



Raytheon



GAGAN Regional Service Availability

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Background for GAGAN (GPS Aided GEO Augmented Navigation)

- Developed by Indian Space Research Organization (ISRO) and Airports Authority of India (AAI) with Raytheon as a major sub contractor
- Phase I Technology Demonstration (TDS) 2001-2007
- Phase II Final Operational Phase (FOP) 2007 - 2014
- Certified for approach with vertical guidance on 21st April 2015.
 - First SBAS in the world to be certified for Approach with Vertical Guidance (APV1) operating in the equatorial region.
 - Third SBAS to achieve APV1 service (WAAS, EGNOS and GAGAN).

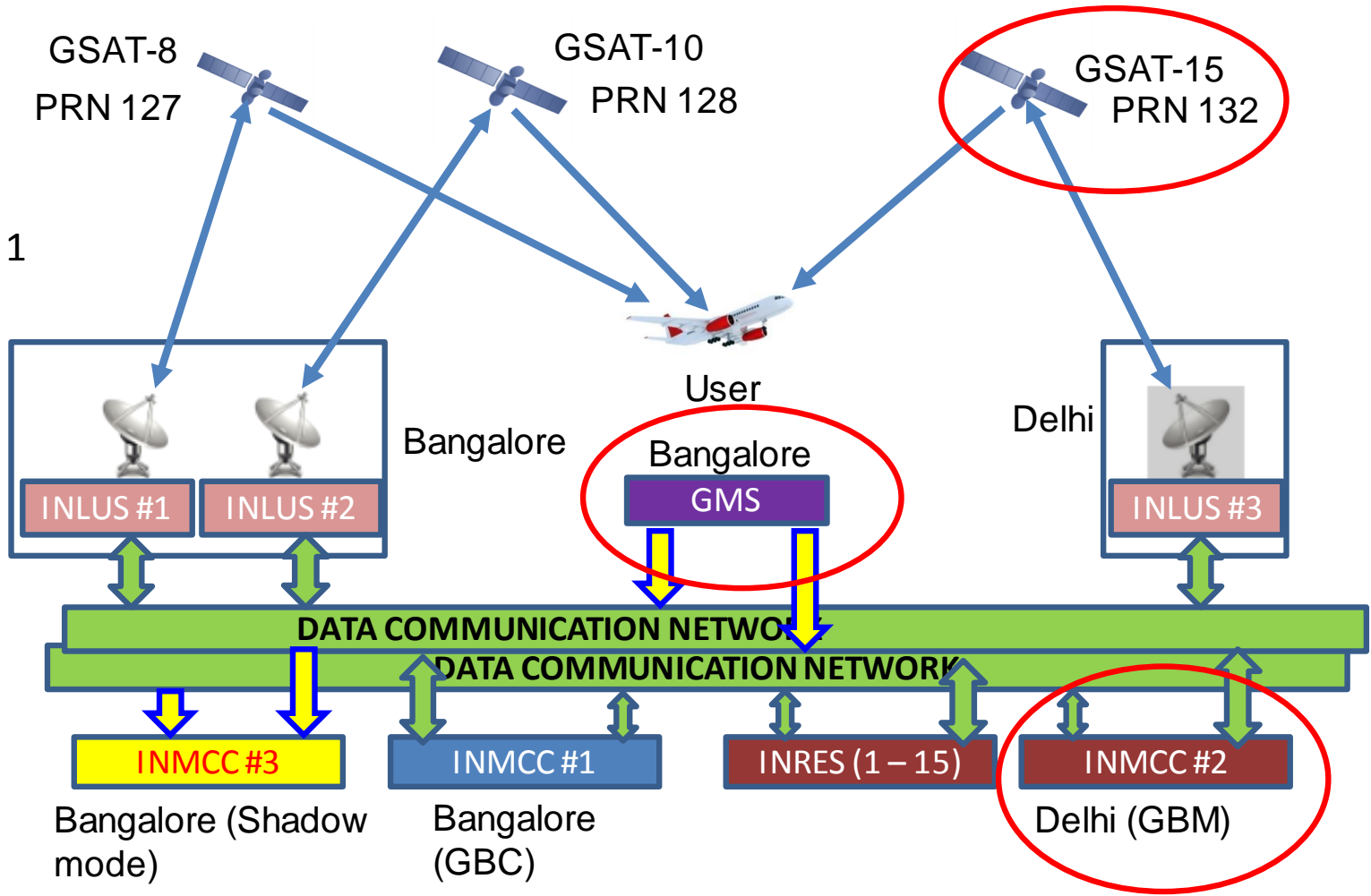


Major activities completed in last year

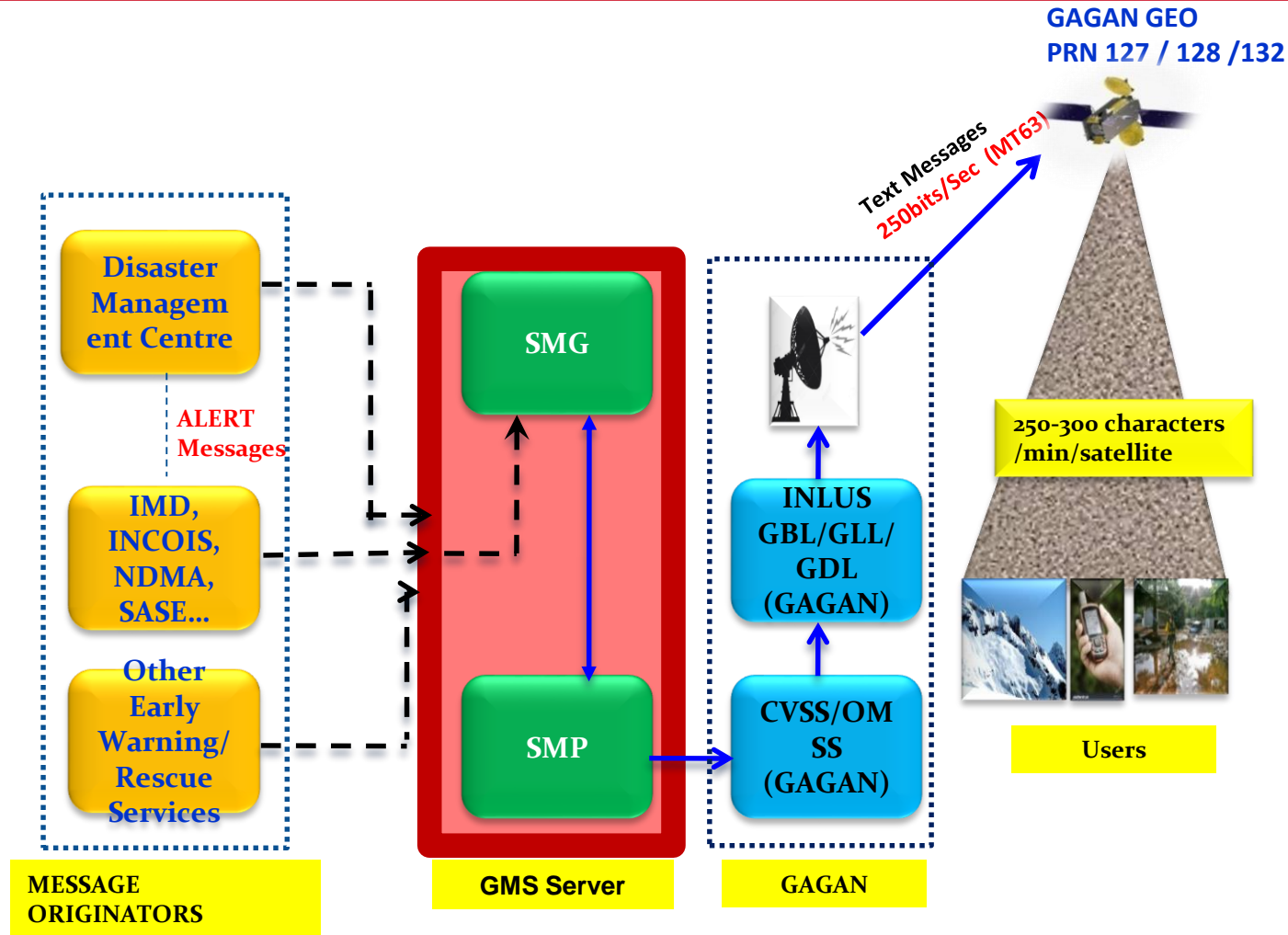
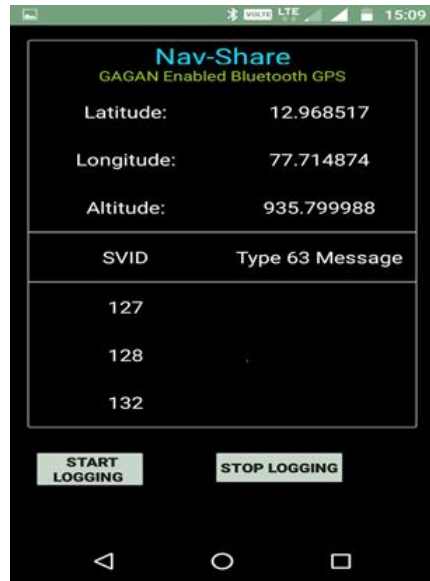
- **GSAT-15/PRN-132 Integration**
 - Increase in-orbit redundancy by adding 3rd GEO
 - Extensive testing with certified GAGAN system
 - Certification documents complete. Awaiting certification from DGCA
- **Relocation of Bangalore INMCC to Delhi**
 - Provides geographical redundancy
 - Closes Hazard record concerning a single point of failure
- **Relocation of GOA INRES**
 - GOA INRES station/site was relocated to nearby location due operational requirements
 - Antenna phase centers of all three antennae were updated
- **GAGAN Messaging Service (GMS)**
 - An external interface is provided from the OMSS to the GAGAN Message Service (GMS) Short Message Processor (SMP) via a firewall and GMS network
 - The GMS capability utilizes SBAS message type 63 (MT63) to provide alert messages to users capable of receiving GAGAN messages

