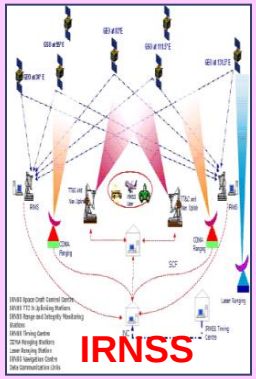
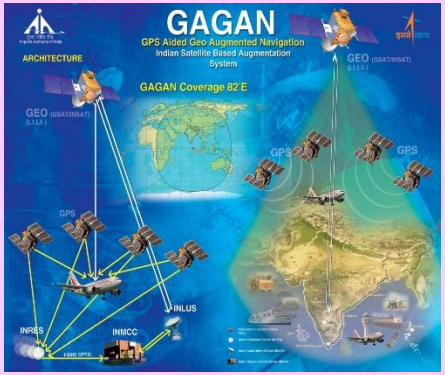
Indian Regional Navigation Satellite System (IRNSS) / Navigation with Indian Constellation (NavIC) and GPS Aided Geo Augmented Navigation (GAGAN)





7 November, 2016

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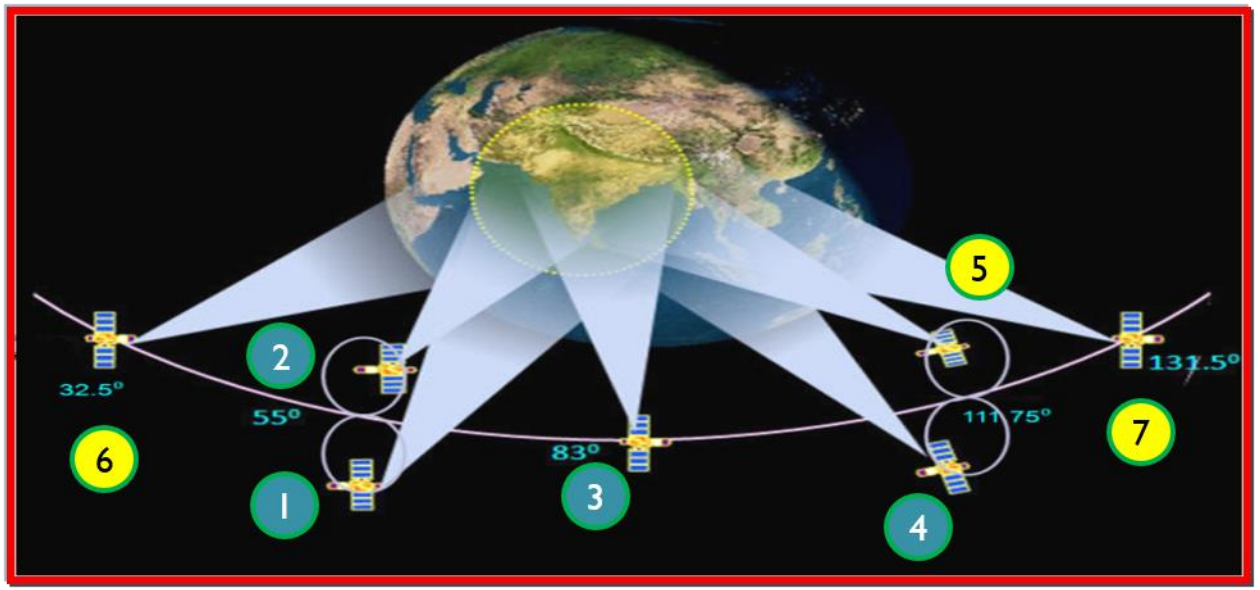
Navigation with Indian Constellation (NavIC)

