GAGAN

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INTERNATIONAL COMMITTEE ON GLOBAL NAVIGATION SATELLITE SYSTEMS

4th September, 2007

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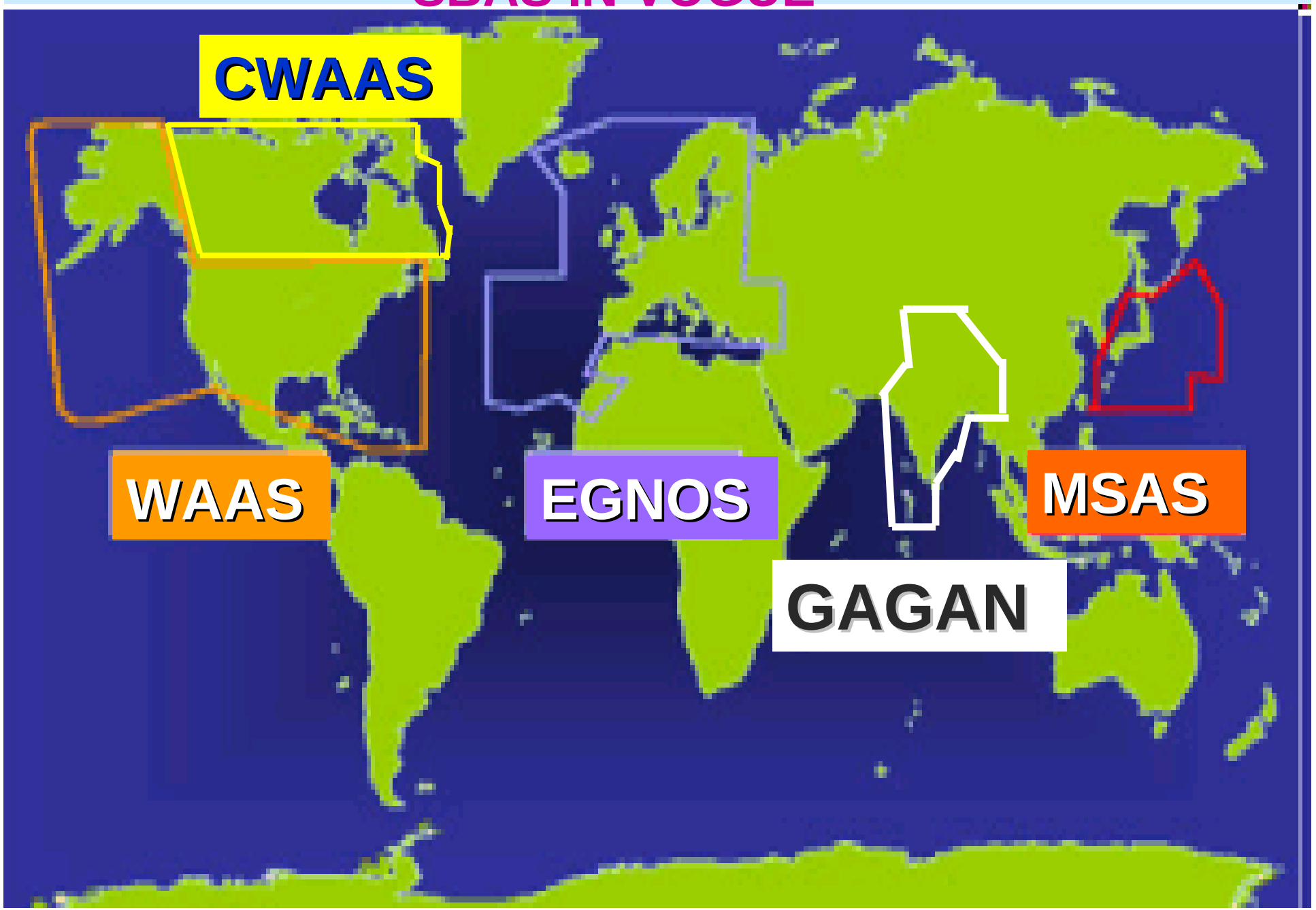
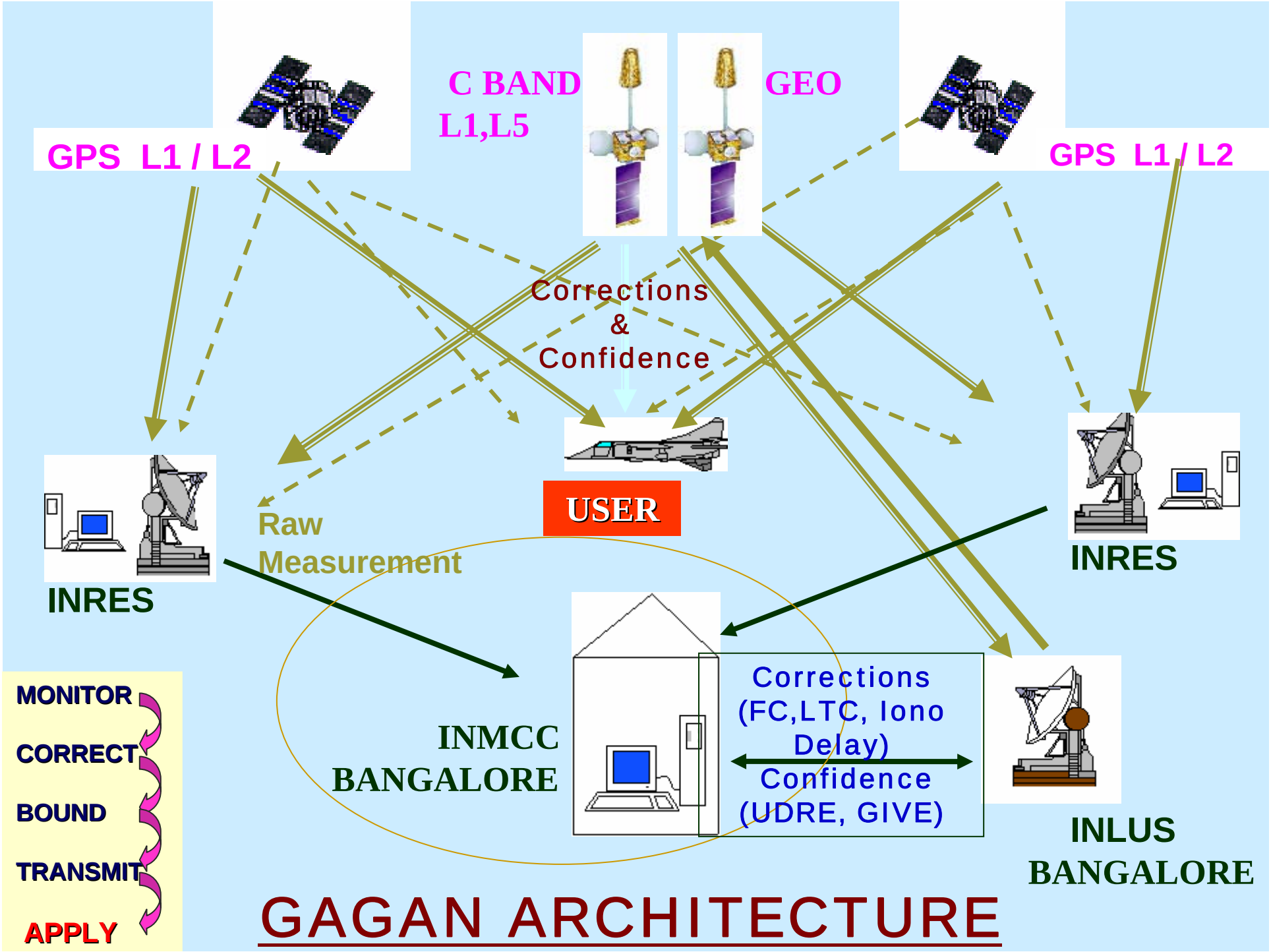
SBAS IN VOGUE