System Configuration

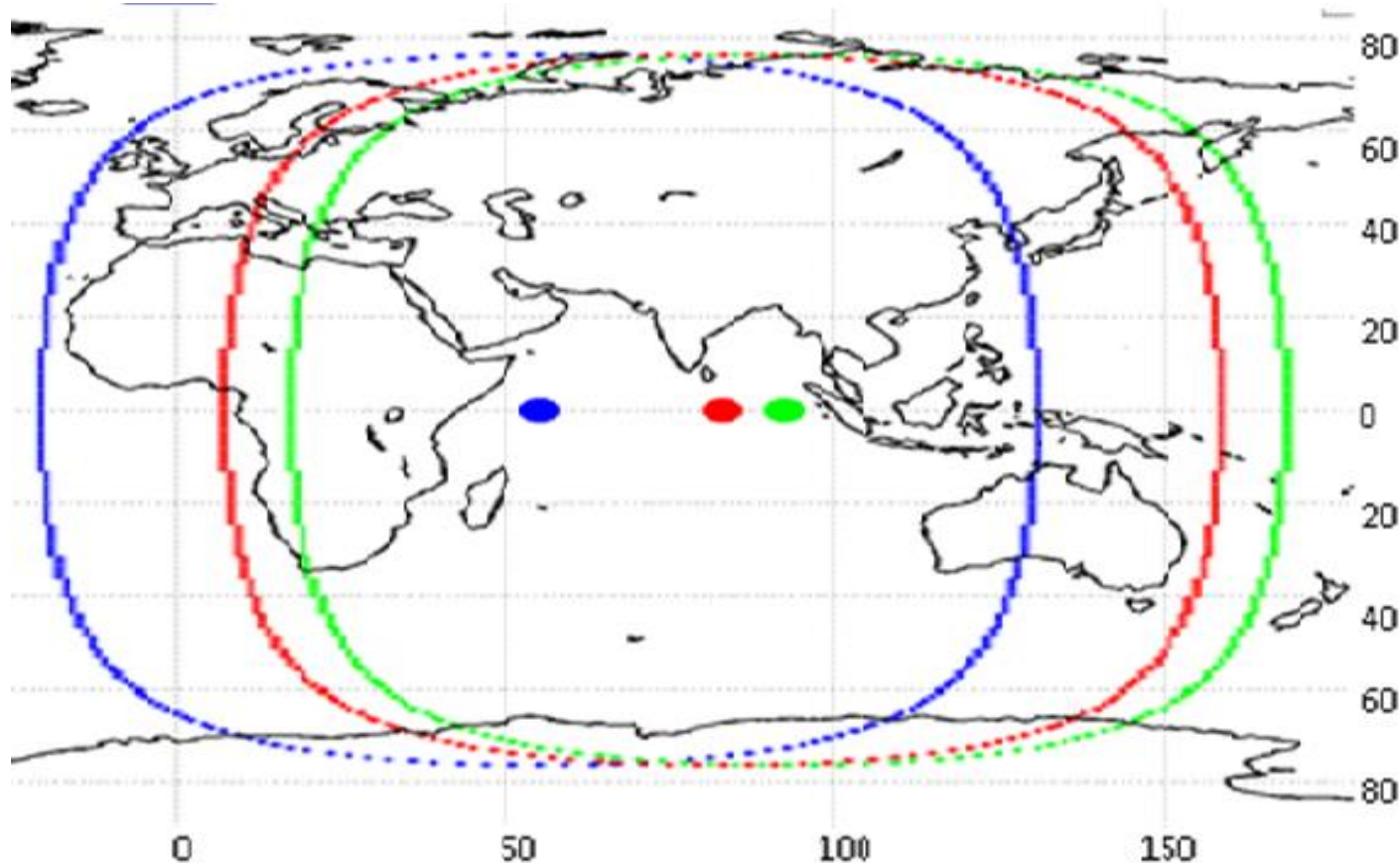
INRES: 15
Uplink: 3
GEOs:3
INMCC:2
Test Shadow: 1



Realization of GAGAN Messaging Service (GMS)



3 GEOs provide excellent coverage



GSAT 8

GSAT 10

GSAT 15

Current APV-1 Service (Availability) over Indian Land Mass

GAGAN APV I Service

7.6m Horizontal Accuracy (95%)

7.6m Vertical Accuracy (95%)

$1-10^{-7}$ Integrity (per approach)

