



GAGAN

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**INTERNATIONAL COMMITTEE ON GLOBAL
NAVIGATION SATELLITE SYSTEMS**

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SBAS IN VOGUE

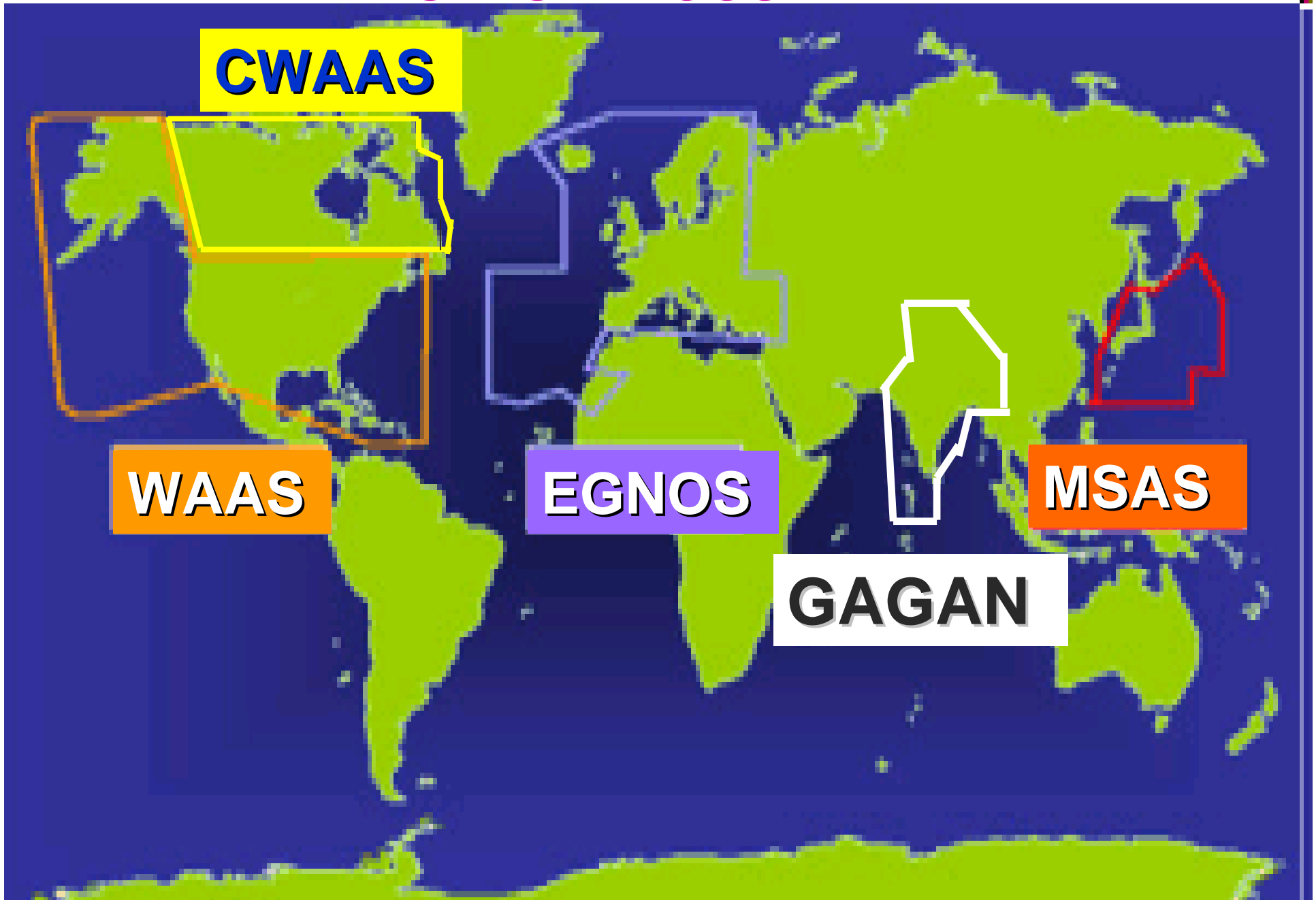
CWAAS

WAAS

EGNOS

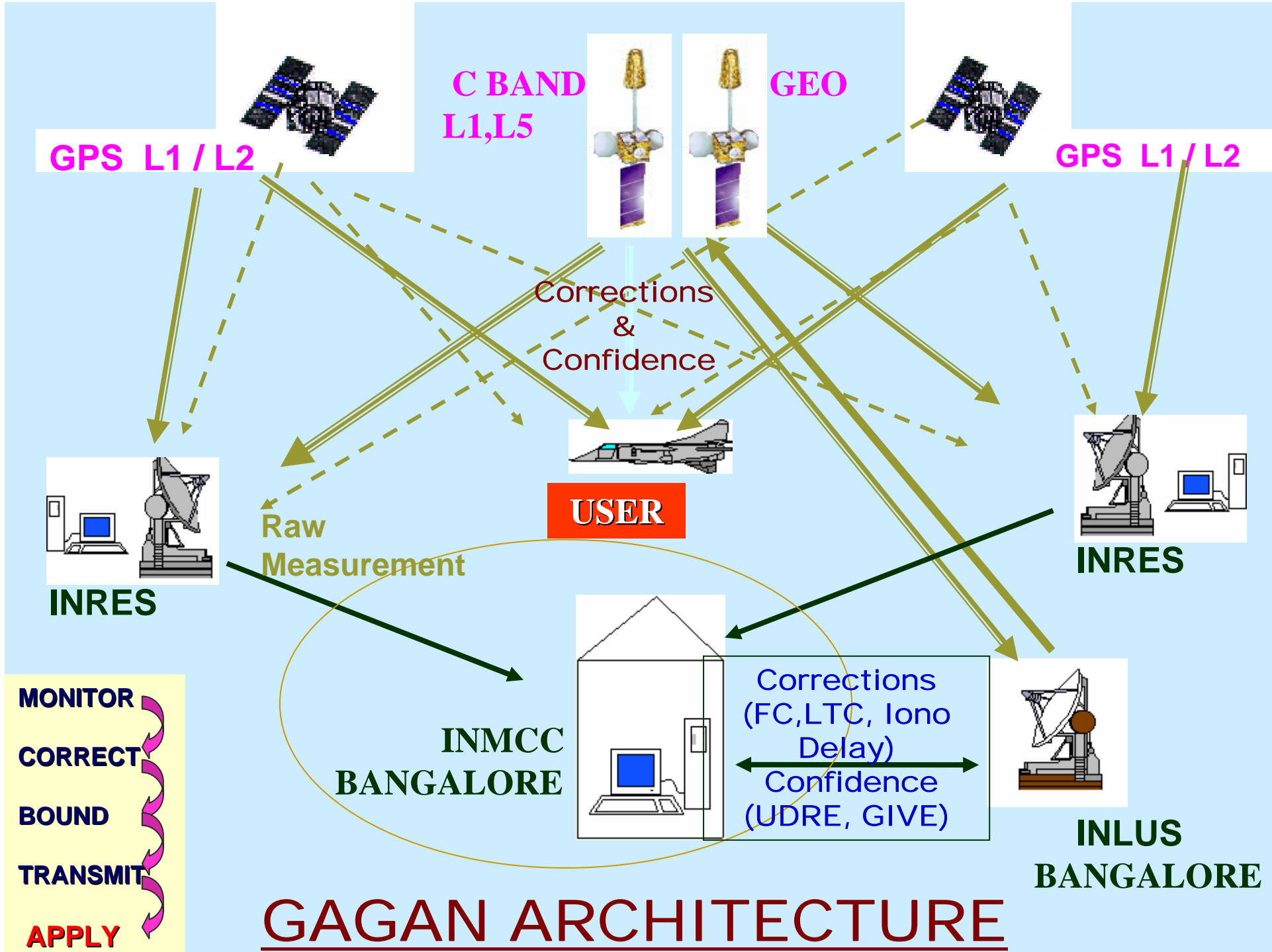
MSAS

GAGAN



