and 17 seconds, the IRNSS-1A satellite was injected to the intended GTO (Geostationary Transfer Orbit) of 282.46 km x 20,625.37 km. After injection, the solar panels of IRNSS-1A were deployed automatically. ISRO's Master Control Facility (at Hassan, Karnataka) assumed the control of the satellite.

IRNSS- 1B :

The **IRNSS-1B** spacecraft was launched on April 4, 2014 on the PSLV-C24 vehicle (XL configuration) from SDSC SHAR. After a flight of about 19 minutes, IRNSS-1B Satellite, with a mass of 1432 kg, was injected to an elliptical orbit of 283 km x 20,630 km, which is very close to the intended orbit. After injection, the solar panels of IRNSS-1B were deployed automatically. ISRO's Master Control Facility (at Hassan, Karnataka) assumed the control of the satellite. In the coming days, five orbit maneuvers will be conducted from Master Control Facility to position the satellite in its GSO (Geosynchronous Circular Orbit) at 55ºE longitude.

IRNSS- 1C : The IRNSS-1C was launched on Oct. 15, 2014 on the PSLV-C26 vehicle from SDSC (launch mass of 1425.4 kg). IRNSS-1C was initially injected into a GTO and then raised into GEO (4^{th} orbit raising maneuver on Oct. 20, 2014). IRNSS-1C is the geostationary satellite in the IRNSS system, located at 83ºE.

IRNSS- 1D : The IRNSS-1D spacecraft was launched on March 27, 2015 on the PSLV-C27 vehicle from SDSC (launch mass of 1425.4 kg).

IRNSS- 1F: The IRNSS-1F spacecraft was launched on January 20, 2016 on the PSLV-C31 vehicle from

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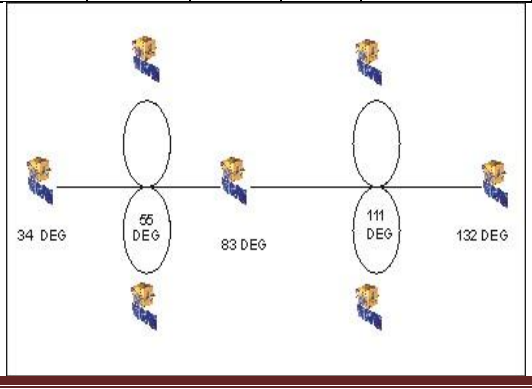
SDSC (launch mass of 1425.4 kg). The **IRNSS-1F** spacecraft was launched on March 10, 2016 (10:31:00 UTC) on the PSLV-C32 vehicle from SDSC (launch mass of 1425.4 kg).This is the 33rd consecutively successful mission of PSLV and the twelfth in its 'XL' configuration. The IRNSS-1E spacecraft, launched on January 20, 2016, was injected into in to the sub-geosynchronous transfer orbit with a perigee of 282 km and an apogee of 20,655 km with an inclination of 19.21º, very close to the intended orbit. ISRO reported that the satellite is in good health and its solar panels have been deployed. After four orbit-raising maneuvers using the satellite's onboard motor, it will be positioned at its allotted GSO (Geosynchronous Orbit) with a 28.1º inclination at a longitude of 111.75º East. **IRNSS-1G :**The **IRNSS-1G** spacecraft was launched on April 28, 2016 on the PSLV-C33 vehicle from SDSC (launch mass of 1425.4 kg). As in the previous six launches of IRNSS satellites, PSLV-C33 uses 'XL' version of PSLV equipped with six strap- ons , each carrying 12 tons of propellant. The launch of the IRNSS-1G satellite completes the space segment of the IRNSS constellation of seven spacecraft.

After separation, the solar panels of IRNSS-1G were deployed automatically. ISRO's MCF (Master Control Facility) at Hassan, Karnataka, took over the control of the satellite. In the coming days, four orbit maneuvers will be conducted from MCF to position the satellite in the Geostationary Orbit at 129.5º East longitude. According to ISRO, the other six satellites of the constellation are functioning satisfactorily from their designated orbital positions. A number of ground facilities responsible for satellite ranging and monitoring, generation and transmission of navigation parameters, etc., have been established in eighteen locations across the country. Today's successful launch of IRNSS-1G, the seventh and final member of IRNSS constellation, signifies the completion of the IRNSS constellation.

