On Indian Satellite based Navigation Systems and Implementation Status

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Provider's System & Service Updates
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Satellite Navigation Program

GAGAN: Indian SBAS

- **GAGAN - G**PS **A**ided **G**EO **A**ugmented **N**avigation
  - **Is an overlay system built around the GPS**
  - **Jointly Implemented by ISRO and AAI**

- **Executed in phases**
- **GAGAN – TDS (Technology Demonstration System)**
- **GAGAN – FOP (Final Operation Phase)**

Configuration in TDS
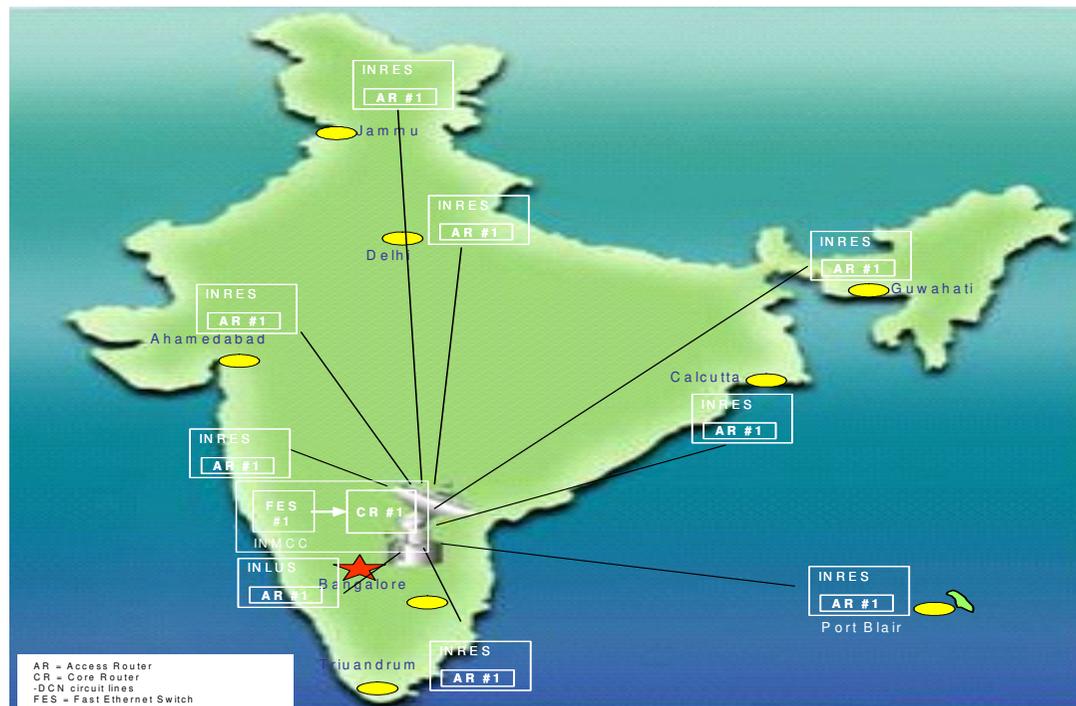
Ground Segment
- **8 INRES: 2 INREEs**
- **1 INMCC**
- **1 INLUS**
- **1 ring of OFC (7 INRES)**
- **1 VSAT link (GPB)**

Space Segment
- **INMARSAT-4F1**

GAGAN Payload Characteristics

Sl. No	System Characteristics	L1 Freq (1575.42 MHz)	L5 Freq (1176.45 MHz)
1	Transmitted EIRP (EOC)	30.2 dBW	29.2 dBW
2	Receive G/T	-2 dB/deg K	-2 dB/deg K
3	Bandwidth	20 MHz	24 MHz
4	Footprint	Global	Global
5	Feeder Link Frequency	C-band	C-band
6	Transmit Polarization	RHCP	RHCP
7	Type of Antenna	Helix	Helix
8	Antenna Gain	15.8 dB	15.8 dB
9	RF Power rating	40 W	40 W
10	Total Payload weight	50 kg	
11	Power DC	240 W	