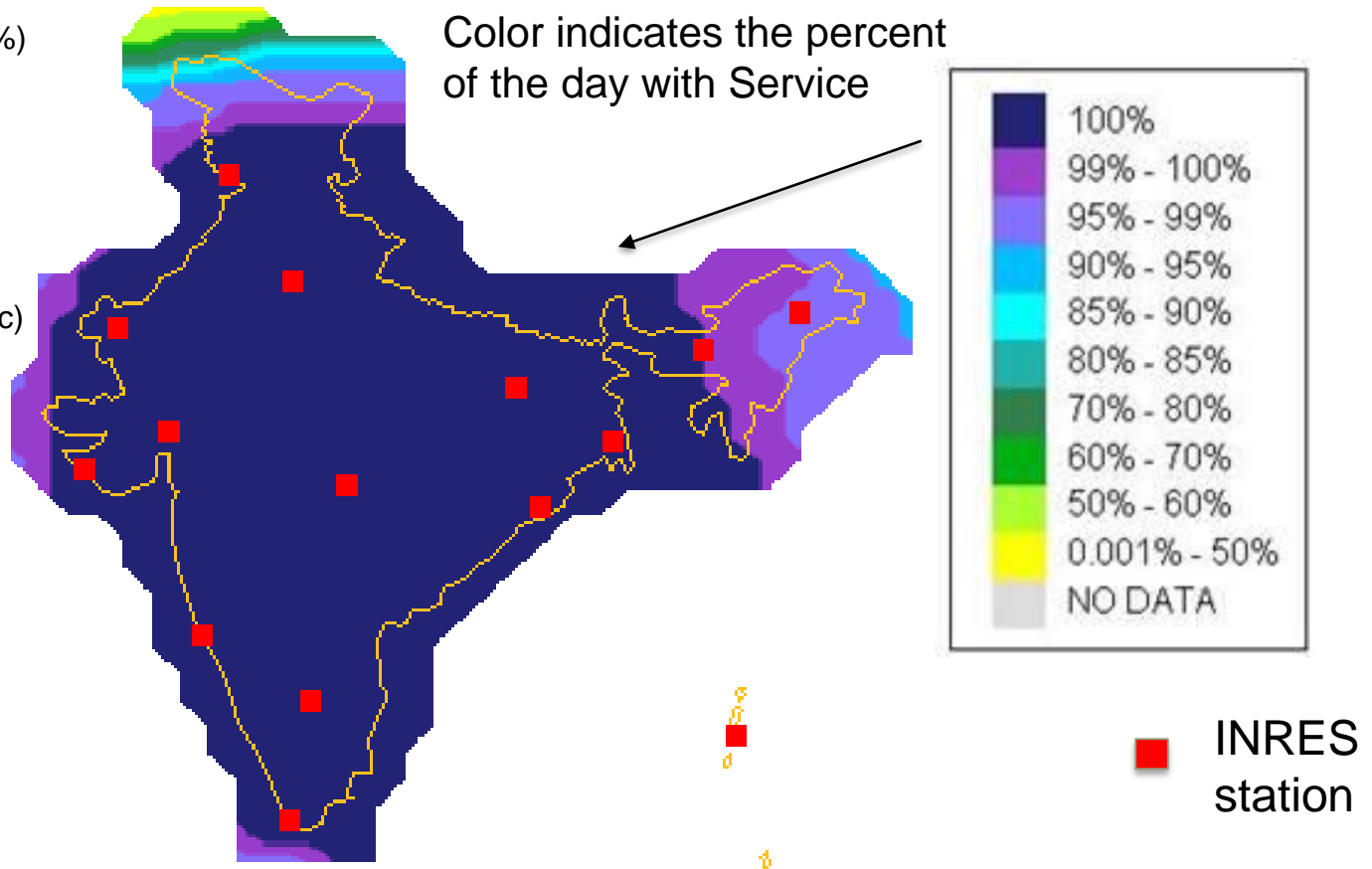
6.2s Time-to-alert

$1-8 \times 10^{-6}$ Continuity (over 15 sec)

99% Availability (greater than)