INDIAN SBAS PROGRAM

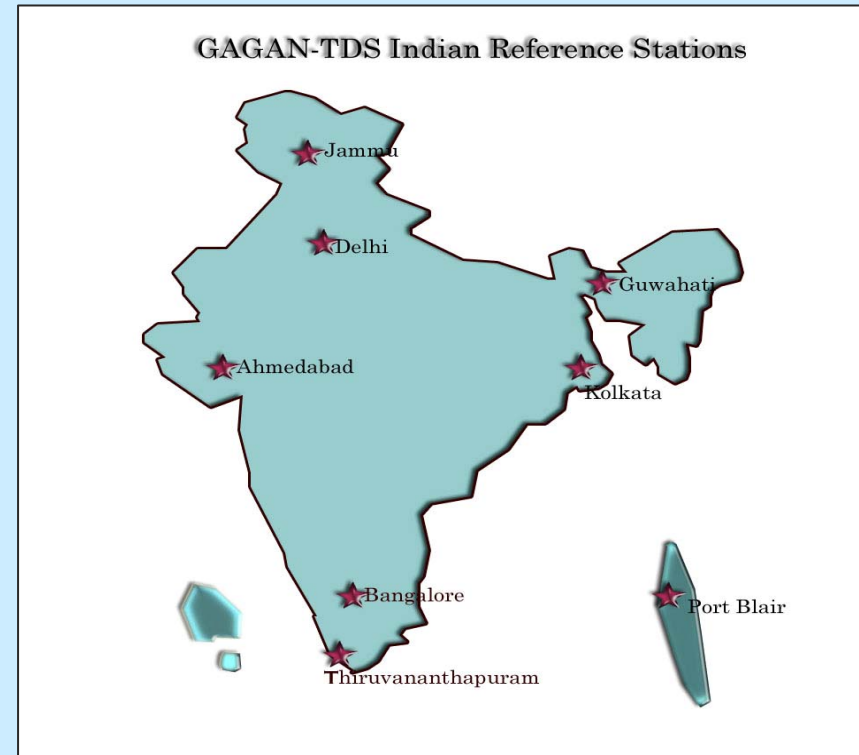
- **GAGAN - GPS Aided GEO Augmented Navigation**
 - Is an overlay system built around the GPS
 - Jointly Implemented by **ISRO** and **AAI**
- Executed in phases
 - GAGAN – TDS (Technology Demonstration System)
 - GAGAN – FOP (Final Operation Phase)