Tests With GAGAN-TDS SIS

GPS Antenna   SBAS Antenna

Δx = 0.678m
Δy = 2.095m
Δz = 0.206m

LON, LAT & HEIGHT DURING FLIGHT TRIAL
FROM HYD-BLR ON 17SEP07
DURATION: 11hr:56mn:-14s to 13hr:32mn:-14s (IST)
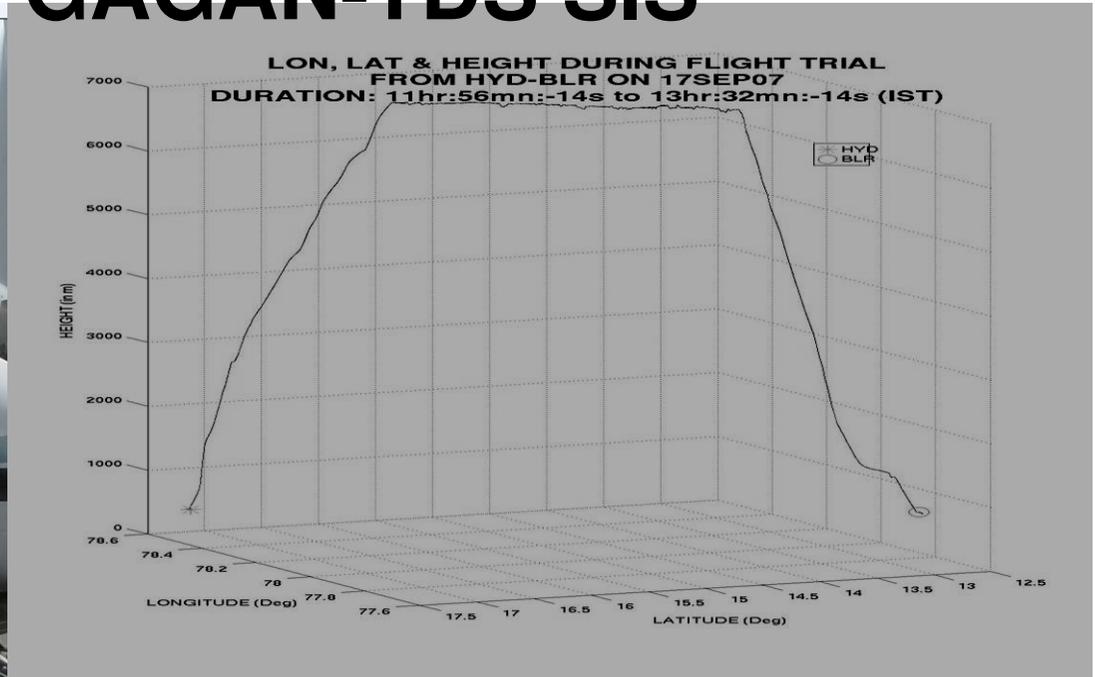