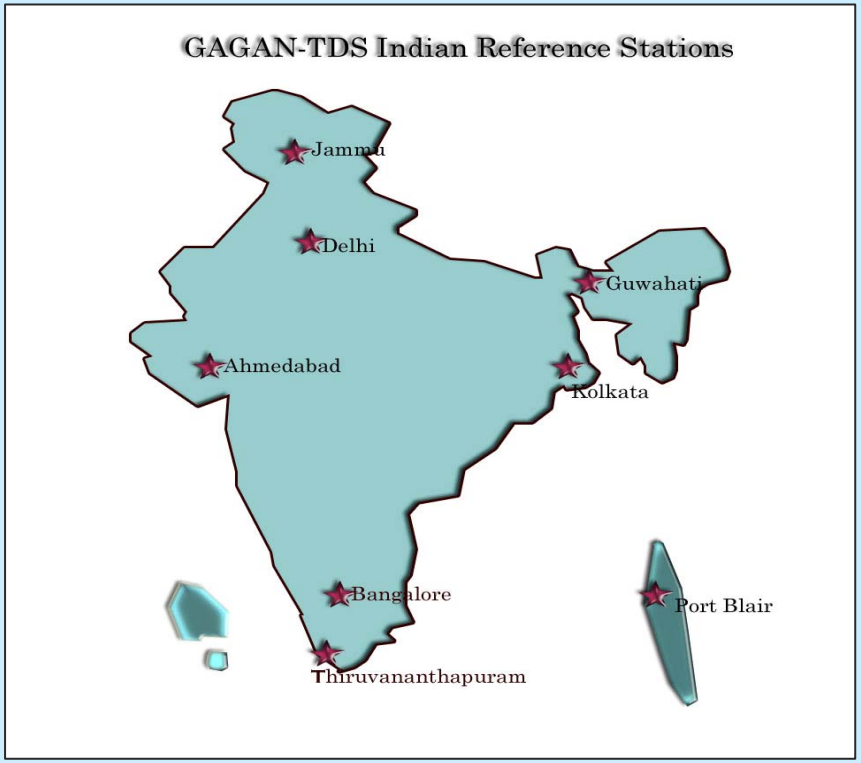


INDIAN SBAS PROGRAM

- **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)**


C BAND
L1,L5
GEO
GPS L1 / L2
GPS L1 / L2
Corrections
&
Confidence
USER
Raw
Measurement
INRES
INRES
INMCC
BANGALORE
Corrections
(FC,LTC, Iono
Delay)
Confidence
(UDRE, GIVE)
INLUS
BANGALORE
MONITOR
CORRECT
BOUND
TRANSMIT
APPLY
GAGAN ARCHITECTURE

GAGAN-TDS Components



- *1 Geostationary Satellites*
- *1Geo 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

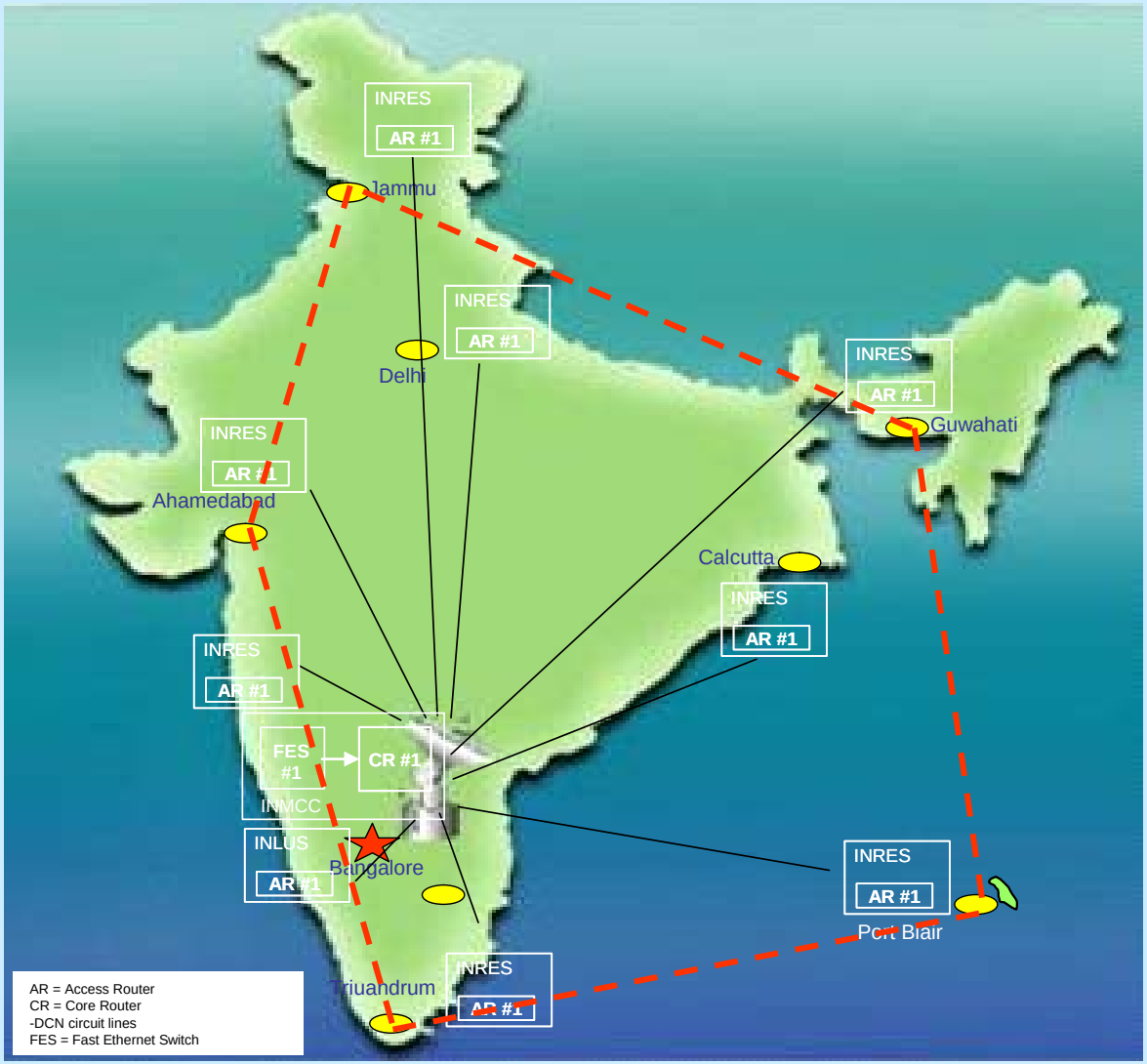
- The GAGAN TDS ground system has been integrated with the INMARSAT 4F1 Navigation Transponder