4. ORBIT:

The three GEO spacecraft are in the equatorial plane at an altitude of 35,786 km located at 32.5º, 83º and 131.5º E. The four GSO (Geosynchronous Orbit) spacecraft, with an inclination of 29º, are located in two planes with daily longitudinal equator crossings at 55º E and at 111.75º E. LAM (Liquid Apogee Motor) is used for all orbit raising maneuvers, placing the spacecraft into their GSO or GEO orbits, respectively. The coverage provided by the constellation encompasses a longitude from 30º to 130º and a latitude region of 30º S to 50º N.

IRNSS spacecraft	Longitude (E)	Inclination	RAAN	Launch Date
1A	55.0º	29º (±2)	135º	July 1, 2013
1B	55.0º	29º (±2)	310º	April 4, 2014
1C	83.0º		274º	October 15, 2014
1D	111.75º	29º (±2)	135º	March 27, 2015
1E	111.75º	29º (±2)	310º	January 20, 2016
1F	32.5º	± 5º	270º	March 10, 2016
1G	129.5º	± 5º	270º	April 28, 2016



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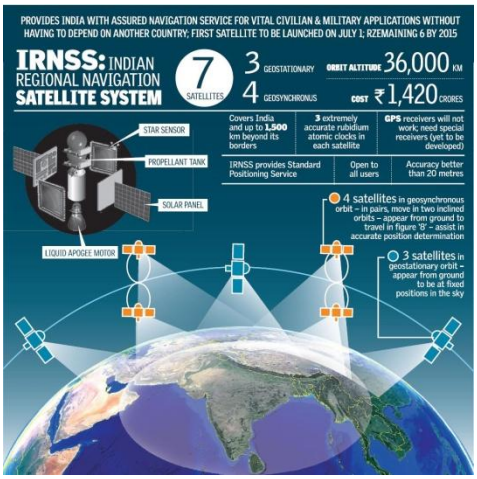
Alternate projection of IRNSS constellation with the GSO spacecraft at their latitudinal extremities (image credit: ISRO)

The IRNSS constellation architecture consists of the following elements

5. SPACE SEGMENT:

The IRNSS satellites carry a navigation payload in a redundant configuration. A separate C-band transponder for precise CDMA ranging is included in the payload configuration. The important functions of the IRNSS payload are: Transmission of the navigational timing information in the L5 bands; transmission of navigation, timing information in S-band; generation of navigation data on-board, CDMA ranging transponder for precise ranging. The navigation payload will have the following subsystems: NSGU (Navigation Signal Generation Unit), Atomic clock unit, comprising of Rubidium atomic clocks, clock management and control unit, frequency generation unit, modulation unit, high power amplifier unit, power combining unit and navigation antenna. The IRNSS spacecraft are dedicated for navigation services and they are configured to be of a class that can be launched by the Indian launcher PSLV. The design incorporates most of the proven subsystems available indigenously tailoring it specifically for the navigation.



Space segment:

The space segment consists of seven satellites:

• 3 satellites in GEO (Geostationary Orbit) at 32.5°, 83° and 131.5° East.

• 4 satellites in geosynchronous orbit placed at inclination of 29° with longitude crossing at 55° and 111.75° East

• Two spare satellites are also planned

• The satellites are specially configured for the navigation. Same configuration for GEO and GSO which is desirable for the production of the satellites.

• Plans call for the IRNSS satellites to be launched by the Indian launcher PSLV

• The first satellite will be launched in the summer of 2013. The subsequent launches are planned once in six months. The full constellation will be operational by 2016.