HPL computed for the flight path and HPL contour for the same duration from INMCC on 17th Sep.
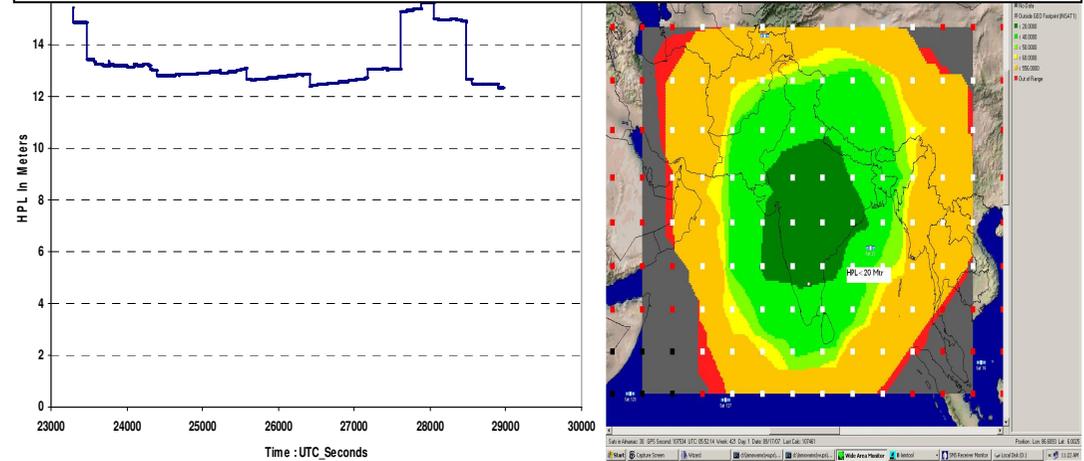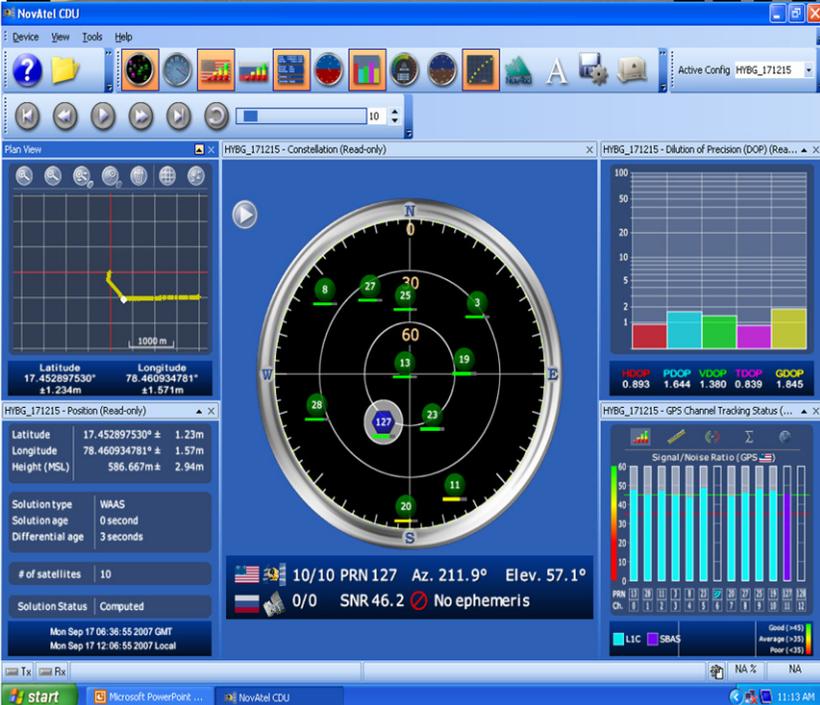
GAGAN Final Operation Phase

