



Agenda Item 6: Assessment of operational requirements in order to determine the implementation of communication, navigation and surveillance (CNS) capabilities improvement for en-route and terminal areas operations

STATUS OF LOW-LATITUDE IONOSPHERE THREAT MODEL FOR GBAS

(Presented by Brazil and United States)

SUMMARY

This working paper presents the status of GBAS (Ground Based Augmentation System) Low-Latitude Threat Model project and a framework for implementation.

References:

- Annex 10, Volume I, to the ICAO Convention;
- SIRIUS Program from Brazil;
- SAM/IG/7 – WP/7;
- SAM/IG/8 – WP/18;
- GREPECAS/16 – IP/15.

ICAO strategic objective:

A - *Safety*

1 Introduction

1.1 Brazilian Department of Airspace Control (DECEA), in cooperation with the Federal Aviation Administration (FAA), has been conducting joint research and development (R&D) projects on Global Navigation Satellite System (GNSS) technologies for over 10 years. The following results of the research were presented at GREPECAS/14 in 2008:

- Space Based Augmentation System (SBAS) implementation in South America will not support precision approach operations because of the high ionospheric activity associated with the geomagnetic equator;
- Performance Based Navigation (PBN) implementation will use GNSS/GBAS/Aircraft-Based Augmentation System (ABAS) as primary means of navigation within Brazilian airspace;
- GBAS capability is the a component required to quickly and economically implement part of Brazil's concept of operations (CONOPS) and provide a technical foundation for SIRIUS/Aviation System Block Upgrade (ASBU).

1.2 DECEA, in cooperation with the FAA - and the U.S. Trade and Development Agency (USTDA), has been conducting a cooperative project to develop an ionospheric threat model capable of supporting GBAS operations in low latitudes.

2 Discussion

2.1 In March 2012, through the PCA 351-3 (National ATM Implementation Plan), DECEA, updating the same document from May 2009, created the SIRIUS Project, aligned with the International Civil Aviation Organization (ICAO) Global Air Navigation Plan (GANP) and ASBU methodology, which presents projects and activities required to implement the Air Traffic Management (ATM) Operational Concept in Brazil.

2.2 Under SIRIUS, there are programs and projects that encompass the areas of Communications, Navigation, and Surveillance (CNS), ATM, Meteorology, Automated Information System/Automated Information Management (AIS/AIM) and Search and Rescue (SAR). Within *Program Improvement of Navigation Systems*, is the project GBAS Implementation, which has the objective of implementing a GBAS station in the severe ionospheric environment of low latitudes.

2.3 GBAS provides a key foundational capability for ASBU Block 0 & 1 upgrades to support future enhancements. GBAS will provide navigation capability for terminal areas, support some en-route applications, and integrity for ASBU applications. Benefits of GBAS include:

- Supports precision approaches to multiple runways and possibly multiple airports, depending on location;
- Potential efficiency benefits, including variable glideslopes, missed approach guidance, guided departures in compliance with Required Navigation Performance (RNP)/Area Navigation (RNAV) criteria, and surface navigation;
- Eliminates Instrument Landing System (ILS) critical areas;
- Enabling technology for high precision terminal area navigation services (4-D dynamic trajectories);
- Supports offset landing thresholds for high density airports helping to implement wake turbulence avoidance procedures pertaining to arrivals;
- Provides capability for continuous descent approaches (CDAs) and curved segmented approaches in extremely low visibility conditions.

2.4 In July 2011, a Honeywell SLS-4000 SmartPath station was acquired and installed at Rio de Janeiro/Galeão–Antonio Carlos Jobim International Airport (SBGL) in order to allow the evaluation of the behavior of a station already certified by FAA for use in mid-latitudes environment, when subjected to intense ionospheric activity with the occurrence of phenomena such as severe gradients, plasma bubbles and scintillation. Approach procedures (for testing purposes only) for runways 10, 28, 15 and 33 were designed and inserted into the SBGL GBAS. (It is important to note that SLS-4000 SmartPath is already operating at airports like Bremen (Germany), Newark (USA), Houston (USA), Malaga (Spain) and Sydney (Australia), all located in the mid-latitudes)

2.5 The station demonstrated sensitivity to ionospheric scintillation in Rio de Janeiro which affected service availability. As a result, the instability of operation demonstrated the threat model used for mid-latitudes did not apply to low latitude regions.

2.6 Thus, Brazil's Airspace Control Institute (ICEA) was assigned to develop an ionospheric threat model and certification of the SLS-4000 station for operations in Brazil. To accomplish this, ICEA implemented a network of GPS receivers around SBGL capable of collecting data on the GPS L1/L2 frequencies and identifying scintillation activity (Polar RxS Septentrio, Trimble and NetR8 GPStation NOVATEL-6 receivers).