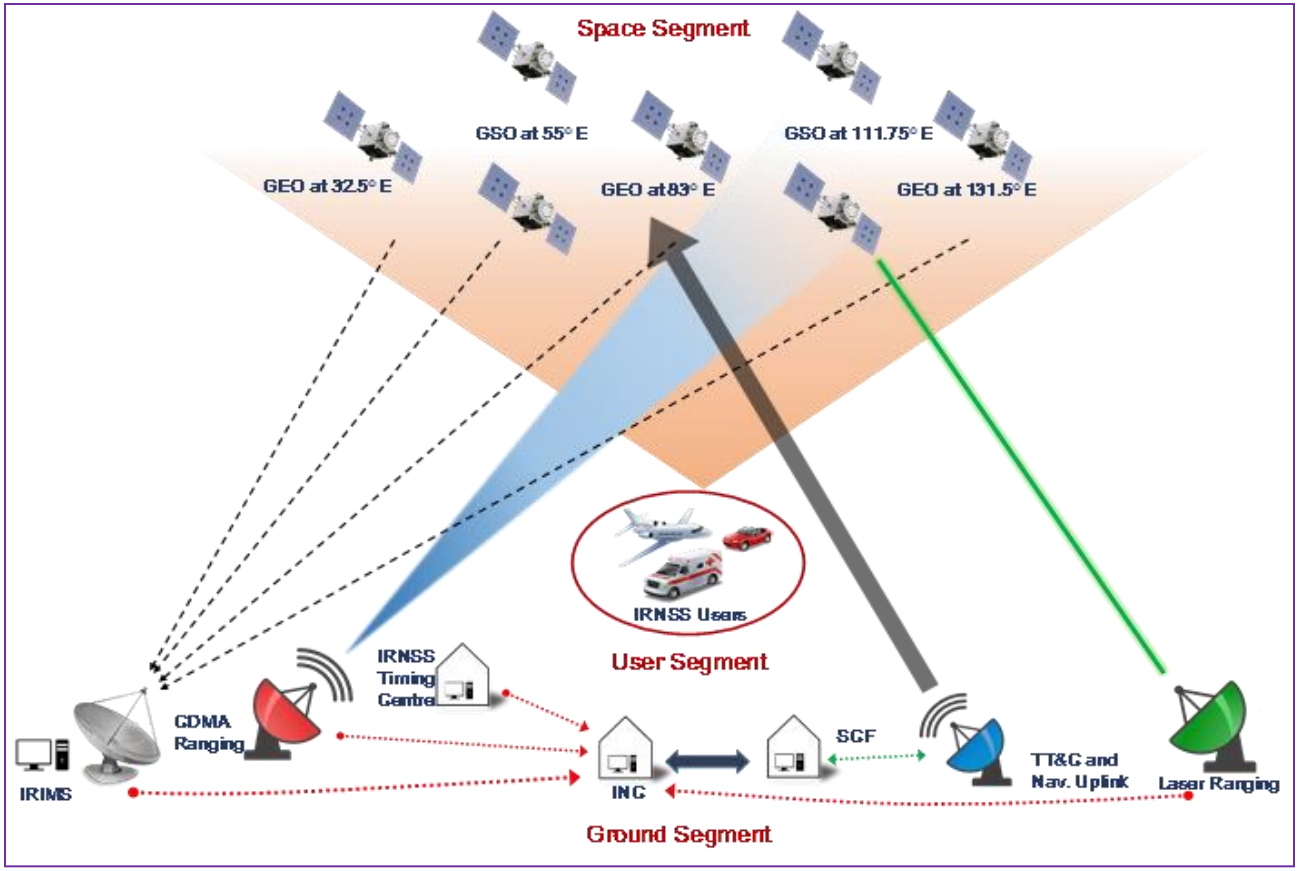


- Indian Regional Navigation Satellite System (IRNSS) is now called
  - NavIC (Navigation with Indian Constellation)
- NavIC/IRNSS consists of 7 Satellites
  - 4 Geo Synchronous Orbit (GSO) satellites at 55° E and 111.75° E at an inclination of 27°
  - 3 Geo Stationary Satellites (GEO) at 32.5° E, 83° E and 129.5° E
- Transmits signals in L5 band (1176 MHz) and S band (2492 MHz)

Navigation with Indian Constellation (NavIC)

- NavIC shall provide two types of services – Standard Positioning Service (SPS) & Restricted Service (RS)
- All 7 Satellites are successfully realized in orbit
  - IRNSS-1A (1July 2013)
  - IRNSS-1B (4 Apr. 2014)
  - IRNSS-1C (10 Nov. 2014)
  - IRNSS-1D (28 March 2015)
  - IRNSS-1E (20 Jan. 2016)
  - IRNSS-1F (10 March 2016)
  - IRNSS-1G (28 April 2016)
- Current constellation satellites are functional with navigation signals in L5 and S-band.
- Use of L1 band in future satellites is Envisaged.