➢ Realize a <u>certified and operational SBAS</u> to provide air navigation services of

- RNP 0.1 en route navigation within Indian FIR

  - APV-1/1.5 precision approach over the landmass of Indian FIR

Key Elements:
- **Integrity**
- **Availability**
- **Continuity**
- **Accuracy**

Compatible and Interoperable with other SBAS

Provides Seamless navigation

➢ Common coverage of GAGAN GEO satellites (55, 82 & 83º) is beyond Indian FIR (GSAT-8, GSAT-10 & GSAT-8R)

➢ GSAT-8 launched on 21-May'11 and GAGAN payload In-Orbit Testing – Completed. GAGAN Space Segment uses SBAS PRN codes 127

➢ Signal-In-Space expected by end of 2011

➢ GAGAN certification by 3rd quarter of 2013

Helix Array Antenna Gagan payload GSAT-8 Gain Contours (Freq 1.575 GHz L1)
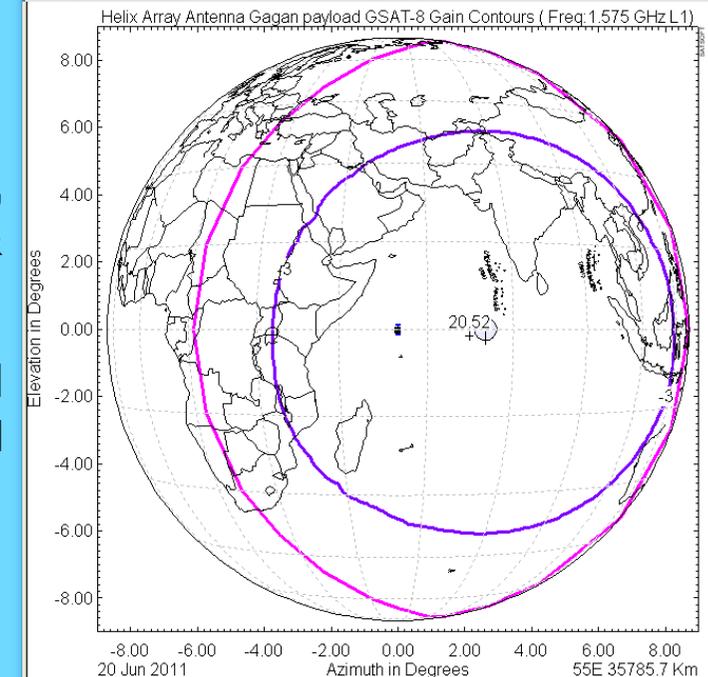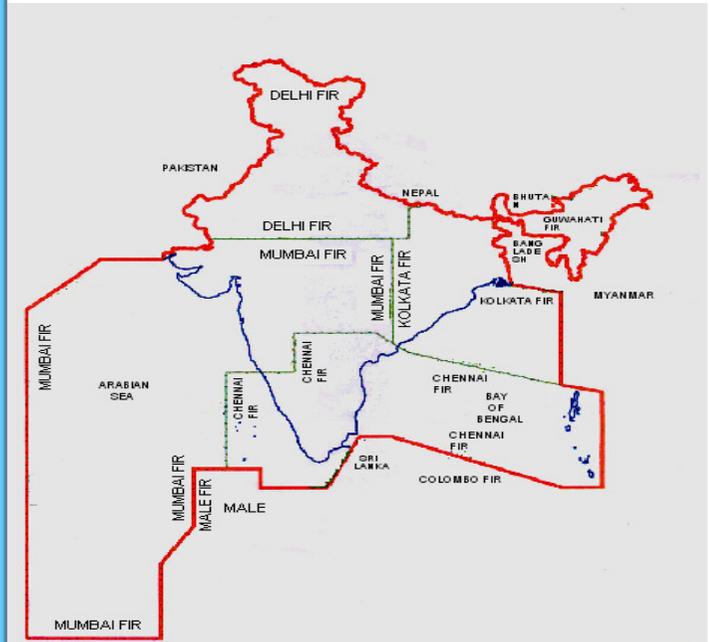
GAGAN Ionosphere Model Development

Approach Category	Flight Phase	Accuracy	Time to Alert	HAL	VAL	Expected Date of Completion
RNP 0.1	En-route	85 m	N/A	185 m	N/A	June 2011
APV 1.5	Precision Approach	7.6 m	6 sec	40 m	50 m	June 2013

Iono. Model

IGM-MLDF (ISRO GIVE Model - Multi Layer Data Fusion):

- Algorithm for computing the ionosphere corrections at pre-defined grid points
- Fuses the delays and confidences at different layers