2.7 In October 2013, the Brazilian foundation Defense Services and Process Technologies (SDTP), signed a contract with a U.S. company, Mirus Technology, to develop an ionospheric threat model for Brazil, using data collected by the SLS-4000, the Global Positioning System (GPS) receiver network, RBMC, LISN, SEPEG, ICEA Septatrio and Trimble receiver network, and CIGALA networks. The project has been conducted as an international/interagency effort with support of organizations such as DECEA, ICEA, FAA, Stanford University, Boston College, the Institute for Space Research (INPE), Institute of Advanced Studies (IEAV), industry, and several Brazilian universities.

2.8 The project used the mid-latitude threat model as the baseline with focus on those specific ionospheric events unique to low latitude. A first cut of the GBAS threat model shows the variability of the ionospheric gradient for baseline distances of less than 100 kilometers (km) versus the elevation of the observing satellite. A Threat Model for low latitudes (equatorial latitudes) must encompass bounding for worst-case ionospheric events prevalent to the region. To this end, about 120 days were selected (in the past three years) based on turbulent ionospheric activities, to study the worst-case gradient observable in the region.

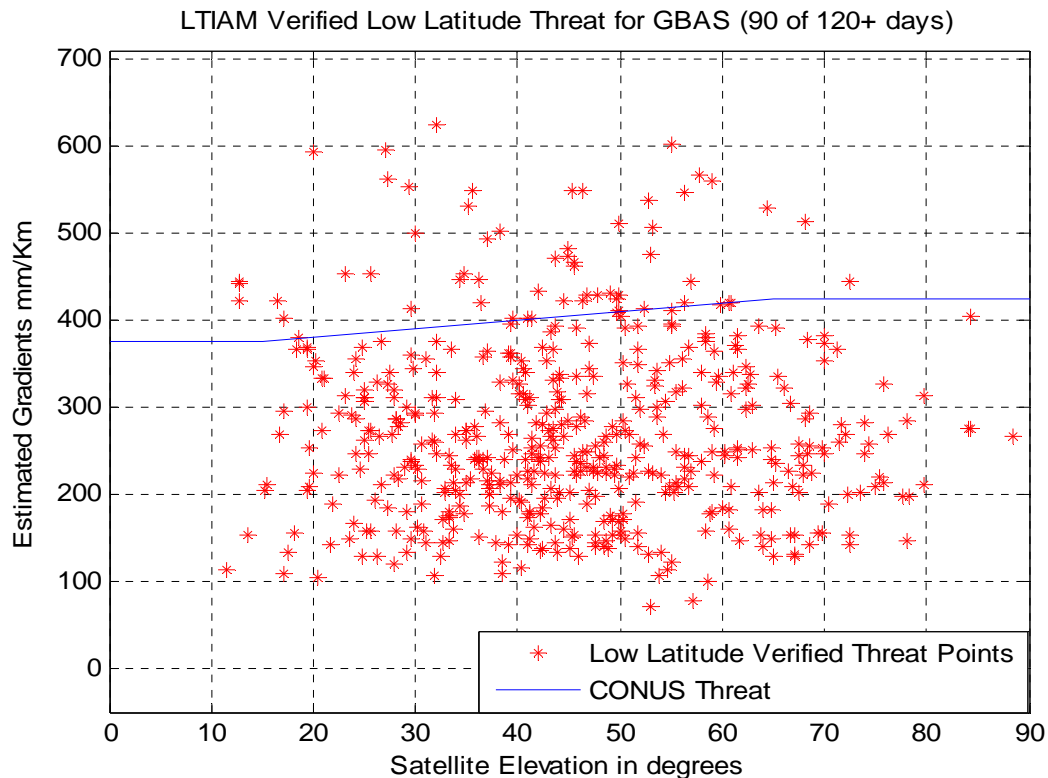


Fig. 1 – Ionospheric threat model composition

2.9 Figure 1 above depicts the composition of the threat model. In the original GBAS algorithm definition, as outlined in Honeywell Algorithm Description Document #4 (Honeywell ADD#4), an anomalous ionospheric gradient was modeled as a semi-infinite wave front with a constant propagation speed and a linear wave front slope connecting the low delay to the high delay ionospheric states. For the case of low-latitude, the threat model is being modified to include simultaneous presence of various depletions with differing gradient, speed, width, directionality and other parameters.

2.10 The Threat Model project has completed data analysis and is in process of validation and test of the low latitude model. Results should be available by the end of 2014.

2.11 FAA is conducting reviews for its certification of GBAS Block II software, with DECEA/ICEA participation. This cooperative effort will provide the foundation for CAT II/III operations in the US and CAT I operations in low latitude regions.

2.12 In May 2014, ICEA initiated a comprehensive effort to certify Honeywell SLS-4000 SmarthPath using the ionospheric threat model in development for use in low latitudes (Block II). The schedule sets July 2015 as the date for System Design Approval, followed by Facility Approval and Service Approval. The plan is to start GBAS operation in Brazil in the first quarter of 2016.

3. Suggested actions

The meeting is invited to:

- a) Note the information presented; and
- b) discuss options for regional cooperation to assist States with implementation of GBAS.

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