- 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

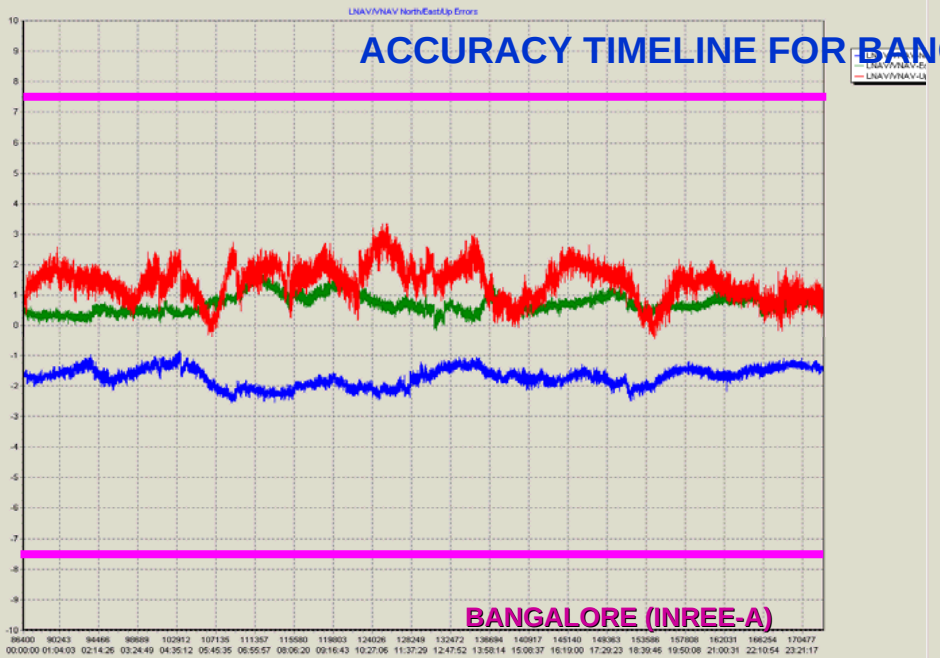
	Site		Count of Missing Epochs During 24 Hr Test Period	Count of Available Epochs During 24 Hr Test Period	% of Available Epochs During 24 Hr Test Period	Count of 7.6 m Threshold Trips During 24 Hr Test Period				% of Available Epochs Below the 7.6 m Accuracy Requirement	
						N	E	Hoiz. (N + E)	U	Hoiz. (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									