Instantaneous IPP Distribution for Bangalore INRES

IGM-MLDF

Performance: IGM-MLDF

= 100% (53.8%)	
99% (77.45%)	
98% (89.52%)	
97% (91.65%)	
96% (93.51%)	
95% (96.42%)	
80% (100%)	
70% (100%)	
60% (100%)	
50% (100%)	
< 50% (100%)	
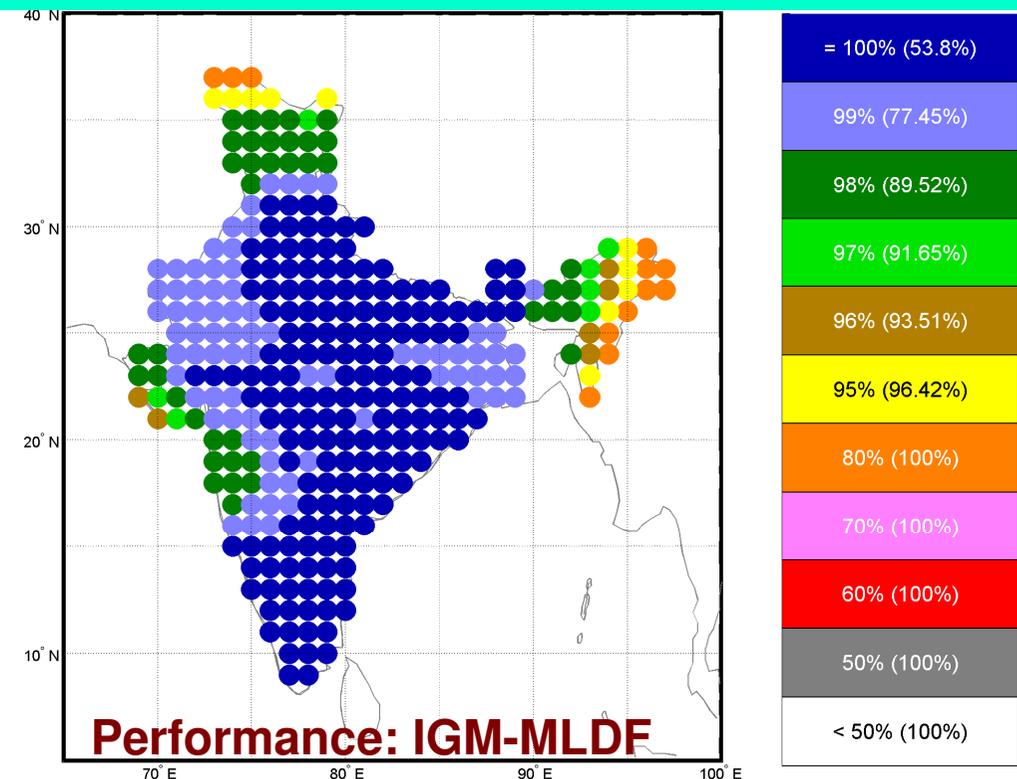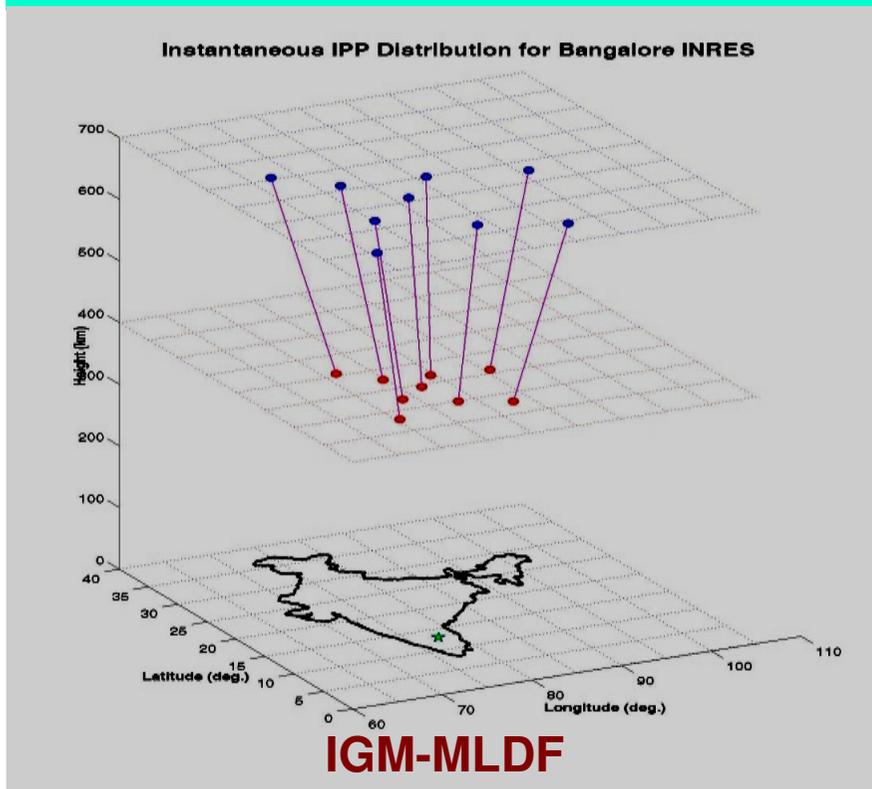
