



*INTERNATIONAL CIVIL AVIATION ORGANIZATION*

**TWENTY-SECOND MEETING OF THE  
ASIA/PACIFIC AIR NAVIGATION PLANNING AND  
IMPLEMENTATION REGIONAL GROUP (APANPIRG/22)**

**Bangkok, Thailand, 5-9 September 2011**

**Agenda Item 3: Performance Framework for Regional Air Navigation Planning  
and Implementation**

**3.4 CNS/ MET**

**REGIONAL SBAS SERVICES THROUGH GAGAN**

(Presented by India)

**SUMMARY**

GPS Aided Geo Augmentation Navigation (GAGAN) – the Indian Satellite Based Navigation System (SBAS) programme with its unique ISRO-MLDF IONOSPHERIC ALGORITHM to meet the challenges posed by Indian sub continent and other Equatorial Ionospheric Anomaly regions is progressing as per the milestones set out and is well on its way to provide a cost effective regional SBAS solution to all States within the footprint of its GAGAN GEOs.

GAGAN is India's efforts to provide regional specific SBAS meeting Annex 10 standards. India invites States in the Asia Pacific region to encourage the use of GAGAN signal-in-space by adding minimal ground stations in their area, of jurisdiction wherever required to derive benefits and meet the ICAO GNSS transition plans of seamless navigation.

**1. INTRODUCTION**

1.1. APANPIRG-20 recognized the need for characterization of ionosphere throughout Asia and Pacific Region and agreed to develop a cooperative effort in developing a standard Ionospheric model for the region to facilitate implementation of GNSS. India submitted the information paper on implementation of Space Based Augmentation system GAGAN for APV 1/1.5 service.

1.2. In May 2011, ICAO Bangkok Office organised Workshop on Ionospheric Data Collection, Analysis and Sharing to Support GNSS Implementation wherein India submitted the IONO work carried out for GAGAN implementation.

1.3. In continuation with the development progress on GPS Aided Geo Augmentation Navigation (GAGAN) – the Indian Satellite Based Augmentation System (SBAS) programme with its unique **ISRO-MLDF IONOSPHERIC ALGORITHM** to meet the challenges posed in Indian sub

continent and other Equatorial Ionospheric Anomaly regions, India proposes to **invite APANPIRG States to make use of GAGAN signal-in-space** for achieving regional harmonization and seamless navigation services in South East Asia.

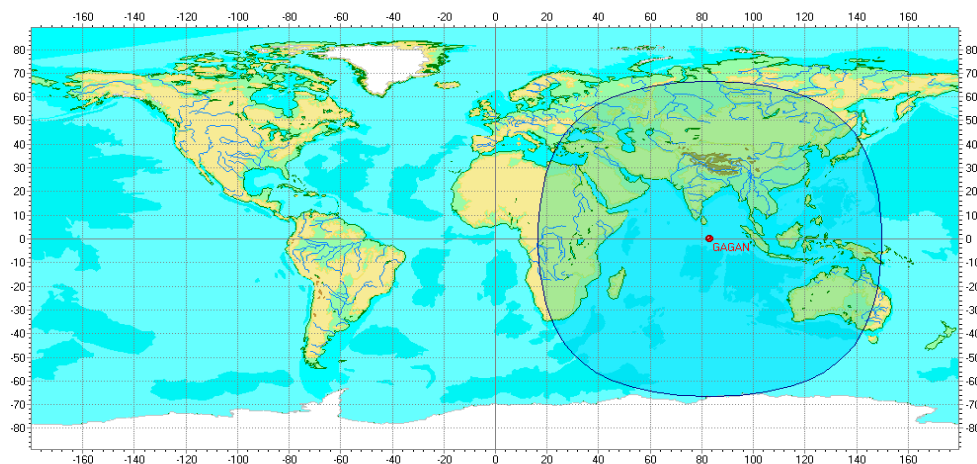
1.4. GAGAN is progressing as per the milestones set out and is well on its way to provide a cost effective regional SBAS solution to all states within the footprint of its GAGAN GEOs.

1.5. GAGAN assures RNP 0.1 service in the Indian flight information region and India is working towards attaining certified APV1 capability over the entire Indian land mass by June 2013.

1.6. GAGAN systems are being validated, both, with historical data (including data for previous solar activity) collected through a network of 26 Total Electron Content (TEC) stations from 2004, International GPS Society (IGS) station at Bangalore (1996) and Hyderabad (2002) and real time data Indian Reference stations (INRES) data obtained from 15 stations established as a part of the GAGAN ground stations network. The results have provided confidence of fitness for aviation use of GAGAN Signal in space conforming to the standards of GNSS ICAO SARPS.

1.7. 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, Bangladesh, and States in the South Asia Region, including parts of Australia and Africa can derive benefit of the Indian experience to provide SBAS services by States appropriately augmenting ground segments.