GAGAN-TDS Components



- **1 Geostationary Satellites**
- **1 Geo Uplink Stations (INLUS)**
- **Communication Links Between INRES & INMCC**

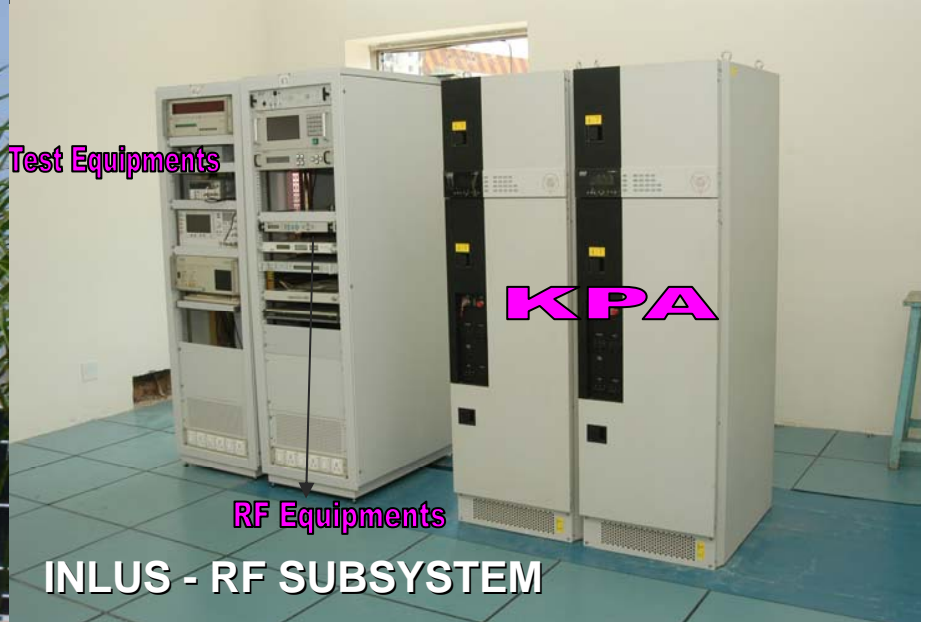


- **8 Network of Reference Stations (INRES)**
- **1 Master Stations (INMCC)**

INMCC –INLUS Facility



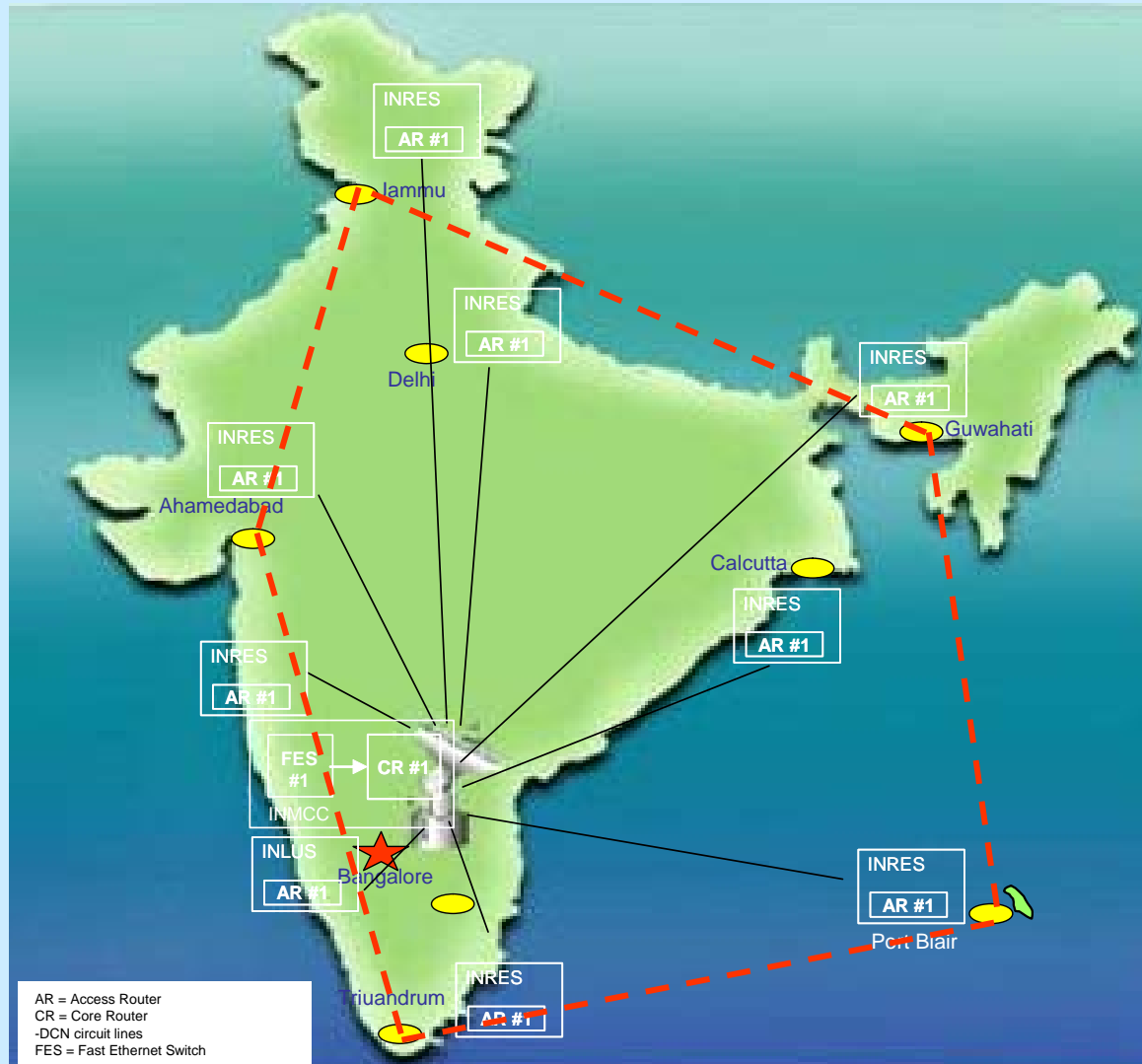
GAGAN – TDS GROUND SEGMENT ELEMENTS



STATUS: FINAL ACCEPTANCE TEST (FSAT) FOR TDS

- The GAGAN TDS ground system has been integrated with the INMARSAT 4F1 Navigation Transponder
- The overall system has completed the Final System Acceptance Test (FSAT) on 13-14 Aug 2007
- During the FSAT following parameters were demonstrated for acceptance:
 - 7.6 meter vertical and horizontal accuracy 95% of the time within the perimeter of the GAGAN-TDS INRES stations
 - Demonstrated time to alarm not to exceed 6.2 seconds, using the type 62 (Test) message
- GAGAN Signal In Space (PRN 127) was received by a SBAS receiver and accuracies were assessed

TDS CONFIGURATION FOR FSAT



Ground Segment

- 8 INRES: 2 INREEs
- 1 INMCC
- 1 INLUS
- 1 ring of OFC (7 INRES)
- 1 VSAT link (GPB)