GAGAN-FOP Configuration
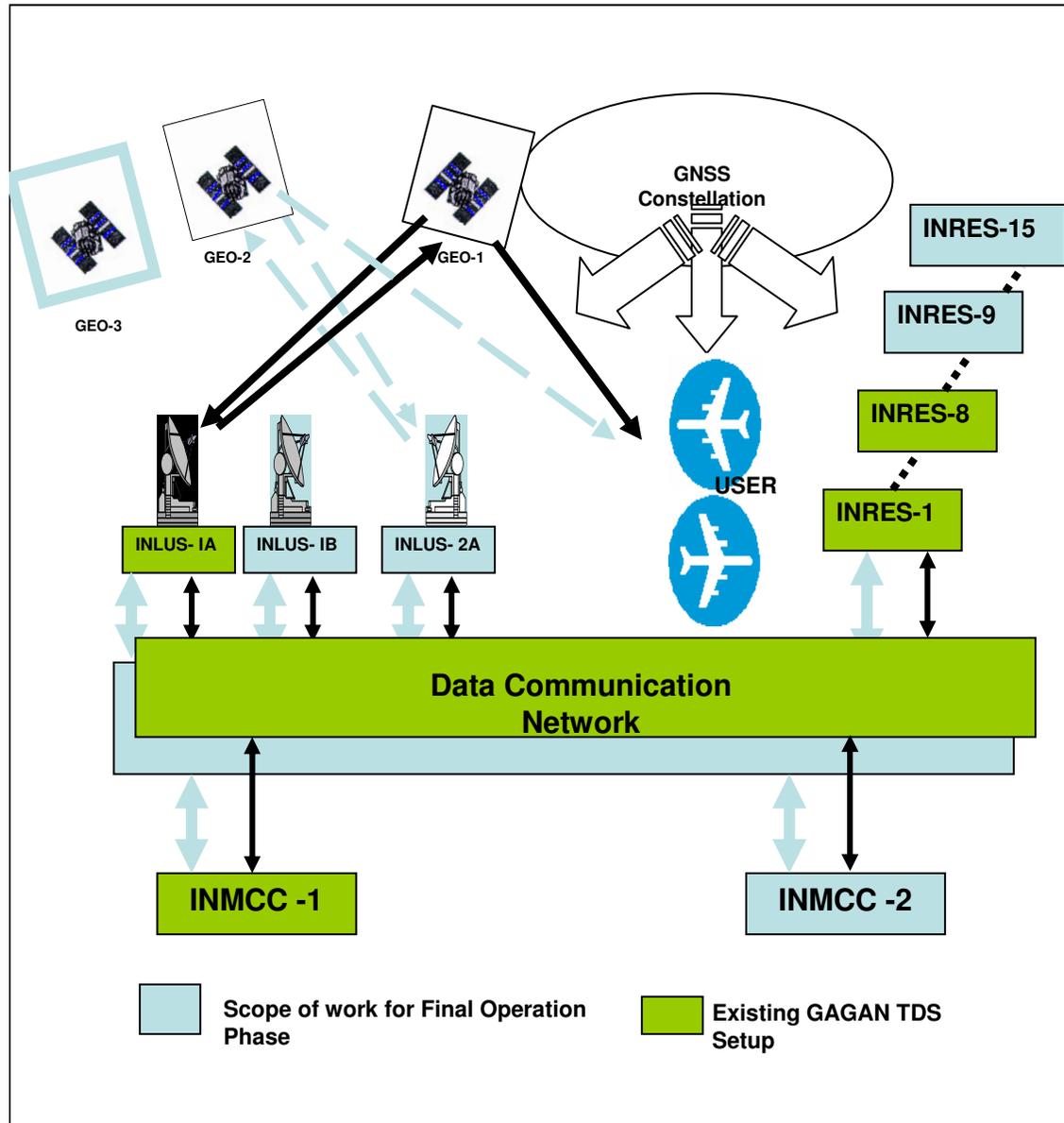
System /Activity	TDS	FOP
INRES	8 (2 chains)	15 (3 chains)
INMCC	1	2
INLUS-SG	1	3 (2 in BLR & 1 in DEL)
O&M	1	2
Iono Model (Equatorial)	WAAS model	IGM-MLDF
Certification	NA	yes
GEO	1	3 (GSAT)
INLUS-RF	1	3 (2 in BLR & 1 in DEL)
COM Links	1	2