50m Vertical Alert Limit

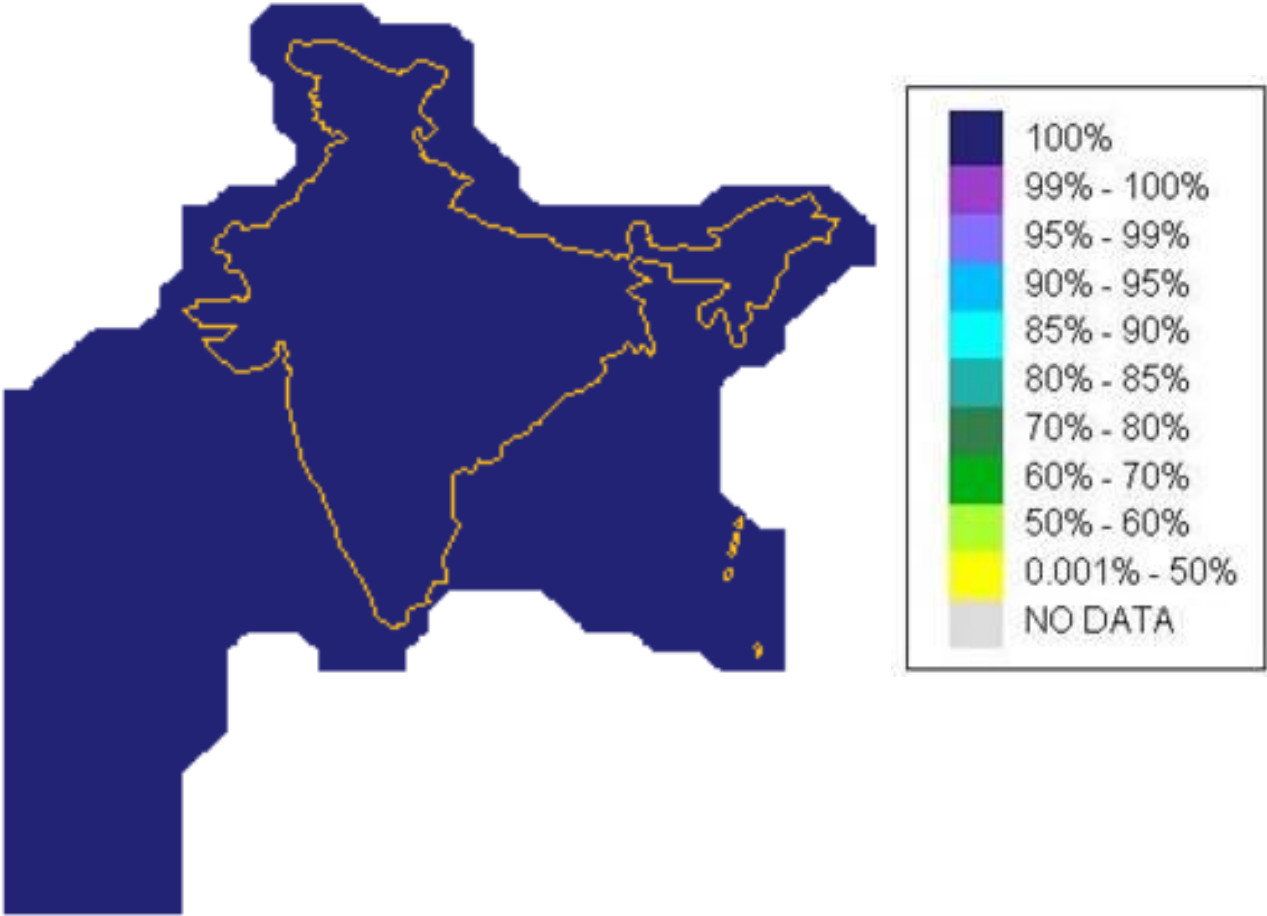
40m Horizontal Alert Limit



Current RNP 0.1 Service (Availability) over Indian FIR

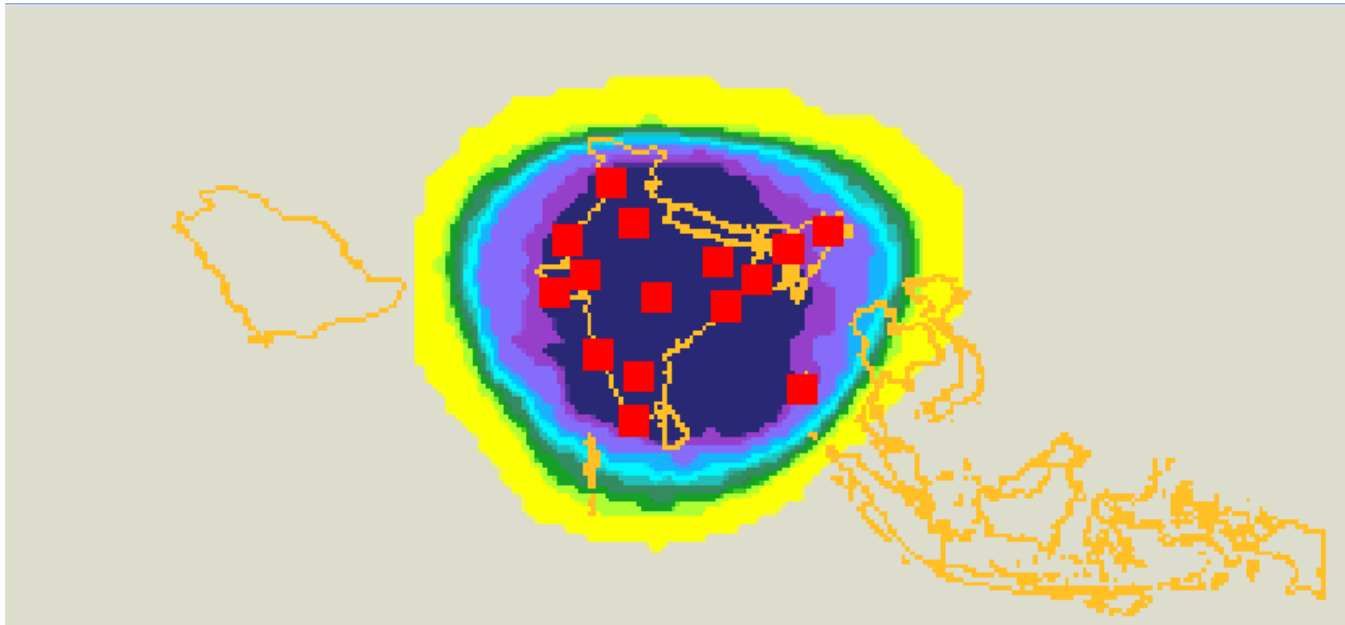
GAGAN RNP 0.1 Service

- 72m Horizontal Accuracy (95%)
- N/A Vertical Accuracy (95%)
- 1-10⁻⁷ Integrity (per approach)
- 10s Time-to-alert
- 1-10⁻⁴ Continuity (per hour)
- 99% Availability (greater than)
- N/A Vertical Alert Limit
- 185.2m Horizontal Alert Limit

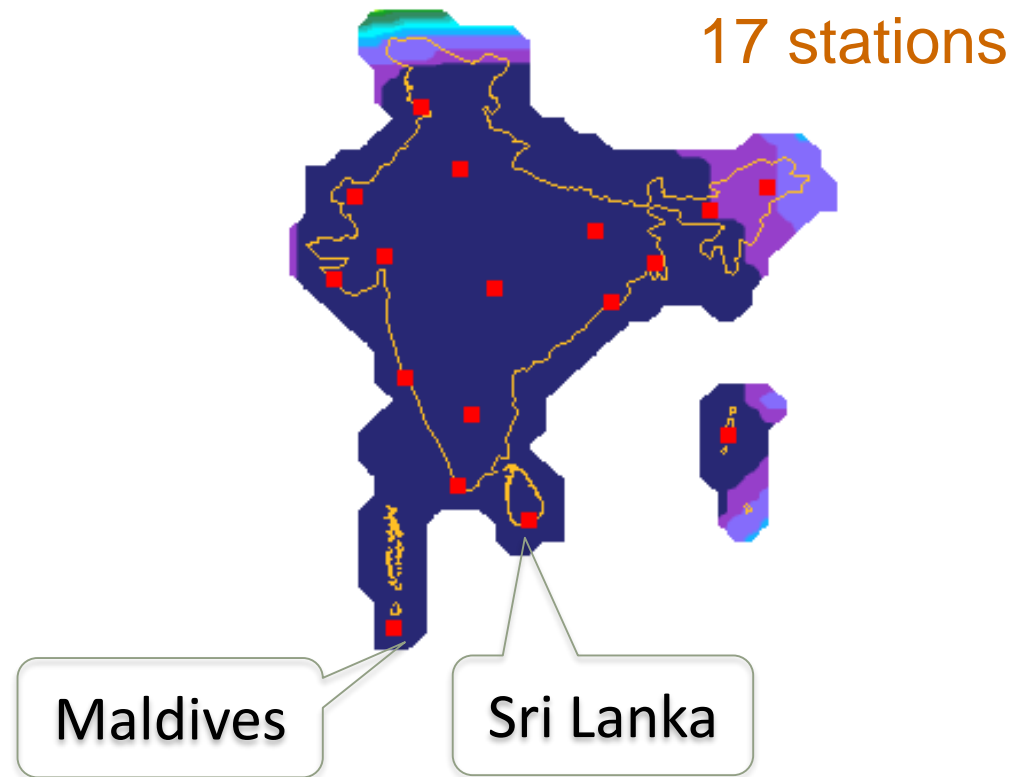


GAGAN Service/Availability today

- Current Service availability is limited for two reasons
 - Ionospheric grid points only cover Indian Region
 - Service degrades at the edge of INRES station coverage
- GAGAN can support up to 45 INRESs (only 15 used today)