Space Segment

- INMARSAT-4F1

FSAT RESULTS: ACCURACY SUMMARY

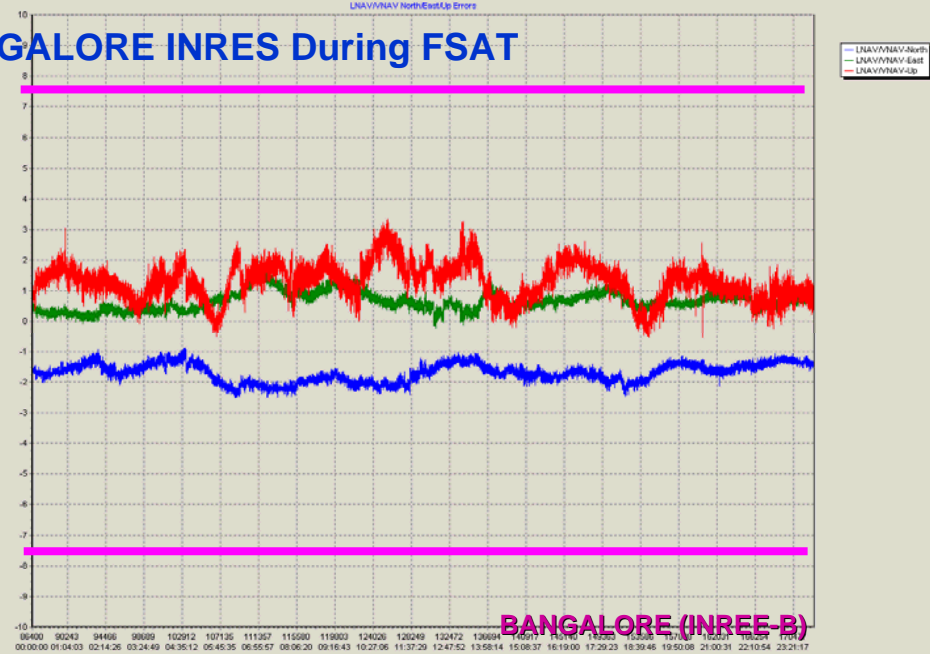
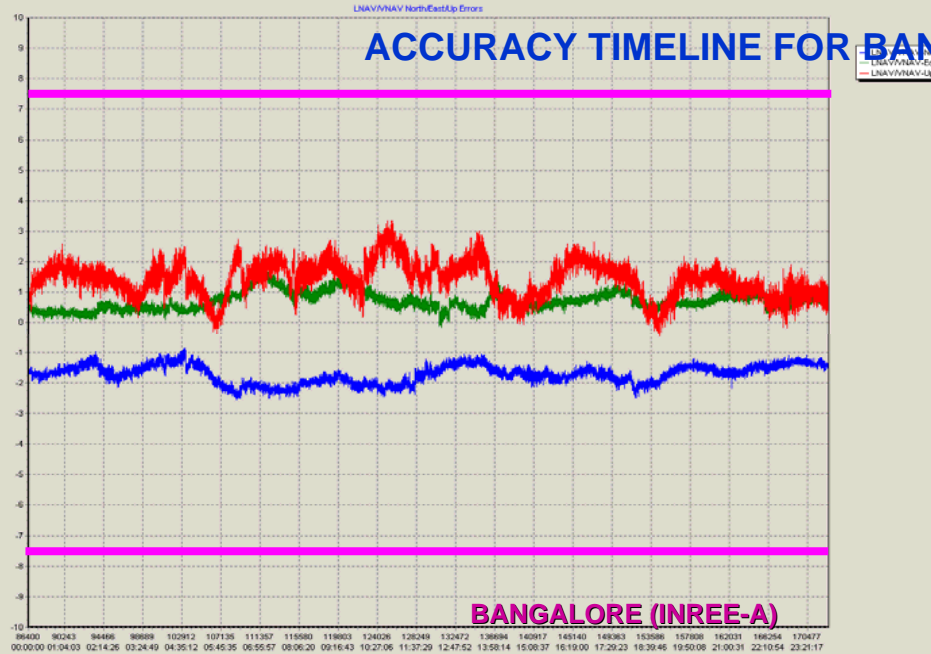
	Site		Count of Missing Epochs During 24 Hr Test Period	Count of Available Epochs During 24 Hr Test Period	% of Available Epochs During 24 Hr Test Period	Count of 7.6 m Threshold Trips During 24 Hr Test Period				% of Available Epochs Below the 7.6 m Accuracy Requirement	
						N	E	Hoiz. (N + E)	U	Hoiz. (N +E)	U
Performance Criteria	GBG	A	2	86398	100%	0	0	0	0	100%	100%
		B	0	86400	100.00%	0	0	0	0	100%	100%
	GDP	A	264	86136	99.69%	0	0	0	0	100%	100%
		B	236	86164	99.73%	0	0	0	0	100%	100%
	GCC	A	3	86397	100.00%	0	0	0	0	100%	100%
		B	2	86398	100.00%	0	0	0	0	100%	100%
Information Only	GAH	A	18	86382	99.98%	0	0	0	0	100%	100%
		B									
	GGT	A	1	86399	100.00%	0	0	0	0	100%	100%
		B									
	GJU	A	9	86391	99.99%	0	0	0	0	100%	100%
		B									
	GPB	A	0	86400	100.00%	0	0	0	0	100%	100%
		B									
	GTV*	A	1434	82593	95.59%	0	0	0	0	100%	100%
		B									