Major Activities

Preliminary System Acceptance Test – Dec' 2010

Launch of GSAT-8 –May' 2011

GEO integration & SIS availability - Oct/Nov' 2011

GSAT-10 Launch – Mar' 2012

Final System Acceptance Test – Jun/Jul' 2012

Stability Run & HMI data collection and analysis

Final Certification – Jun/Jul' 2013

P R O J E C T   S C H E D U L E

Satellite Navigation Program

IRNSS Objective

- **IRNSS Refers to Indian Regional Navigation Satellite System implemented by the Indian Space Research Organisation.**

- **IRNSS is an independent Navigation Satellite System providing Navigation services in the Indian Region.**

- **IRNSS system provides the user with a targeted position accuracy of better than 20m over India and the region extending to about 1500 km around India.**

IRNSS Architecture

Space Segment

❑ **Spacecraft Bus Elements & Navigation Payload**

Ground Segment

❑ **Range & Integrity Monitoring Stations, Navigation Centre, CDMA & Laser Ranging Stations, Satellite Control Centre & Uplink Stations, Data Communication Links, Network Timing Facility.**

User Segment

❑ **Single & Dual Frequency Receivers for SPS and RS**

Frequency Band	SPS	RS
L5 band (1176.45 MHz)	**BPSK**	**BOC (5,2)**
S band (2492.028 MHz)	**BPSK**	**BOC(5,2)**

IRNSS Signals

L5 Band

Service	Frequency Band	Centre Frequency (MHz)	Allocated Bandwidth (MHz)	Polarization	Modulation	Code rate (Mcps)
SPS	**L5-band**	1176.45	24 MHz (1164.45 - 1188.45 MHz)	RHCP	BPSK(1)	1.023
RS data	**L5-band**	1176.45	24 MHz (1164.45 - 1188.45 MHz)	RHCP	BOC(5,2)	2.046
RS pilot	**L5-band**	1176.45	24 MHz (1164.45 - 1188.45 MHz)	RHCP	BOC(5,2)	2.046

S Band

Service	Frequency Band	Centre Frequency (MHz)	Allocated Bandwidth (MHz)	Polarization	Modulation	Code rate (Mcps)
SPS	**S-band**	2492.028	16.5 MHz (2483.778 – 2500.278 MHz)	RHCP	BPSK(1)	1.023
RS data	**S-band**	2492.028	16.5 MHz (2483.778 – 2500.278 MHz)	RHCP	BOC(5,2)	2.046
RS pilot	**S-band**	2492.028	16.5 MHz (2483.778 – 2500.278 MHz)	RHCP	BOC(5,2)	2.046

Space Segment

- **Consists of 7 Satellites, 3 in Geo-Stationary orbit at 32.5°, 83° and 131.5° East.**

- **4 Satellites in GEO Synchronous orbit at inclination of 29° with Longitude crossing at 55° and 111.75° East.**

