



ASSEMBLY — 42ND SESSION

TECHNICAL COMMISSION

Agenda Item 24: Aviation Safety and Air Navigation Priority Initiatives

NAVIGATING SOLAR ACTIVITY: ADDRESSING GNSS LIMITATIONS IN EQUATORIAL AND LOW-LATITUDE REGIONS

(Presented by India)

EXECUTIVE SUMMARY

The increasing reliance on global navigation satellite system (GNSS) for aviation operations has highlighted persistent challenges arising from solar activity and ionospheric disturbances, particularly in equatorial and low-latitude regions. These areas experience unique ionospheric behaviours—including intense scintillation, irregular plasma bubbles, and strong spatial gradients—that significantly impact GNSS accuracy and availability.

Current GNSS Standards and Recommended Practices (SARPs) and minimum operational performance standards (MOPS) are predominantly modelled around mid-latitude ionospheric conditions, and the algorithms incorporated in satellite-based augmentation system (SBAS)/ground-based augmentation system (GBAS) systems do not adequately account for the specific characteristics of the equatorial ionosphere.

To support the implementation of the Global Air Navigation Plan (GANP) and uphold the No Country Left Behind strategy, ICAO must revisit and revise its GNSS-related standards. These updates should incorporate new ionospheric models, real-time monitoring strategies, and tailored error bounding approaches suitable for equatorial operations

Action: The Assembly is invited to:

- take note of information provided in this paper;
- request ICAO to initiate a review of current GNSS SARPs and MOPS with a special emphasis on developing ionospheric correction algorithms applicable to equatorial regions; and
- recommend the establishment of regionally inclusive Space Weather Advisory Centers to improve global GNSS resilience.

<i>Strategic Goals:</i>	This working paper relates to <i>Every Flight is Safe and Secure</i> .
<i>Financial implications:</i>	No additional resources are required.
<i>References:</i>	Annex 10 — <i>Aeronautical Communications</i> , Volume I — <i>Radio Navigation Aids</i> Doc 9750, <i>Global Air Navigation Plan</i> Doc 9849, <i>Global Navigation Satellite System (GNSS) Manual</i>

1. INTRODUCTION

1.1 Global navigation satellite system (GNSS) enables critical navigation and surveillance functions in aviation. However, equatorial and low-latitude regions face disproportionately higher risks due to solar-induced ionospheric anomalies.

1.2 These include severe scintillation, abrupt variations in total electron content (TEC), and plasma bubble formation—phenomena that are inadequately addressed by existing GNSS augmentation systems.

2. CHALLENGES IN CURRENT GNSS SARPS AND MOPS

2.1 The ionosphere tends to be relatively stable over mid-latitude regions, which allows satellite-based augmentation system (SBAS) systems to perform effectively in accordance with existing ICAO Standards and Recommended Practices (SARPs) and RTCA minimum operational performance standards (MOPS) DO 229B. However, these standards do not fully account for the dynamic and complex behaviour of the ionosphere in equatorial and low-latitude regions, where SBAS performance often deteriorates.

2.2 GAGAN, the only certified SBAS system operating in equatorial conditions, has reported repeated availability degradations of APV-I Service during the ongoing solar maximum conditions, exposing the need for alternative modelling techniques and real-time corrections.

2.3 Moreover, no GBAS system has yet been operationally certified in these regions, partly due to the unpredictability of ionospheric behaviour.

2.4 Automatic dependent surveillance — broadcast (ADS-B) surveillance also suffers from GNSS performance loss, further endangering air traffic management integrity.

3. WAY FORWARD

3.1 ICAO should:

- a) promote the rapid deployment of dual-Frequency multi-constellation (DFMC) GNSS, while acknowledging the long lead time required for full implementation;
- b) update SARPs and MOPS to include algorithms designed specifically for ionospheric correction in equatorial and low-latitude zones;
- c) expand the geographic coverage of ICAO-designated Space Weather Centres to include equatorial space weather monitoring capabilities;
- d) encourage member states and research institutions to collaborate in developing open-source equatorial GNSS performance models; and
- e) addressing these gaps is essential to ensure global GNSS service continuity, equitable airspace access, and the safety of air navigation across all regions.

4. **CONCLUSION**

4.1 The aviation community must recognize that current GNSS SARPs and MOPS do not adequately reflect the realities of equatorial ionospheric disturbances.

4.2 There is an urgent need to integrate region-specific modelling and resilience mechanisms into international standards.

4.3 Through timely policy reform and inclusive collaboration, ICAO can ensure that GNSS infrastructure supports the safe and seamless navigation of aircraft in all parts of the world — including those most impacted by solar activity.

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