Content

• Background
• Major activities completed
• System Configuration
• Realization of GAGAN Messaging Service (GMS)
• Work in Progress
• Current GEO Coverage/Availability
• Improve Coverage/Availability with neighboring countries
• HW required for a new station/site
• Conclusion
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)

**Nav-Share**

GAGAN Enabled Bluetooth GPS

- **Latitude:** 12.968517
- **Longitude:** 77.714874
- **Altitude:** 935.799988

**SVID**

<table>
<thead>
<tr>
<th>Type 63 Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>127</td>
</tr>
<tr>
<td>128</td>
</tr>
<tr>
<td>132</td>
</tr>
</tbody>
</table>

**Alert Messages**

**Disaster Management Centre**

**IMD, INCOIS, NDMA, SASE**...

**Other Early Warning/Rescue Services**

**SMP**

**GMS Server**

**SMG**

**INLUS GBL/GLL/GDL (GAGAN)**

**CVSS/OM SS (GAGAN)**

**GAGAN GEO**

PRN 127 / 128 / 132

Text Messages 250bits/Sec (MT63)

250-300 characters /min/satellite

**Users**
3 GEOs provide excellent coverage
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
- 1-8x10^{-6} Continuity (over 15 sec)
- 99% Availability (greater than)
- 50m Vertical Alert Limit
- 40m Horizontal Alert Limit

Color indicates the percent of the day with Service

INRES station

INRES station
Current RNP 0.1 Service (Availability) over Indian FIR

GAGAN RNP 0.1 Service

- **Horizontal Accuracy (95%)**: 72m
- **Vertical Accuracy (95%)**: N/A
- **Integrity (per approach)**: $1 \times 10^{-7}$
- **Time-to-alert**: 10s
- **Continuity (per hour)**: $1 \times 10^{-4}$
- **Availability (greater than)**: 99%
- **Vertical Alert Limit**: N/A
- **Horizontal Alert Limit**: 185.2m

![Map of India indicating GAGAN RNP 0.1 Service coverage](image)
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

India only
15 stations

Maldives

17 stations

Sri Lanka
Incremental Benefits of Expansion

19 stations
- Nepal
- Bhutan

20 stations
- Bangladesh
Total of 35 INRES stations

- Thailand (5)
- Indonesia (7)
- Malaysia (3)
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

Saudi Arabia (7)
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