Notes

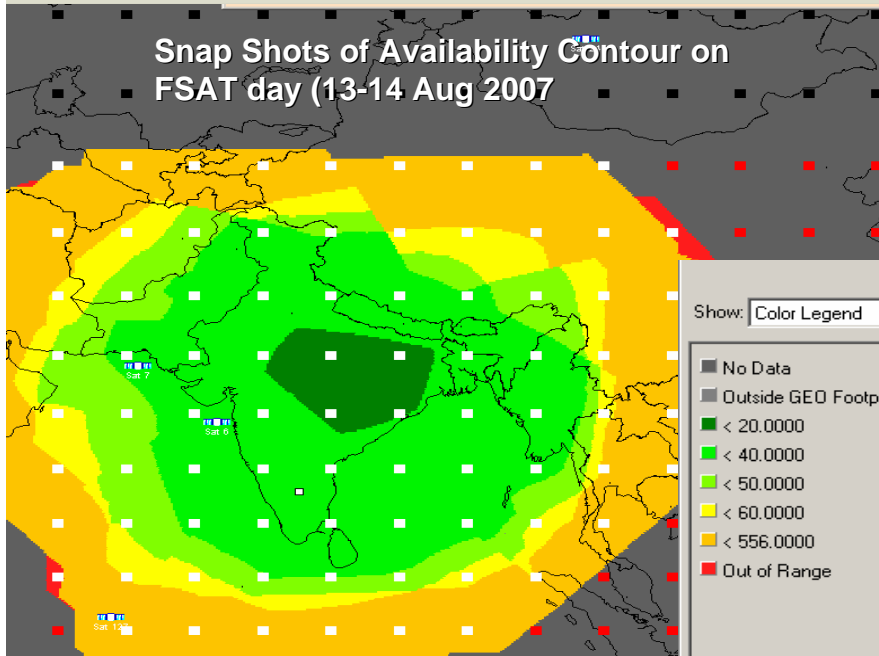
* Unaccounted for epochs were due to a fault at GTV 20:16 UTC 8/13/07

FSAT RESULTS

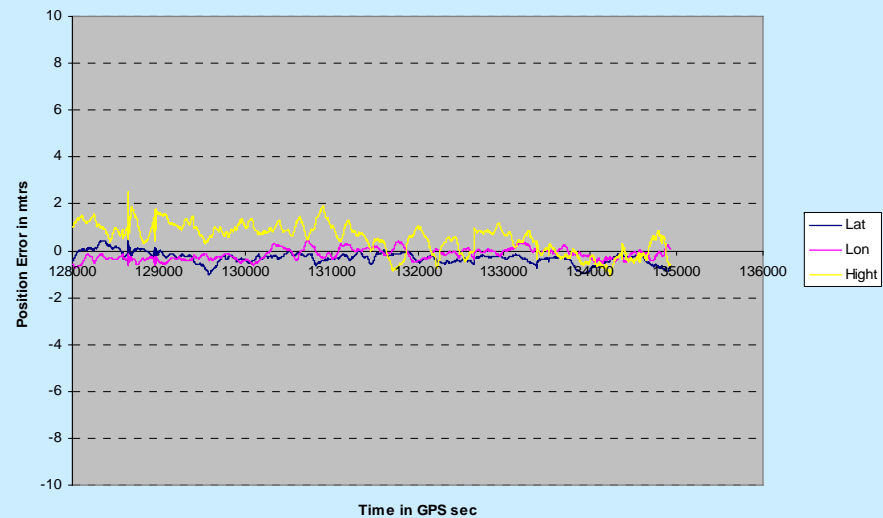
ACCURACY TIMELINE FOR BANGALORE INRES During FSAT



Snap Shots of Availability Contour on FSAT day (13-14 Aug 2007)



SBAS Rx Performance During FSAT



SIS Utilization

- **SBAS receivers on Aircraft for SBAS procedures verification & accuracy assessment**
- **Static tests outside the service area**
- **Performance evaluation with SBAS Rx at various locations**
- **Utilization of SIS for all other applications like remote sensing, mapping, marine, surveying, engineering, multi-modal navigation (requiring no SOL), Precision Agriculture, forestry etc**

GAGAN-TDS cannot be applied for SOL applications.

It provides accuracy & no integrity. The system is certified at FOP only.