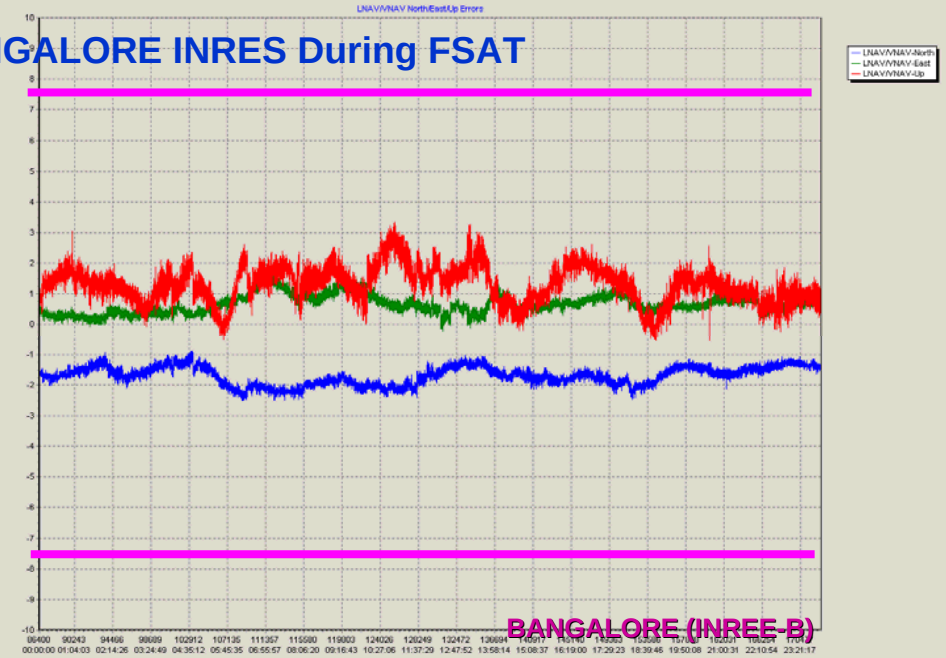
Notes

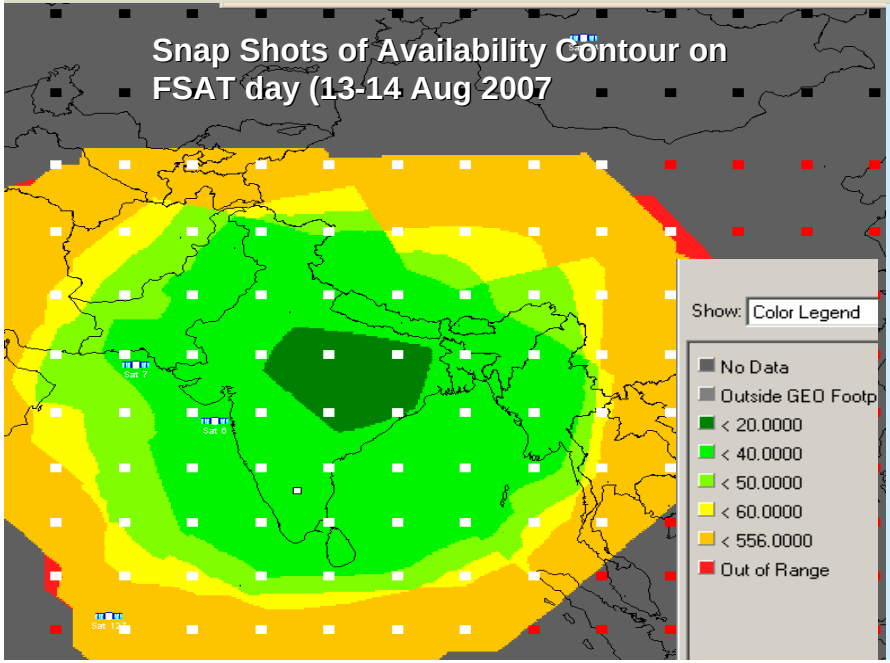
* Unaccounted for epochs were due to a fault at GTV 20:16 UTC 8/13/07