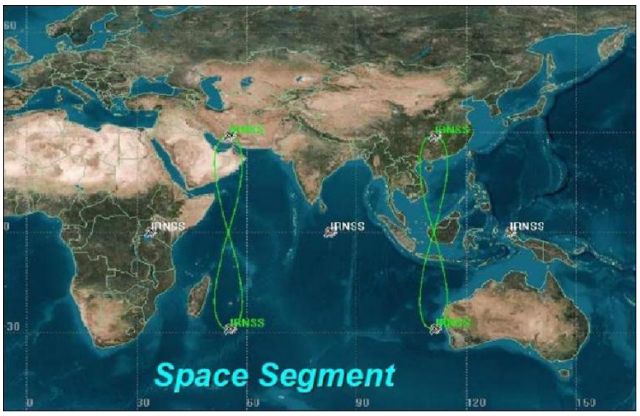


Figure 1: The IRNSS constellation with the daily lemniscates projection of the 4 GSO spacecraft onto Earth (image credit: ISRO)

Ground segment:

The IRNSS ground segment includes the major systems for controlling the satellite constellation and will consist of the IRNSS Spacecraft Control Facility (IRSCF), IRNSS Navigation Control Facility, IRNSS Range and Integrity Monitoring Stations, ranging stations, a timing center, IRNSS TTC and uplink

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stations, and the IRNSS Data Communication Network.

IRNSS Ground Segment Elements:

• IRSCF (IRNSS Satellite Control Facility). IRSCF controls the space segment through Telemetry Tracking & Command network. In addition to the regular TT&C operations, IRSCF also uplinks the navigation parameters generated by the INC.

- IRTTC (IRNSS TTC and Land Uplink Stations)

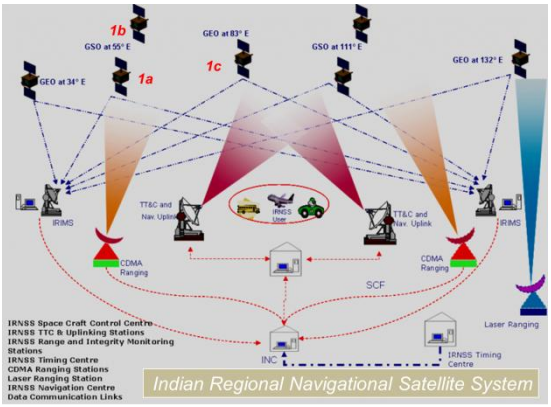
- IRSCC (IRNSS Satellite Control Center)

• IRIMS (IRNSS Range and Integrity Monitoring Stations). IRIMS perform continuous one way ranging of the IRNSS satellites and are also used for integrity determination of the IRNSS constellation.

• INC (ISRO Navigation Center), located at Byalalu. INC is the nerve center of the IRNSS Ground Segment. INC primarily generates navigation parameters.

• IRDCN (IRNSS Data Communication Network). IRDCN provides the required digital communication backbone to IRNSS network.

Seventeen IRIMS sites will be distributed across the country for orbit determination and ionospheric modeling. Four ranging stations, separated by wide and long baselines, will provide two-way CDMA (Code Division Multiple Access) ranging. The IRNSS timing center will consist of highly stable clocks. The navigation center will receive all this data through communication links, then process and transmit the information to the satellites.



The ISRO Navigation Centre (INC), established at Indian Deep Space Network (IDSN) complex at Byalalu, about 40 km from Bangalore, was inaugurated onMay 28, 2013. IRNSS will have a network of 21 ranging stations geographically distributed primarily across India. They provide data for the orbit determination of IRNSS satellites and monitoring of the navigation signals. The data from the ranging/monitoring stations is sent to the data processing facility at INC where it is processed to generate the navigation messages. The navigation messages are then transmitted from INC to the IRNSS satellites through the spacecraft control facility at Hassan/Bhopal. The state of the art data processing and storage facilities at INC enable swift processing of data and support its systematic storage.