Navigation with Indian Constellation (NavIC)



- **NavIC/IRNSS Architecture:**
  - Ground Segment
  - Space Segment
  - User Segment

Navigation with Indian Constellation (NavIC)

- **NavIC/IRNSS Space Segment:**
- Navigation Payload
  - Rubidium Atomic Frequency Standard (RAFS)
  - Navigation Signal Generation Unit (NSGU) generates navigation signals in L5 and S bands
- Ranging Payload
  - CDMA Ranging Payload in C-band

NavIC Ground Segment

IRNSS CDMA Ranging Stations (IRCDR)

ISRO Navigation Centre (INC)

IRNSS Range & Integrity Monitoring Stations (IRIMS)

IRNSS Network Timing Facility (IRNWT)

IRNSS Data Communication Network (IRDCN)

IRNSS Spacecraft Control Facility (IRSCF)

Navigation with Indian Constellation (NavIC)

- **NavIC/IRNSS User Segment:**
- Standard Positioning Service (SPS) for civilian users
- Restricted Services (RS) for authorized users
- Single Frequency Users (L5/S band)
  - Grid based Ionosphere related corrections
- Dual Frequency Users (L5 & S band)

Tests were conducted various combinations like NAVIC-L5 only, NAVIC-S only, NAVIC DF and NAVIC L5+GPS hybrid mode.

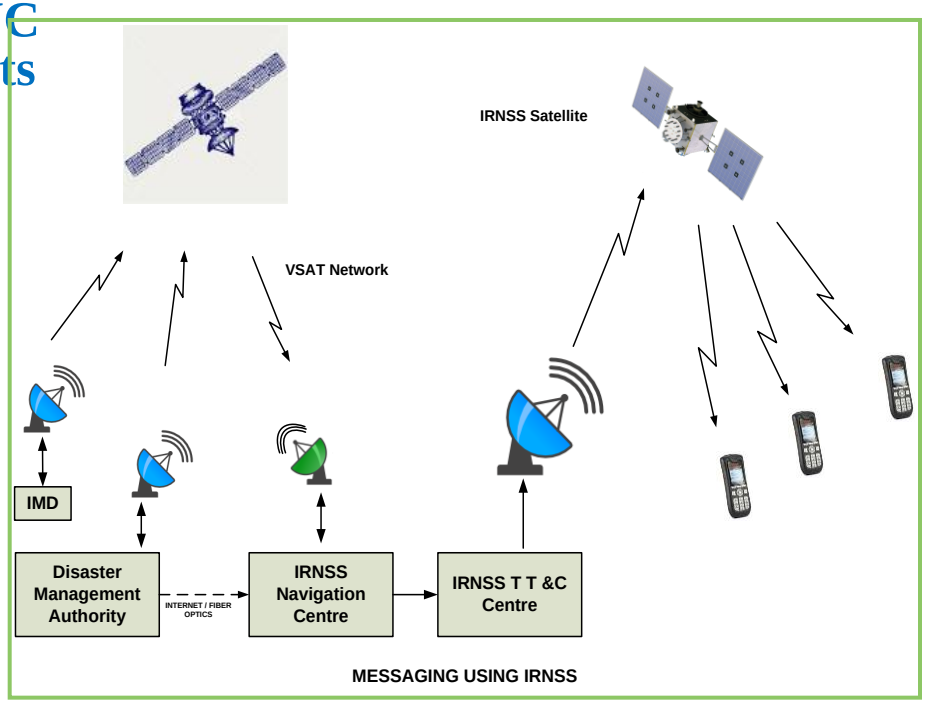
It is observed that NAVIC Position accuracy meets the specification of 20 m across all the participating stations

NavIC: PERFORMANCE OBSERVATIONS

- NavIC/IRNSS Position Error better than specification across all the participating stations in IRNSS-L5 only, IRNSS-S only, IRNSS-DF and IRNSS L5 + GPS hybrid modes.
- NavIC/IRNSS L5 + GPS 3D RMS PE is lowest across all stations compared to the other three modes.
- NavIC/IRNSS S-only 3D RMS PE is less compared to IRNSS-DF and IRNSS–L5 only Solutions.
- Hybrid GPS - L1 + IRNSS – L5 gives improved Position Availability (PA) compared to IRNSS-L5 Only or GPS-L1 Only mode.