FSAT RESULTS

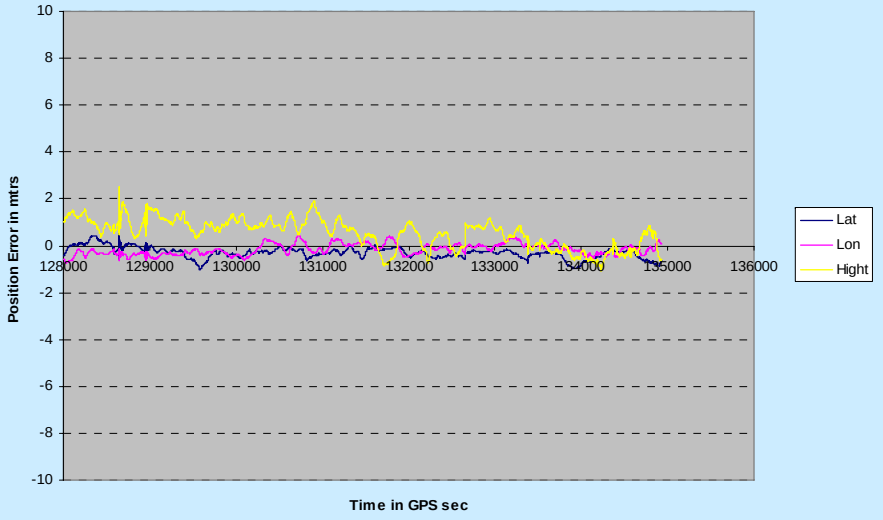
ACCURACY TIMELINE FOR BANGALORE INRES During FSAT







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**

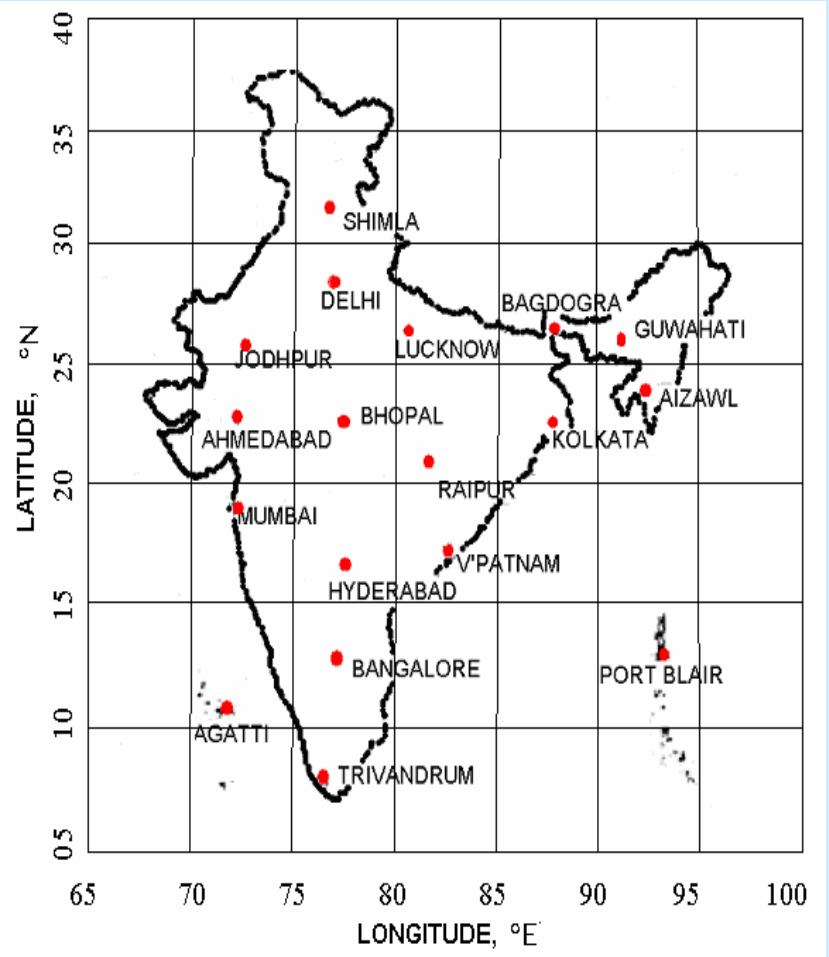
- **Following studies have been carried out with TEC data:**
  - **TEC Estimation using: Thin Shell, Multi-Shell, Tomography**
  - **Grid Based model: Planar, Kriging, Large Scale Model**
  - **Scintillation**
  - **Morphological studies on occurrence of ionospheric depletions over the Indian region**

