INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO)

GNSS WORKSHOP
(26 MARCH 2012, BANGKOK)

WORKING PAPER

GAGAN CURRENT STATUS-AND VALIDATION PROCESS

Executive Summary

India's GAGAN program is progressing as per set milestones and with the integration of space segment (GSAT8-launched on May 20th, 2011) with the ground elements has provided GAGAN signal in space. Data collection and validation process has begun to demonstrate the GAGAN performance criteria as per Annex 10 standards.

This paper provides the steps taken by India to accomplish the objectives and discusses the way validation process is proposed to be taken up for GAGAN.

1. INTRODUCTION

1.1 The first Workshop on Ionospheric Data Collection, Analysis and Sharing held at ICAO Regional Office, Bangkok, Thailand from 5 to 6 May 2011 recognized and discussed the need to characterize the ionosphere over Asia and Pacific region for implementation of GNSS. India had shared the information and experience gained on ionospheric studies for GAGAN.

1.2 India participated and presented a paper in the recently concluded Ionospheric Study Task Force meeting held at Tokyo on IONO analysis carried out in general and specifically in respect of IGM-MLDF algorithm for GAGAN.

1.3 India is working towards attaining APV1.0 capability over the entire land mass. As the footprint of the GAGAN space segment covers large portion of the Asia-Pacific region i.e., the whole of Indian region and neighboring countries such as Srilanka, Pakistan, Afghanistan, Bhutan, Nepal and Bangladesh, all can derive benefit of the Indian experience to provide SBAS services by states appropriately augmenting ground segments.

2. GAGAN Implementation Progress:

2.1 Ground Segments have been installed, tested and integrated with GEO satellite GSAT-8. GSAT-10 is planned to be launched by 1st half of 2012 carrying 2nd payload for GAGAN.

2.2 **Final System Acceptance Test (FSAT)** of the GAGAN system is planned to be conducted in 2012 including GSAT-8 and GSAT-10.

2.3 GAGAN certification process is progressing with technical assistance from MITRE Corporation USA who has been associated with similar processes for MSAS and WAAS.

2.4 A technical review team formed by DGCA India, is studying the integrity threats with GAGAN.

3. GAGAN Service Characteristics – Nominal Days

3.1 A comprehensive study was carried out by collecting 21 days clean GAGAN data and analyzed using various ionospheric models to arrive at technical consensus for fine tuning the IGM-MLDF algorithm. The results have been encouraging as demonstrated through empirical formulations.

3.2 The following table provides expected levels of GAGAN APV 1.0 service over Indian landmass.

GAGAN APV 1/1-5 Service Characteristics	**Annex 10 volume 1: SARPS for APV-I service**
• 7.6m Horizontal Accuracy (95%) • 7.6m Vertical Accuracy (95%) • 1-10^{-7} Integrity (per approach) • 6.2s Time-to-alert • 1-8×10^{-6} Continuity (over any 15 seconds) • 99% Availability (greater than) • 50m Vertical Alert Limit • 40m Horizontal Alert Limit	• 16.0m Horizontal Accuracy (95%) • 20.0m Vertical Accuracy (95%) • 1-2×10^{-7} Integrity (per approach) • 10s Time-to-alert • 1-8×10^{-6} Continuity (over any 15 seconds) • 99% Availability (greater than) • 50m Vertical Alert Limit • 40m Horizontal Alert Limit

4. GAGAN certification process

4.1 GAGAN certification process involves system, facility, service approvals.

- System approval process will be carried out through a joint acceptance team of experts who will verify the laid down requirements.
- Facility approvals will involve development of Operations test and evaluation tools, offline monitoring tools and testing the performance parameters against standards.
- Service approvals will involve development and testing of procedures, through ground and flight validation process.

4.2 Overall philosophy of certification is that the approach and algorithms are assumed to be incorrect until proven valid. Algorithmic differences in GAGAN from WAAS require a re-evaluation of the key assertions and a modification of the proofs.

4.3 India will apply the same safety assurance process for GAGAN that was used for WAAS. Review and approval process for GAGAN will focus on differences between GAGAN and WAAS. WAAS artefacts (documents, analyses, ..) that are unchanged for GAGAN will be approved by virtue of FAA's approval of the WAAS artefact.

4.6 The GAGAN Safety Analysis will show that the integrity algorithms mitigate all relevant integrity threats – and provide the required level of signal-in-space integrity performance.

4.7 The Fault Trees will be adapted to the GAGAN configuration, environment, and unique systems. They will provide the probability allocations that the integrity algorithms must meet. The Delta HMI Analysis will provide the analyses showing that the integrity monitors meet those allocations.

4.8 TRT will review GAGAN Hazard Records (HRs) pertaining to integrity and loss of function.

4.9 **Flight validation for SBAS-GNSS procedure**

4.9.1 At present there are no specific ICAO guidelines or other requirements for flight evaluation of SBAS system. However, with technical assistance from MITRE India is developing the flight evaluation plan in line with the procedures followed by FAA for WAAS and JCAB for MSAS.

4.9.2 The evaluation process would include both for en-route as well as terminal phase (approach) phases of flight. Initially procedures shall be designed at a few selected airports.

4.9.3 The performance results obtained from the analysis of data collected during flights will be verified with those obtained during Operation testing and evaluation static testing.