NavIC Messaging: Disaster Warning System

- Agencies like IMD, INCOIS, CWC etc. generate disaster related alerts
- Alerts transmitted via VSAT network to INC
- Alert message is uplinked to IRNSS Sat. by TT&C Centre
- IRNSS navigation message structure can transmit certain short messages
- Short message is received by all INRSS User Receivers

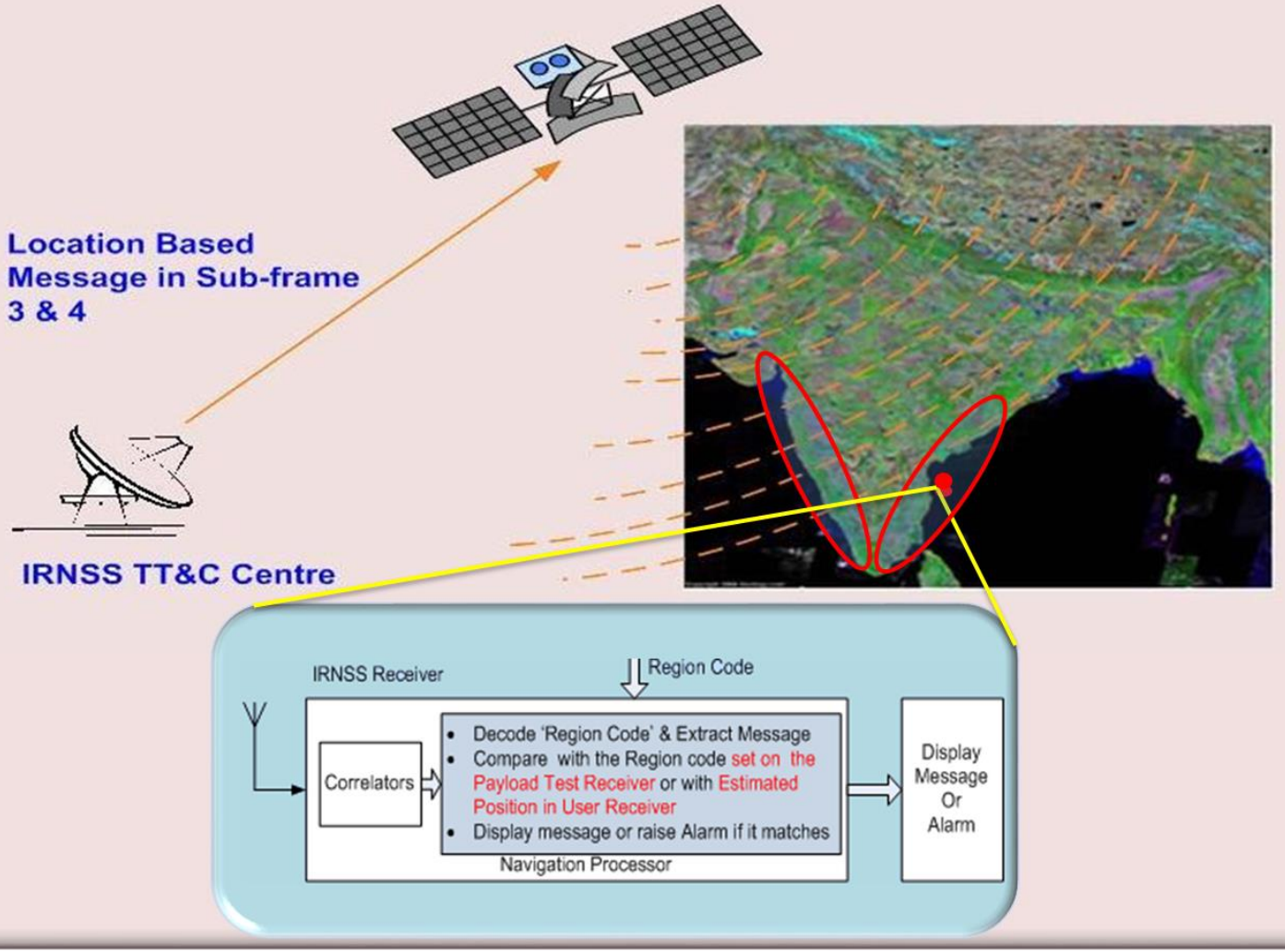


Code_Upload

Satellite	Text Message
IRNSS-1A	NAVIC WELCOMES HON.
IRNSS-1B	NAVIC WELCOMES HON.
IRNSS-1C	NAVIC WELCOMES HON.
IRNSS-1D	NAVIC WELCOMES HON.
IRNSS-1E	NAVIC WELCOMES HON.
IRNSS-1F	NAVIC WELCOMES HON.
IRNSS-1G	No Msg to display
IRNSS-1H	No Msg to display
IRNSS-1I	No Msg to display
IRNSS-1J	No Msg to display
IRNSS-1K	No Msg to display

