International Civil Aviation Organization SAM/IG/9-WP/19
South American Regional Office 7/05/12
Assistance in the implementation of an ATM regional system according to the ATM operational concept and the corresponding technological CNS support
Ninth Workshop/Meeting of the SAM Implementation Group (SAM/IG/9) - Regional Project RLA/06/901
Lima, Peru, 14 to 18 May 2012

Agenda Item 6: **Assessment of operational requirements in order to determine the implementation of communications and surveillance (CNS) capabilities improvement for en-route and terminal area operations**

GUIDE FOR GBAS IMPLEMENTATION
ANALYSIS OF IONOSPHERE IMPACT ON GBAS

(Presented by Brazil)

SUMMARY

This working paper reports a methodology for the analysis of the ionosphere impact on GBAS for inclusion in the draft Guide for GBAS Implementation presented at SAM/IG/8 meeting.

REFERENCE:

- SAM/IG/8-WP/18; and
- Final report of SAM/IG/8 meeting.

ICAO strategic objectives:	*A – Safety* *C - Environmental Protection and Sustainable Development of Air Transport*

1. Background

1.1 Brazil presented SAM/IG/8-WP/18, which included a draft Guide for GBAS Implementation, as action to Activity A2.2 – *Provide practical guidance for the implementation of GBAS systems*, of the PBN Supporting Air Navigation Systems Project, PBN Programme.

1.2 The meeting deemed the guide as an initial document to be taken under consideration and saw the possibility of including in the document detailed aspects on an analysis on the impact of the ionosphere over the GBS systems in support of the GBAS service.

1.3 The **Appendix** presents a proposal on this topic, to be included in the Guide.

2. Analysis

2.1 The Appendix should be included under Item 3.5 - *Considerations for GBAS Implementation* of the GBAS Implementation Guide, after *Certification and Operational approvals.*

3. **Action suggested**

3.1 The Meeting is invited to take note of the information provided in the Appendix, and make respective comments.

- - - - - -

APPENDIX

ANALYSIS OF IONOSPHERE IMPACT ON GBAS

Ionosphere is a challenge for GBAS implementation. Under normal conditions, this layer of the atmosphere is already causing delays in the signals from GPS satellites, varying according to the region of the globe.

SAM region, located in the vicinity of the geomagnetic equator, suffers greater impacts because of the ionosphere particularly with the phenomena of scintillation and plasma bubbles, which can cause errors in receivers and even cause loss of information from satellites.

Stanford University has developed a threat model to increase the availability of GBAS stations based on the geometrical arrangement of satellites in space. In addition, they have modeled abnormal shaped ionosphere gradients as linear wavefronts semi-infinite with constant speed propagation. The gradient is assumed as a linear variation in the vertical ionosphere delay between a maximum and a minimum (http://waas.stanford.edu/~wwu/papers/gps/PDF/LeeIONGNSS06.pdf).

Thus, three parameters are essential in this threat model:

- Delay difference between two points;
- Distance between the points;
- Speed of the wavefront.

This threat model, however, applies to date only to the architecture of the station Honeywell SLS-4000 and was conducted only with data collected in the continental U.S. and is valid for mid-latitude regions.

A State that purchases a station from other company must ensure the same equipment certification in accordance with the requirements of accuracy, availability, continuity and integrity required for the phase of flight that is required to support, even during hostile ionosphere conditions. It must be clear that manufactures can use a different threat model in their systems and they must be certificated according to State regulations.

Ensuring that a GBAS system is robust enough to operate at low latitudes may require simulations or even tests facing the actual events of the ionosphere. The problem of using actual events is that they are unpredictable and periods of high solar activity, when events become more frequent, occur every 11 years.

A State wishing to validate Stanford threat model for a specific region should set up a structure which allows collecting data from GPS satellites to identify and measure the ionosphere gradients and their speeds. To do this it is necessary to:

1- Install GPS receivers around the area of interest

The receivers must be in large number to allow identification of delays at various points in the ionosphere.

The receivers must be spaced apart no more than 100 km in order to provide a good definition of the gradients calculated.

The receivers must be able to receive L1 and L2 frequencies, for a better definition of the ionosphere delays.

Data acquisition rate of the receivers must be greater than 1Hz for greater definition of the measures, which will generate a large amount of data.

The mounting location of GPS antennas should preferably be free of obstacles from 5 degrees elevation.

2- Collect and store data from receivers

Data should be collected periodically from the stations and stored.

Data collection can be accomplished by an external storage device or by a network that performs the download to a storage server.

3- Identify the occurrence of severe ionosphere events

A software must be used to identify, within the amount of data collected, the occurrence of significant ionosphere event.

4– Calculate the velocities of the wavefronts and gradients

A software must be used to calculate the velocity of the wavefronts and the gradients referent to the data with significant ionosphere event.

5- Comparison with the threat model

Finally, the calculated points will be entered into the threat model allowing the evaluation of the applicability of the model.

It is important to point out that the validation of Stanford threat model is a huge effort, demanding a high budget to cover expenses with equipment, software and research, and also requires the support of institutions capable of doing this kind of work.

Besides, the completion of this kind of analysis in an area subject to worse ionosphere behavior is very useful to areas with better ionosphere.

- END -