User segment:

The user segment consists of IRNSS receivers operating in:

• Single frequency (L5 at 1176.45 MHz or S-band at 2492.028 MHz)

• Dual frequency (L5 and S-band)

The single frequency and dual frequency receivers shall receive both SPS (Special Positioning System), which is provided to all users, and RS (Restricted/Authorized Service) signals, which is an encrypted service provided only to authorized users. The IRNSS user receiver calculates its position using the timing information embedded in the navigation signal, transmitted from the IRNSS satellites.

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The timing information being broadcast in the navigation signal is derived from the atomic clock onboard the IRNSS satellite. The IRNWT (IRNSS Network Time) is determined from a clock ensemble composed of the cesium and hydrogen maser atomic clocks at the INC (Indian Navigation Centre) ground stations. As with UTC, IRNWT is also a weighted mean average time, but with two substantial differences. IRNWT will be made available in real time and is a continuous time without leap seconds. The IRNSS satellites carry a rubidium atomic frequency standard onboard. At INC through navigation software, these onboard clocks are monitored and controlled. The deviation between each of the satellite and IRNWT is modeled with a quadratic function of time, and the parameters of this model are calculated and transmitted as a part of the IRNSS broadcast navigation messages.

The parameters are often called as clock bias (A0) or the clock offset (in seconds), drift (A1) or the relative frequency instability (in seconds/second) and aging (A2), also referred to as relative frequency shift (in seconds/second^2). Apart from these corrections, any IRNSS users should consider the necessary relativistic time adjustment. With these adjustment parameters, which are usually calculated once per day, are then transmitted to the satellites, thus the satellite clock errors are expected to be well within 5^{-10}ns which fulfills the requirement. The estimated accuracy is < 20 m over the Indian ocean region, and < 10 m over main land India.

IRNSS COVDERAGE 1,500 – 2000 km around land-mass

IRNSS signals: The IRNSS constellation is expected to provide a position accuracy (2σ) of better than 20 m over India and a region extending outside the Indian land mass to about 1,500 km. The system will provide two types of services:

1) SPS (Standard Positioning Service)

2) RS (Restricted/Authorized Service)

Both of these services will be provided at two frequencies, one in the L5 band and the other in S-band. SPS will use bi-phase shift keying BPSK (1) modulation, whereas the RS service will employ binary offset carrier (BOC (5, 2)) modulation. An additional BOC pilot signal is being provided for the RS Service in order to help provide better acquisition and performance. As each L5-band and 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 coverage in right-hand circularly polarized (RHCP) signals. Thus, user receivers can operate in single-and/or dual-frequency mode.

6. APPLICATIONS :

IRNSS applications include terrestrial, aerial and marine navigation, precise timing, disaster management, mapping and geodetic data capture, automated logistics in factories, construction sites and mines, vehicles tracking and fleet management, terrestrial navigation for hikers and travellers and integration with mobile phones. Surveying emergency response, business solutions, geographical data collection, natural resources, land management, scientific research and geodynamics are some of GAGAN's applications.

REFERANCE :

1.G Madhavan Nair, "Satellites for Navigation," Press Information Bureau of the Government of India, Aug. 8, 2006, URL:

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A Peer Reviewed Open Access International Journal

http://www.pibbng.kar.nic.in/feature2.pdf

2) D. Gowrisankar, S. V. Kibe, "India's Satellite Navigation Programme," APRSAF-15 (15th Session of Asia-Pacific Regional Space Agency Forum) Hanoi, Vietnam, Dec. 9-12, 2008, URL:

http://www.space.mict.go.th/activity/doc/aprsaf15_17.pdf

3) Surendra Pal, A. S. Ganeshan, K. N. S. Rao, L. Mruthyunjaya, "Indian Regional Navigation Satellite System," Proceedings of the 58th IAC (International Astronautical Congress), International Space Expo, Hyderabad, India, Sept. 24-28, 2007, IAC-07-B2.1.01

4) Parimal Majithiya, Kriti Khatri, J. K. Hota, "Indian Regional Navigation Satellite System," Inside GNSS, January/February 2011, pp. 40-46, URL:

http://www.insidegnss.com/auto/IGM_janfeb11-IRNSS.pdf