NavIC : Location Based Disaster Warning System

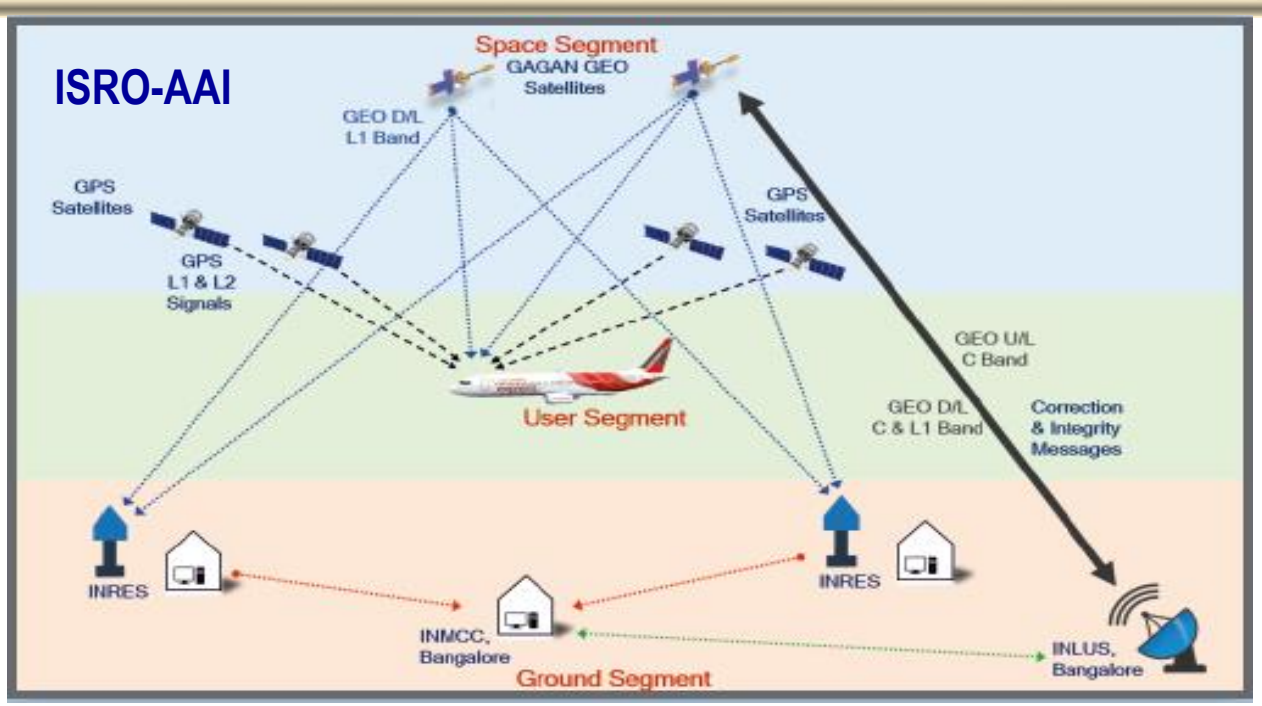
- **Location Based Messaging During Disaster and Alert Situations**



NavIC : LoGO Release – 15 Sept., 2016

7th Nov., 2016

GAGAN (GPS Aided Geo Augmented Navigation)