- **IRNSS Satellites are to be launched by the Indian launcher PSLV.**

- **The first Satellite will be launched by Second Quarter of 2012.**

- **The full constellation will be operational by 2015.**

Indian Regional Navigational Satellite System

Ground Segment Architecture
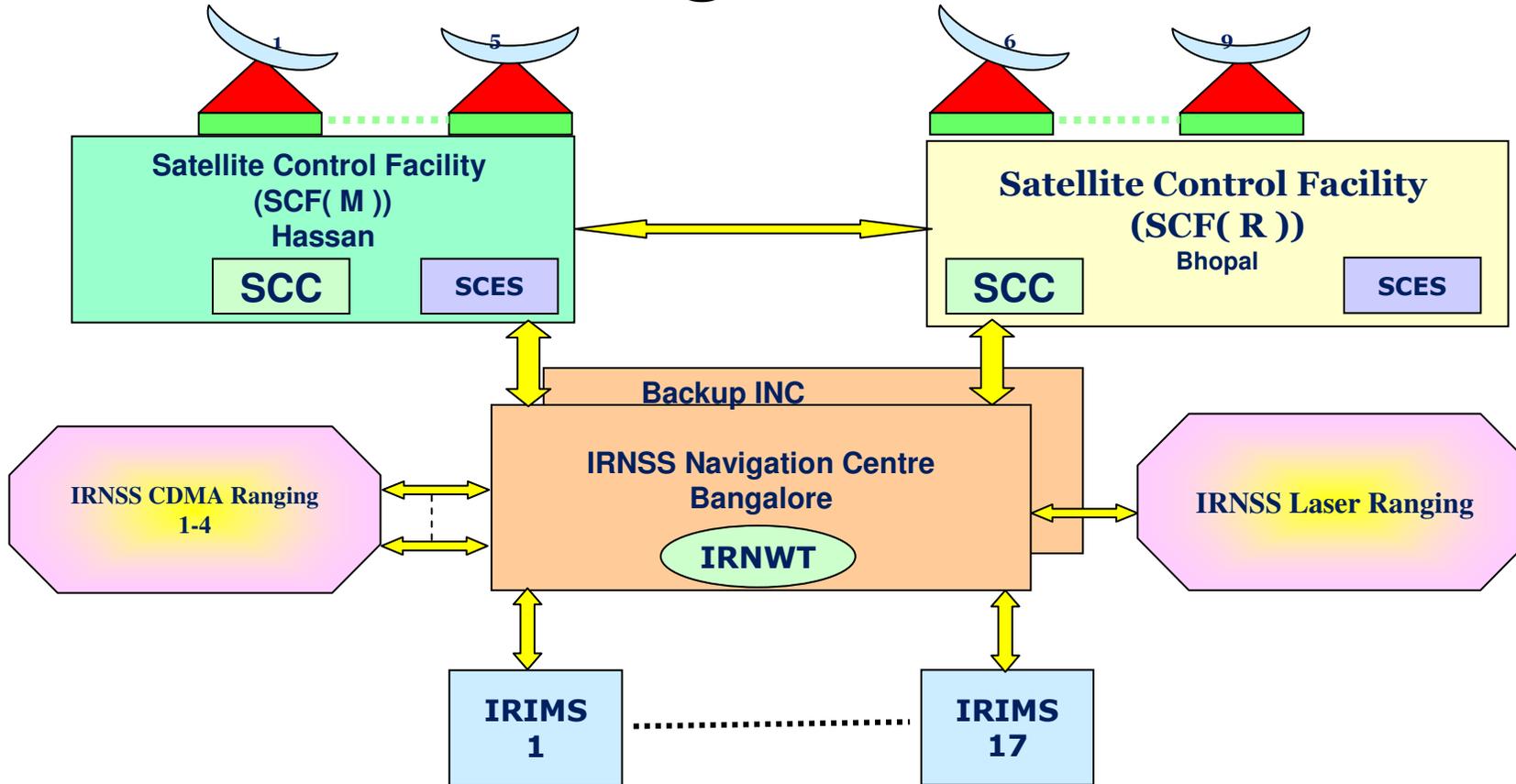
- ❏ **IRNSS Satellite Control Earth Stations (SECS)**   **- 9 Nos**
- ❏ **IRNSS Satellite Control Centre (SCC)**   **- 2 Nos**
- ❏ **IRNSS Range & Integrity Monitoring Stations (IRIMS)**   **- 17 Nos**
- ❏ **IRNSS Navigation Centre (INC)**   **- 2 Nos**
- ❏ **IRNSS Network Time (IRNWT)**   **- 2 Nos**
- ❏ **IRNSS CDMA Ranging Stations (IRCDR)**   **- 4 Nos**
- ❏ **IRNSS Data Communication Network (IRDCN)**   **- 2 Nos**

User Segment

- **The user segment consists of IRNSS receivers operating in**

  - **Single Frequency (L5 or S band)**

  - **Dual Frequency (L5 and S band)**

- **Single frequency and dual frequency receivers shall receive both SPS and RS signals. SPS is for civilian users.**