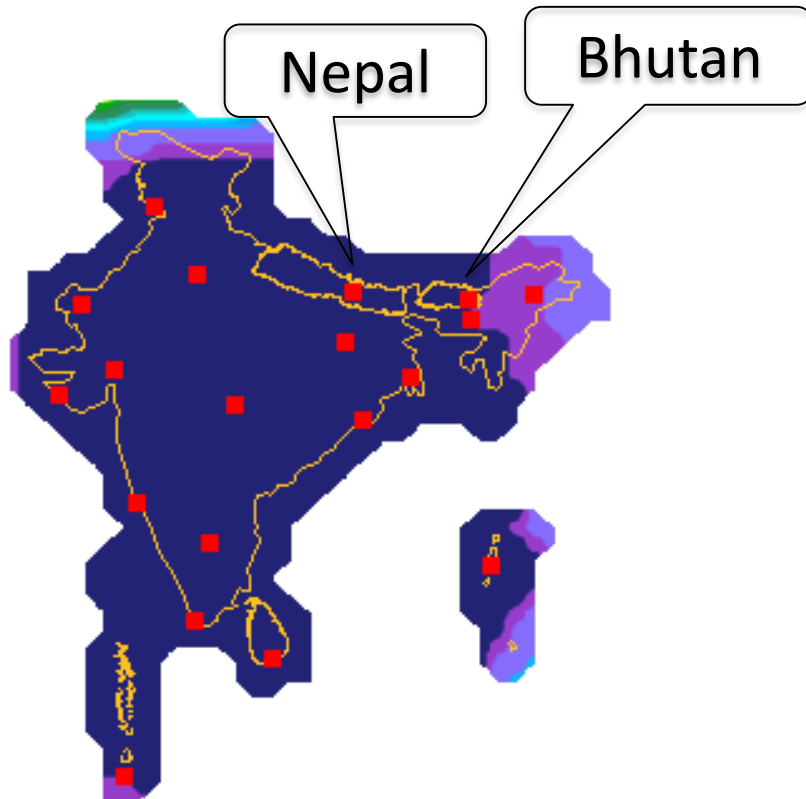


Incremental Benefits of Expansion



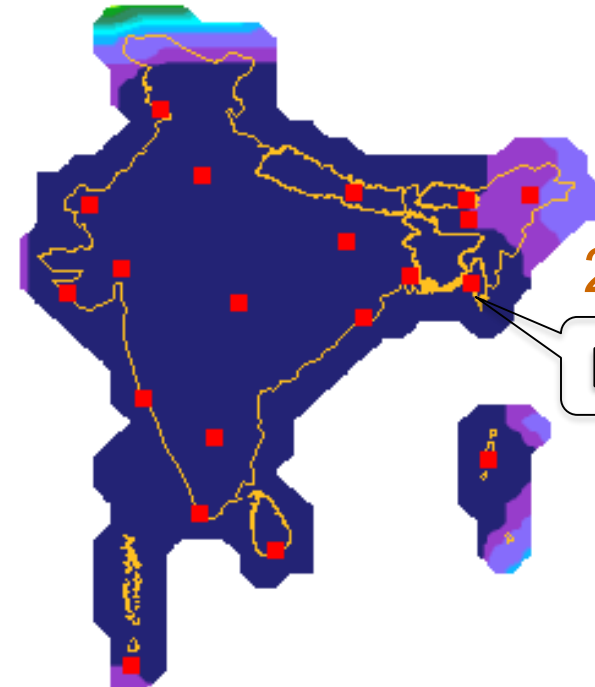
Incremental Benefits of Expansion

19 stations

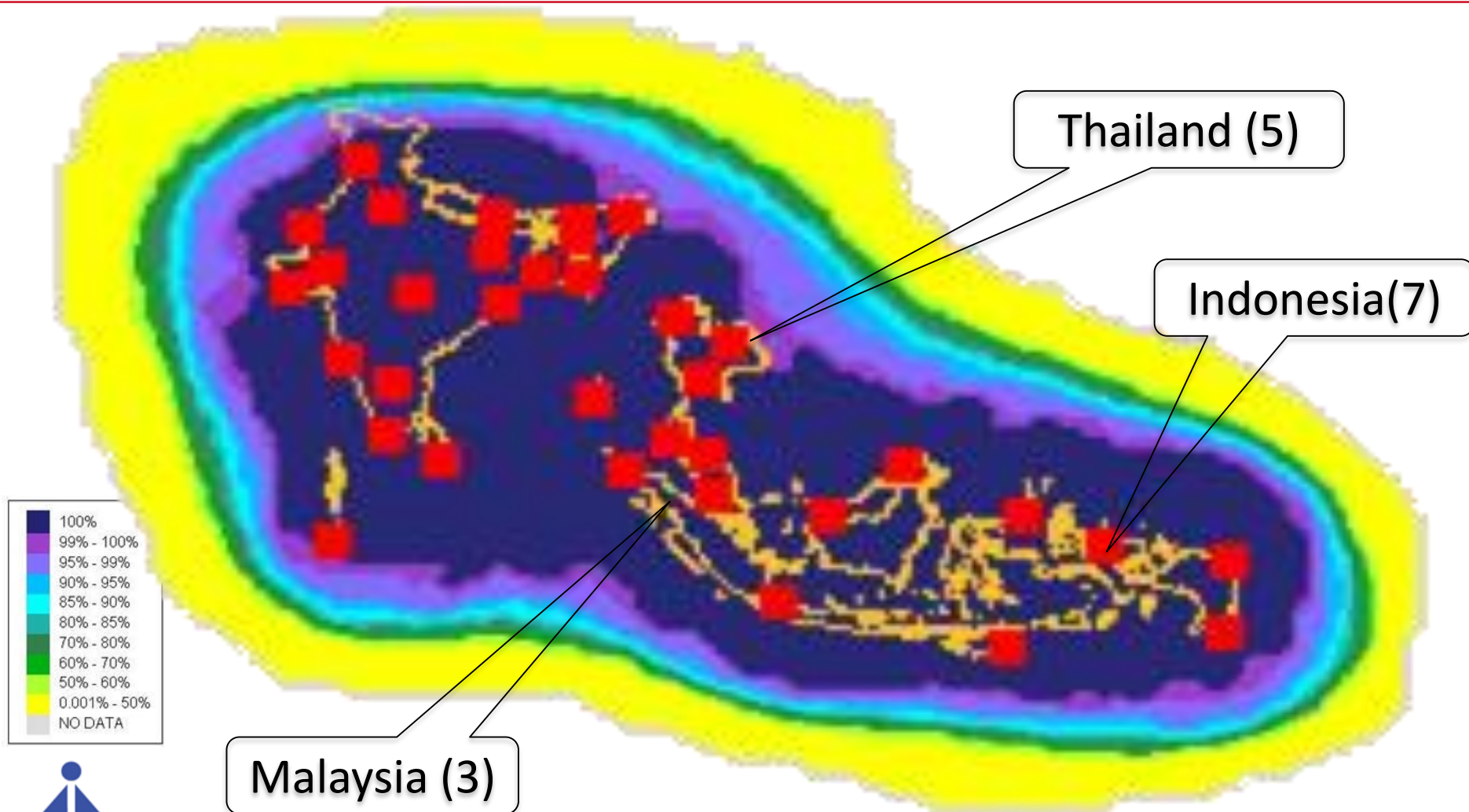


20 stations

Bangladesh

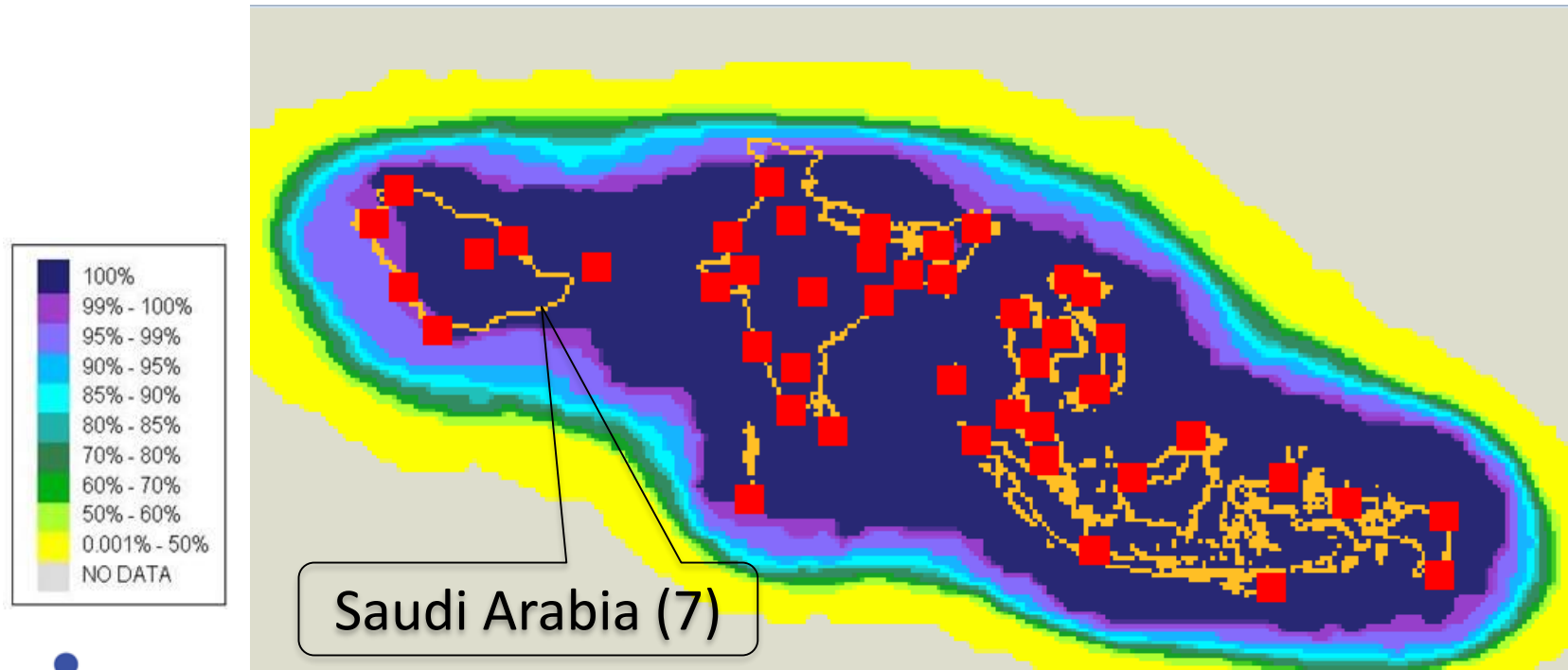


Total of 35 INRES stations



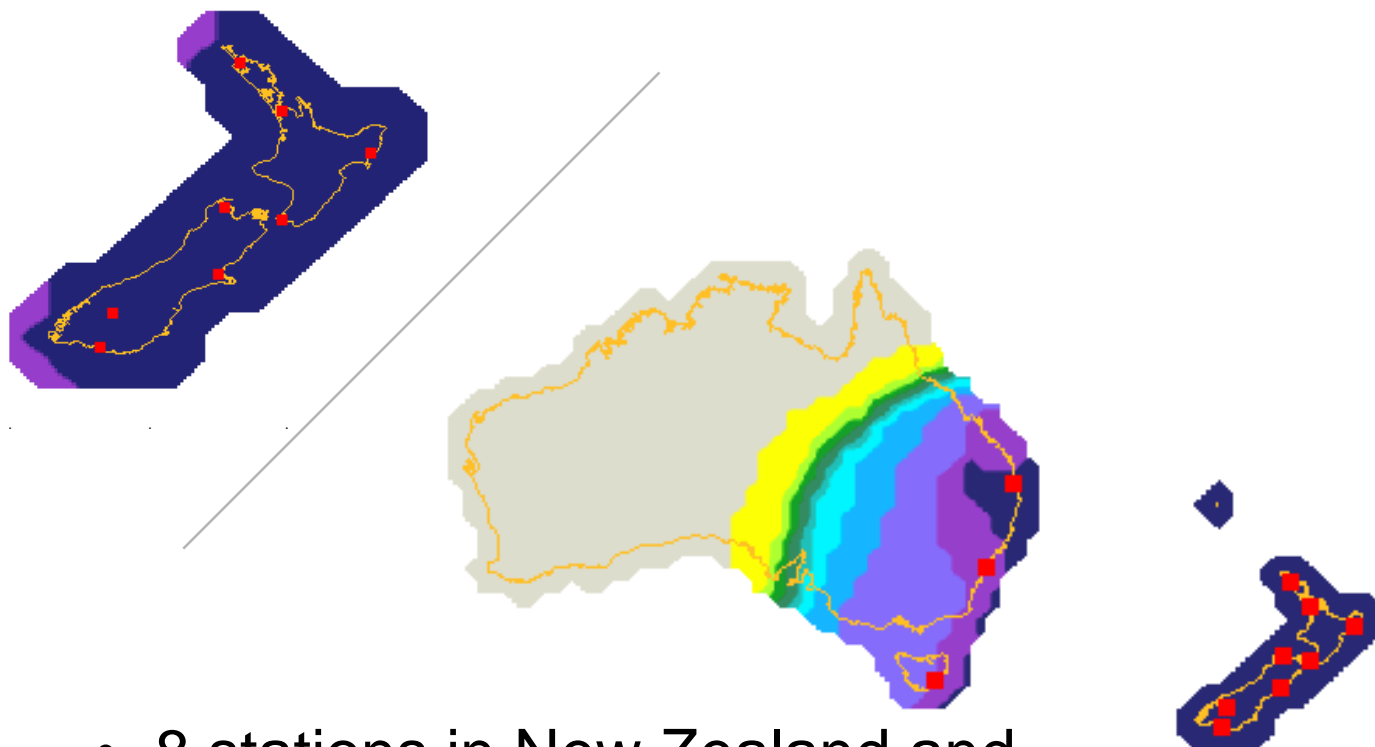
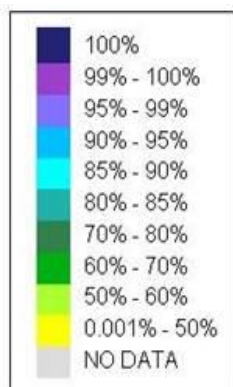
System Performance with 45 INRES

- Excellent APV 1 Service availability throughout the region
- Additional stations improve service in India and provides service to neighboring economies



System Performance for New Zealand

- 8 stations in New Zealand with GAGAN GEOs adjusted to cover the region



- 8 stations in New Zealand and 3 stations in Australia along the coast

INRES Hardware



Using GAGAN in your airspace

The approach to approving use of GAGAN may vary by country. Coordination with AAI will be required.

- Every time INRES are added to the system from a new region, analysis is carried out to show safety requirements are met in the new region.
- Exchange technical information about the GAGAN system architecture, requirements, performance and safety certification.
- Develop a Notice To Air Men (NOTAM) system to alert users of service outages based on real time monitoring of the system. AAI manages a NOTAM system for GAGAN.
- Develop approach procedures and arrange for precise airport surveys required to support the development of approach procedures.
- If hosting a reference station, sparing, trained maintenance staff and maintenance procedures must be coordinated.

Conclusion

- SBAS is an internationally accepted standard with operational systems in India, North America, Europe and Japan
- SBAS user equipment is interoperable with all 4 systems
- SBAS benefits every sector of transportation and many different industries.
 - Additional users will emerge as Industry takes advantage of GAGAN's extremely accurate and highly reliable signal combined with nationwide coverage
 - In India's civil aviation sector, GAGAN will continue to modernize the airspace, reduce flight delays, save fuel and improve flight safety
- GAGAN expansion is a low cost/expedited way for nearby countries to take advantage of all of the benefits of an SBAS such as Performance Based Navigation (PBN) and ADS-B