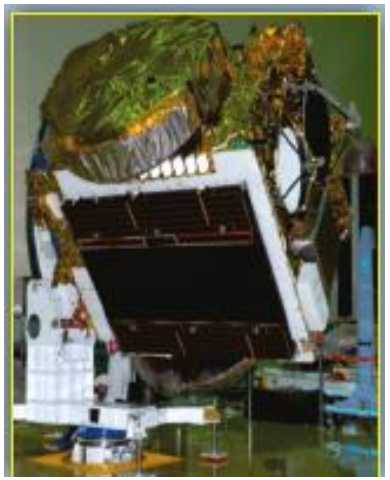


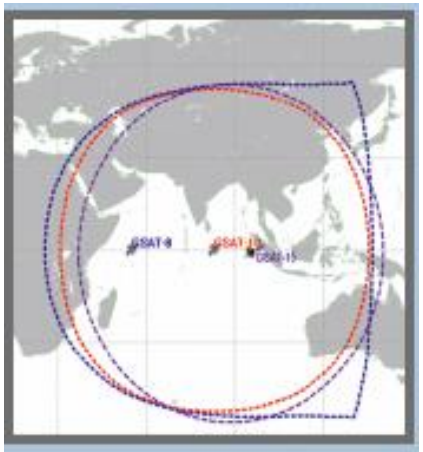
- Two Satellites GSAT-8 (PRN127) & GSAT-10 (PRN128) carrying GAGAN payloads are already operational.
- GAGAN Payload (PRN132) onboard GSAT-15 serves as the on-orbit spare.
- GAGAN is the first SBAS system in the world to have the capability of vertical guidance in the Equatorial Anomaly Regions, i.e. India

GAGAN SPACE SEGMENT

All 3 GAGAN Satellites are in **Geo - Stationary Orbit** and transmit signals in **L1** (1575.42 MHZ) and **L5** (1176.45 MHz) frequencies.

Satellite	Launch Date	Position	Signal
GSAT 8	21st May, 2011	55°E	PRN127
GSAT 10	29th Sep, 2012	83°E	PRN128
GSAT 15	11th Nov, 2015	93.5°E	PRN132





Signal Footprint

GAGAN GROUND SEGMENT

- 15 INRES (Indian Reference Stations)

  - Each having pair of receivers

- 2 INMCC (Indian Master Control Centre)

- Located at Bengaluru

- 3 INLUS (Indian Navigation Land Uplink Station)

  - Established at Bengaluru ; Redundant INLUS at Delhi

- Communication links between INRES & INMCC

  - Highly reliable optical fiber links have been established

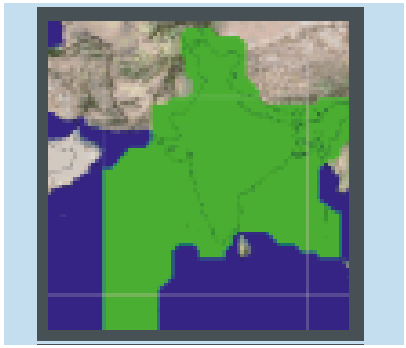
GAGAN FOR CIVIL AVIATION

- GAGAN operations are fully certified for en-route Navigation (RNP 0.1) in Indian Flight Information Region (FIR) since Dec 30, 2013
- GAGAN operation are also certified for Precision Approach with Vertical guidance APV 1 since April 21, 2015

GAGAN PERFORMANCE

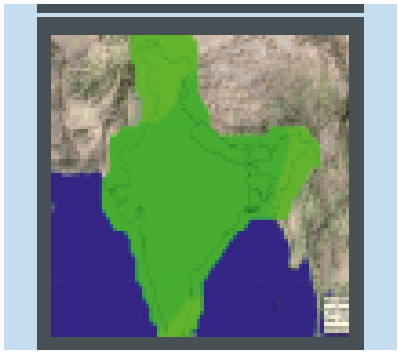
En-Route - RNP 0.1 Service

Parameter	Requirement	Measured Performance
Availability	> 99% over Indian FIR	> 99%
Horizontal Accuracy	< 72m 95% bound	0.7m
Vertical Accuracy	NA	1.5m Avg



Precision Approch - APV 1.0 Service

Parameter	Requirement	Measured Performance
Availability	> 99% over 76% of India	> 99% over 86.57% of India
Horizontal Accuracy	< 7.6 m 95% bound	~ 3.0m
Vertical Accuracy	< 7.6 m 95% bound	~ 4.0m