INDIGENOUS EFFORTS- IONOSPHERIC STUDIES

- **ISRO has installed TEC receivers at 18 airports all over the country to understand and model the ionosphere in this region**

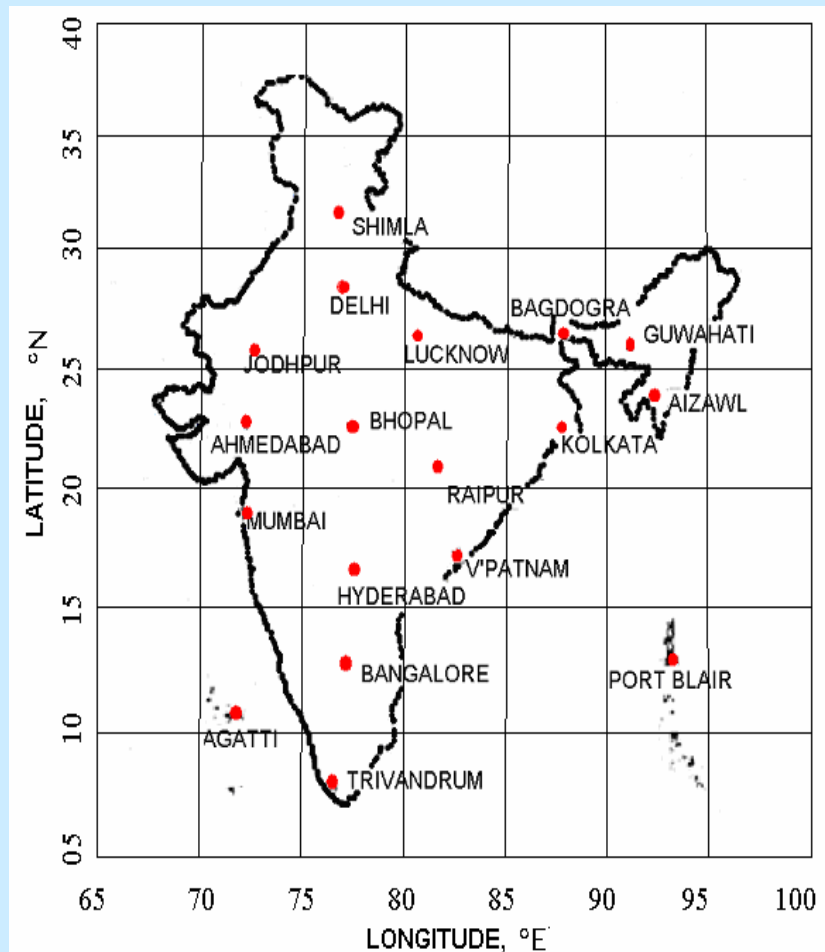
- **Following studies have been carried out with TEC data:**
 - **TEC Estimation using: Thin Shell, Multi-Shell, Tomography**
 - **Grid Based model: Planar, Kriging, Large Scale Model**
 - **Scintillation**
 - **Morphological studies on occurrence of ionospheric depletions over the Indian region**

Ionospheric Modelling Activities

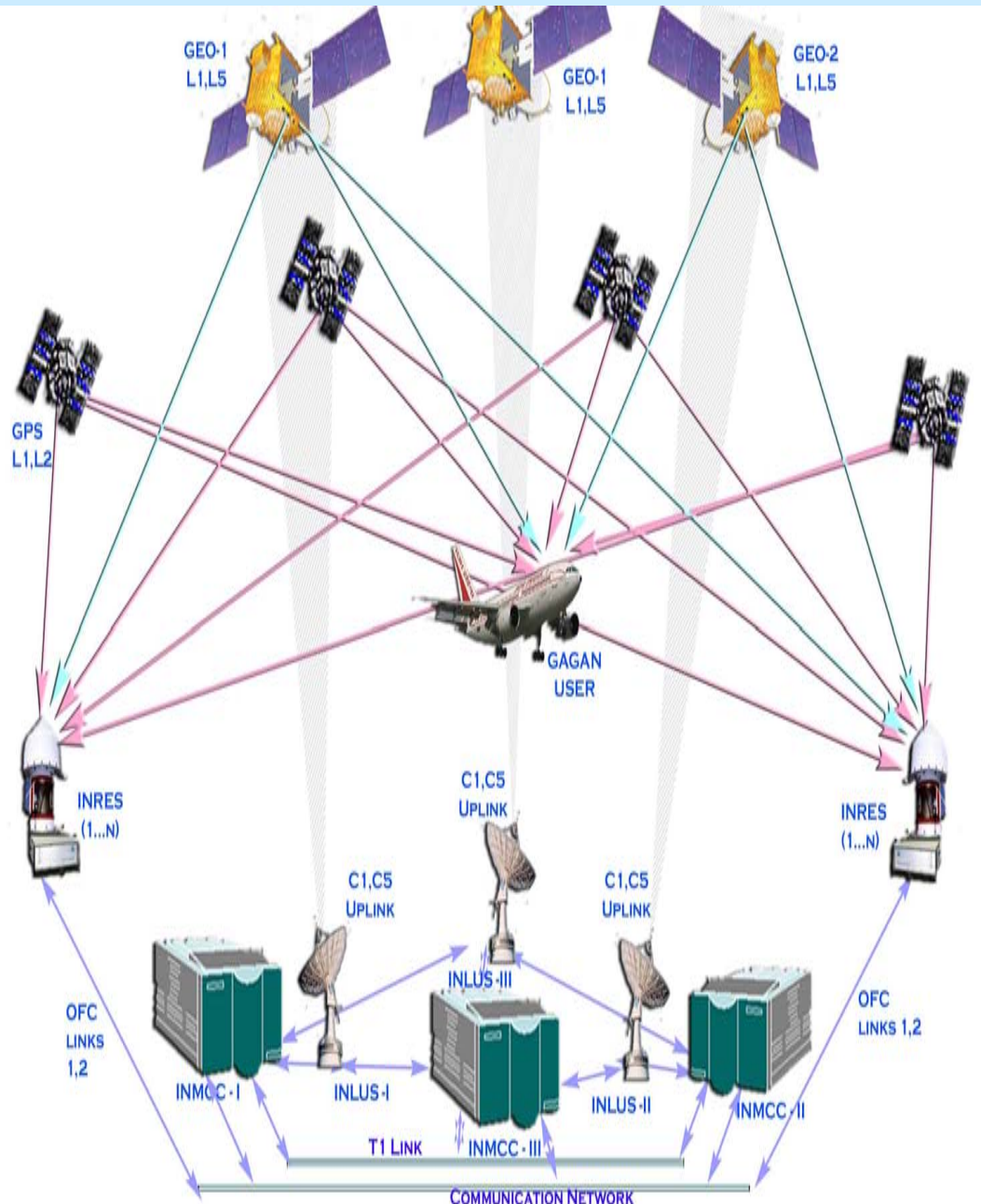
Activities include:

- Data Collection and Archival
- Model Comparison and Validation
- Testing New Algorithms

Data Collection Stations



GAGAN FOP CONFIGURATION



- Additional Indian Reference Stations (INRES): 3 chains each
- Redundant Indian Master Control Centre (INMCC)
- Additional Indian Navigation Land Uplink Station (INLUS)
- 2 Navigation Payloads on Indian GEOs + 1 on-orbit spare
- Additional Communication links

APPROACH TO FOP

- **Installation of the FOP system**
- **GNSS approach procedures**
- **Air traffic Control (ATC) Interface**
- **Certification**
- **Development of User Receiver (including depletion models)**

FOP: EXPECTED BY EARLY 2010

FUTURE SCOPE OF GAGAN

- **Interoperability with WAAS, EGNOS and MSAS**
- **To provide SBAS service beyond the Indian FIR (within GEO coverage)**
 - **Co-operation with other countries in deploying few INRES stations outside the country. Larger Coverage of SBAS SIS benefiting the South- East Asia & Asia- Pacific regions**

GNSS APPLICATIONS

■ NAVIGATION

- SPACECRAFT
- AIRCRAFT
- SHIP
- VEHICLE

■ GEOGRAPHIC DATA COLLECTION

- **MAPPING**
- SURVEYING
- ENGINEERING

■ SCIENTIFIC RESEARCH

- **ATMOSPHERIC STUDIES**

■ GEODYNAMICS

- **CRUSTAL MOVEMENTS**
- CRUSTAL DEFORMATIONS

■ MILITARY

■ NATURAL RESOURCE AND LAND MANAGEMENT

- GIS INGEST
- FOREST MENSURATION
- TOWN PLANNING
- FLEET MOVEMENT
- ROUTING/ALIGNMENT

■ AGRICULTURE

- PRECISION FARMING

■ EMERGENCY RESPONSE

- SEARCH AND RESCUE

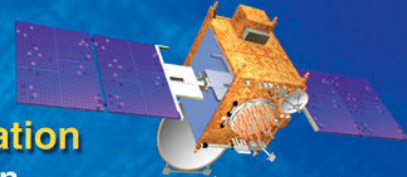
■ BUSINESS SOLUTIONS

- LOCATION BASED SERVICES
 - MOBILE
 - TOURISM
 - RETAILING

... **MANY MORE**

GAGAN

GPS Aided Geo Augmented Navigation
Indian Satellite Based Augmentation System



ARCHITECTURE



GAGAN Coverage 82°E

GEO (GSAT/INSAT)
(L1, L5)

GEO (GSAT/INSAT)
(L1, L5)

GPS

GPS

GPS

- Navigation - Air, Sea And Land Positioning Applications
- Survey
- Image Correction
- GIS
- Timing
- Surveillance/fleet Monitoring

Indian Land Optimix Station (INLOS)
Indian Master Control Centre (INMCC)

THANK YOU