1.8. The neighboring States can draw benefit of GAGAN services by a minimal augmentation of reference stations for APV (approach with vertical guidance) level performance. Larger States will require many reference stations. GAGAN is capable of taking data from as many as 30 more reference stations.



**2. DISCUSSION**

2.1 To meet the required GAGAN performance in the presence of large ionosphere gradients, scintillation and depletion over Indian region, it was necessary to develop and provide best equatorial ionosphere algorithm without the need for changing MOPS and thereby maintaining interoperability of SBAS systems. India has developed the algorithms and schemes to fully comply with the RTCA standards for SBAS systems.

2.2 GAGAN APV 1/1-5 planned Service Characteristics against Annex 10 standards

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

2.3 ISRO/AAI has developed a region-specific ionosphere model called ISRO GIVE Model - Multi Layer Data Fusion (IGM-MLDF). Single shell ionosphere model falls apart when the ionosphere exhibits sudden changes in electron content as in the case over the equatorial region. Hence there is a need for multi-layer model which can still provide the ionosphere corrections without change in the existing MOPS structure. IGM-MLDF employs an innovative approach for computing the ionosphere corrections and confidences at pre-defined grid points at 350 km shell height. IGM-MLDF consists of computing ionosphere delays at 250 and 450 km shell heights in order to capture the vertical movement and large scale irregularity of the Indian ionosphere and then employing data fusion for fusing the delays and confidences at 350 km shell height. Ionosphere storm detection algorithm utilizes goodness of fit test to protect the user from irregular behaviour of ionosphere. Moreover, IGM-MLDF models the associated uncertainties to protect a GAGAN user from ionosphere abnormalities. Another important feature of this algorithm is that, it does not require any changes in the user message structure, resulting in ease of GAGAN message usage by all the users, including the legacy users.

**2.4 GAGAN Current Status:**

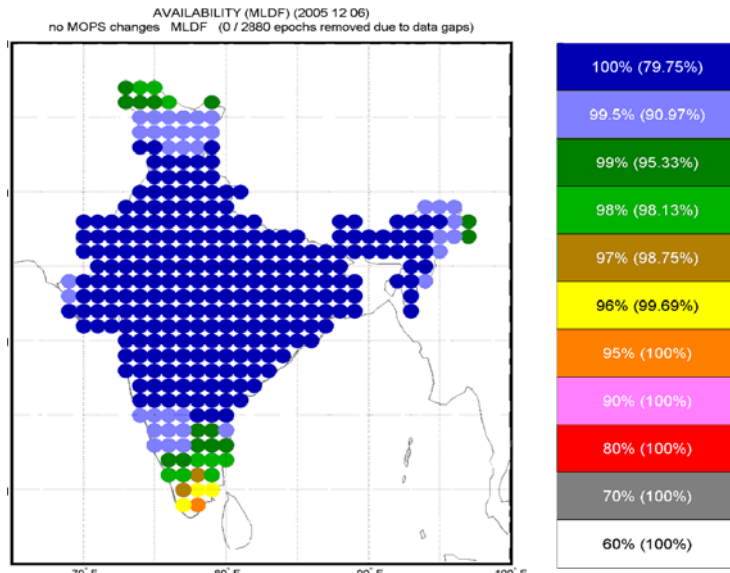
2.4.1 All Ground segments comprising of Indian reference stations (INRES-15), Indian UPLINK stations (INLUS-02) and Indian Master Control Centres (INMCC-02) are installed and are involved in data collection for validation. Space segment comprising of the GEO-GSAT 8 launched on 20<sup>th</sup> May 2011 has completed in orbit tests and is undergoing integration process. The application with RNP 0.1 build has been installed and tested against field data. Additional augmentation of GSAT 10 (GEO) will be launched by first quarter of 2012.

2.4.2 Technical consensus of GAGAN ISRO-IGM-MLDF Iono-algorithm is complete and has been validated with sample data to demonstrate the level of service matched against requirements.

2.4.3 The GAGAN System certification process has commenced with the installation of systems and data collection for HMI analysis. A Technical Review Team (TRT) formed by DGCA

comprising of experts in the field of SBAS certification will be involved in reviewing the GAGAN results.

2.4.4 GAGAN is on the threshold of providing open service by the year end, while continuing its efforts in certification for safety of life applications by July 2013. Sample availability diagram is provided below.



**3. ACTION BY THE MEETING**

3.1 The meeting is invited to:

- take note of the GAGAN developments as a viable SBAS solution within Equatorial Ionospheric Anomaly Region capable of providing RNP0.1 service and APV 1/LP services at selected airports;
- consider the GAGAN option for SBAS services over States with assured coverage for regional harmonization of systems and provision of seamless navigation; and
- encourage States for SBAS implementation to achieve the Global GNSS transition plans and provide for regional harmonization of systems so that the States can mutually benefit from India’s efforts in launching GAGAN services.

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