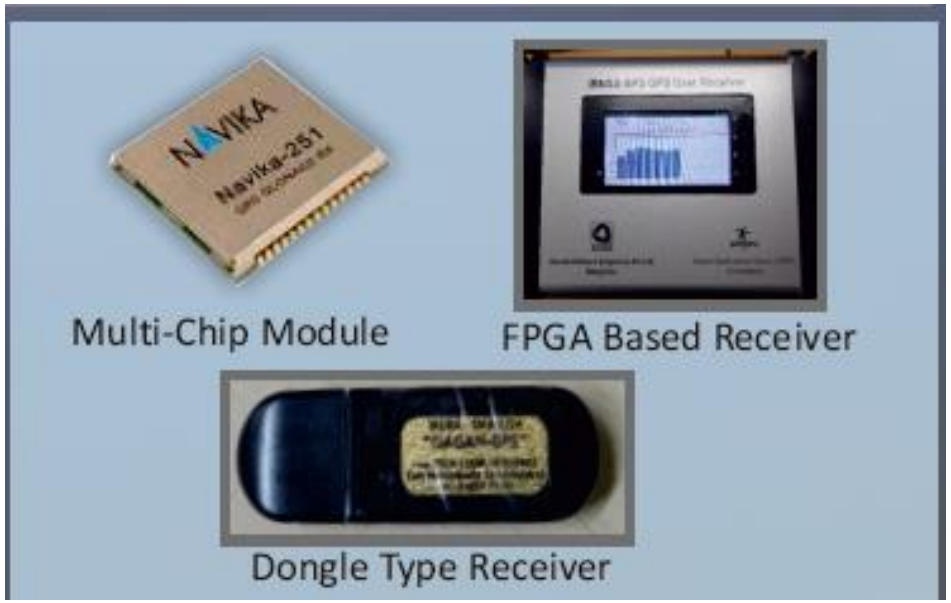


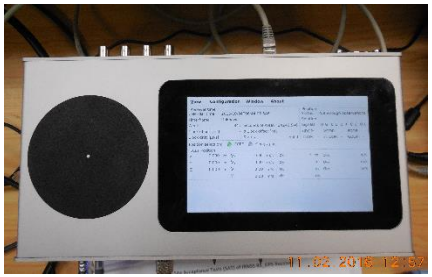
NavIC and GAGAN RECEIVERS

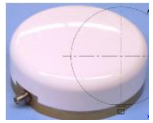
Features

- ❖36 Hardware Channels
  (11 L5 + 11 S + 12 GPS + 2 GAGAN)
- ❖ NavIC and Hybrid Modes
- ❖Simultaneous Position Solutions
- ❖NavIC Text Messages Display
- ❖NMEA v2.30 supported
- ❖Hardware Fabricated by Industry

NAVIC Antenna

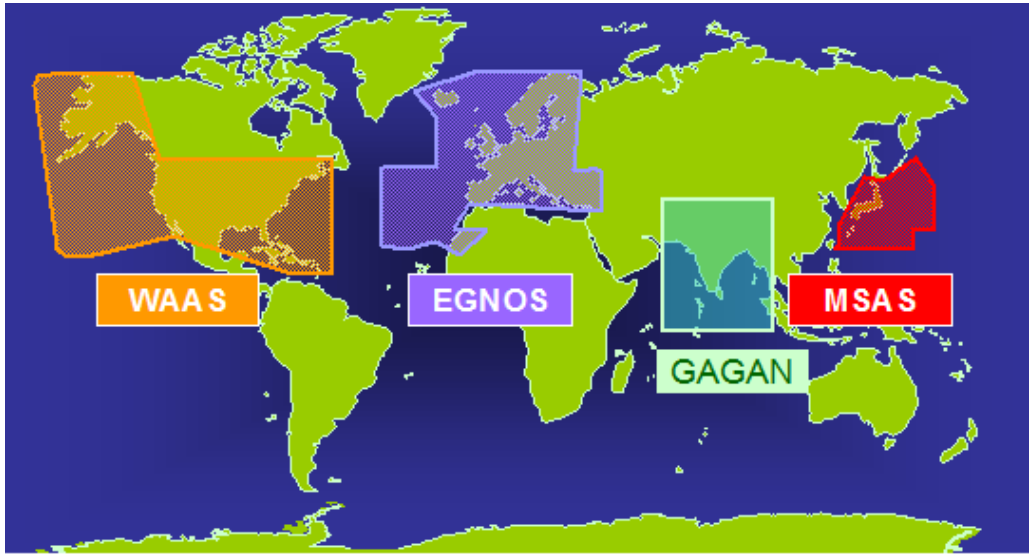






7th Nov., 2016

NavIC and GAGAN : FUTURE ACTIONS



- ISRO is in liaison with different National agencies for the adoption of IRNSS & GAGAN receivers.
- India is actively engaged in dialogue with other GNSS operators in establishing the compatibility.
- India continues to work with international forum like ICG, ITU RES-609 for addressing compatibility and interoperability matters.

THANK YOU

The future depends on what we do in the present.

- Mahatma Gandhi

7th Nov., 2016