Ionospheric Modelling Activities

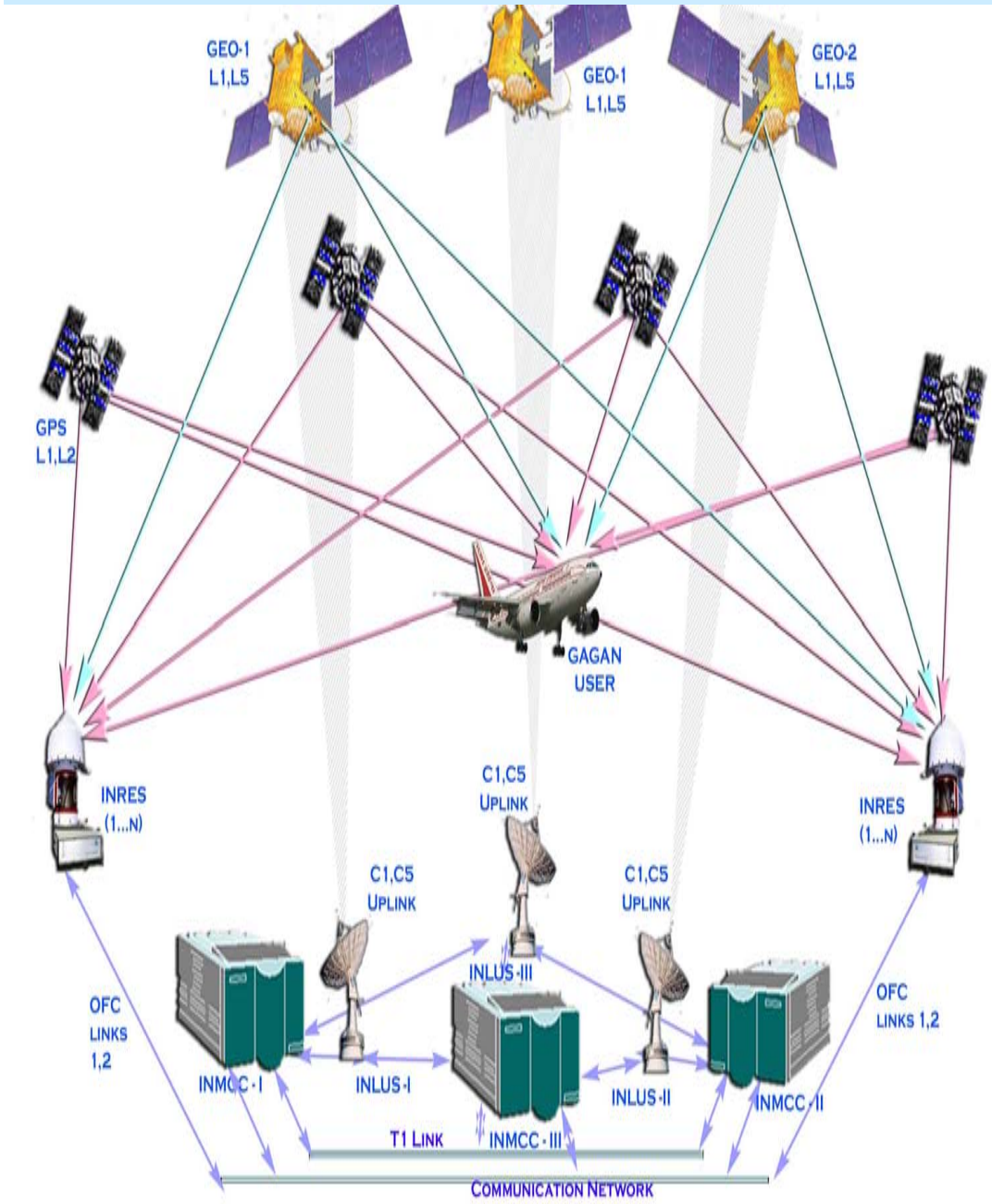
Activities include:

- 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

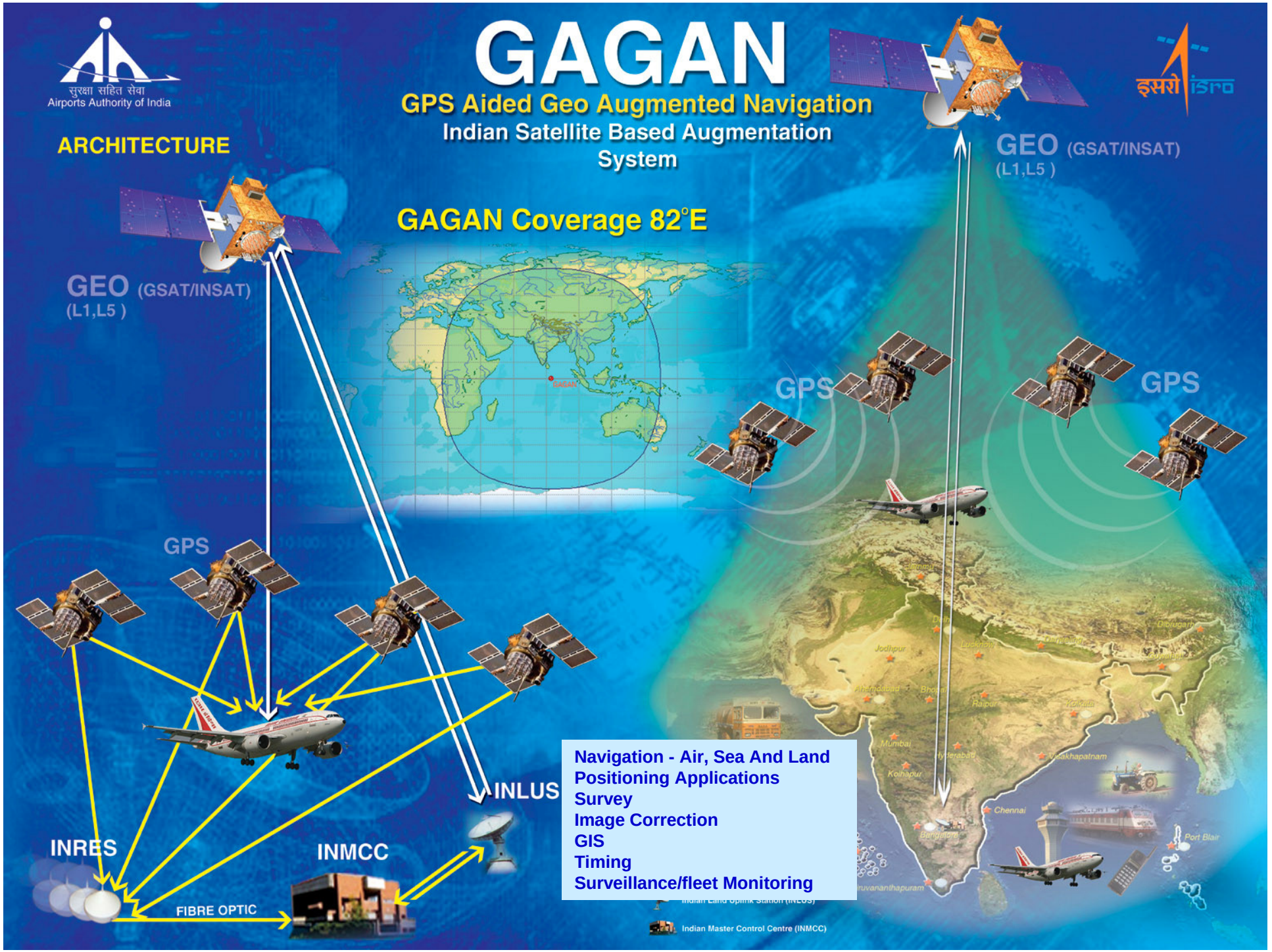
- Interoperability with WAAS, EGNOS and MSAS
- To provide SBAS service beyond the Indian FIR (within GEO coverage)
  - Co-operation with other countries in deploying few INRES stations outside the country. Larger Coverage of SBAS SIS benefiting the South- East Asia & Asia- Pacific regions

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


सुरक्षा सहित सेवा
Airports Authority of India
GAGAN
GPS Aided Geo Augmented Navigation
Indian Satellite Based Augmentation System
इसरो ISRO
ARCHITECTURE
GEO (GSAT/INSAT)
(L1,L5)
GAGAN Coverage 82°E
GAGAN
GEO (GSAT/INSAT)
(L1,L5)
GPS
GPS
GPS
INLUS
INRES
INMCC
FIBRE OPTIC
Navigation - Air, Sea And Land
Positioning Applications
Survey
Image Correction
GIS
Timing
Surveillance/fleet Monitoring
Indian Master Control Centre (INMCC)

THANK YOU