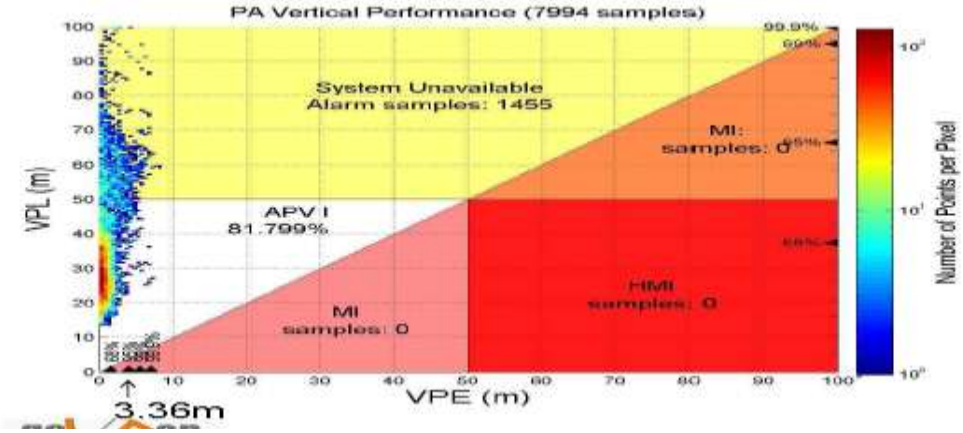
4.9.4 Specially equipped aircraft with SBAS receivers along with other systems for data recording will be used for the purpose.

4.9.5 Based on the analysis of the results obtained by flight evaluation, it will be determined whether GAGAN system will be applicable for LPV or LNAV/VNAV or LNAV only procedures.

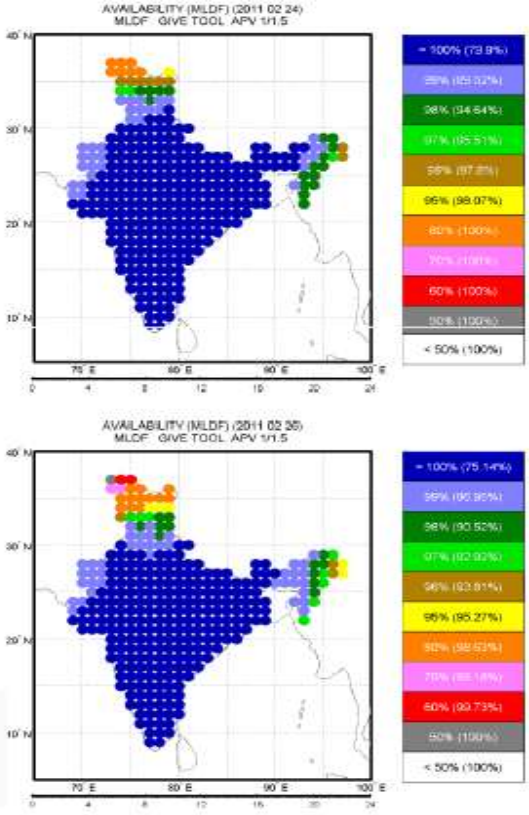
5.0 **Test results demonstrated during technical Consensus:**

- **Accuracy:**

95% accuracy is read off of a Stanford chart. The Stanford chart contains measurements from all of the 15 INRES stations. Of the 35 day analysed, March 12 (pictured), a day with ionospheric disturbances, had the worst accuracy. None of the cases came near causing HMI.



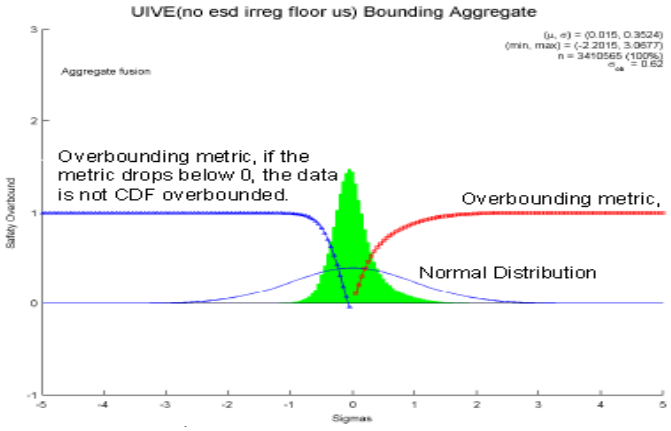
- **Availability:**



APV-I service is available when the VPL<50m and the HPL<40m. The 99% availability contour indicates the percent of the Indian Land mass which achieves 99% availability over the day.

- **Integrity:**

UIVE bounding (UB) shows that the GIVE is sufficiently large to meet the integrity requirements



- **Continuity:**

GAGAN is said to have a loss of continuity at a specific location if there is a loss of APV-I service and APV-I service was predicted to be available. Loss of availability due to solar storms does not count against the availability and continuity requirements. Solar storms are defined to be present when the GAGAN storm detector trips.The probability of a loss of continuity shall be less than 8 X 10 -5 per approach (8 X 10 -6 per 15 seconds. Continuity analysis was performed on 30 days of data.

5. Conclusion:

India is continuing its efforts in providing the SBAS services capable of APV1 approaches. The certification process will be completed by Mid-2013.

6. **Action by the meeting**:

The meeting is invited to note for comments and suggest any modification in proposed validation processes for GAGAN certification.