INTERNATIONAL CIVIL AVIATION ORGANIZATION

GNSS TASK FORCE

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Agenda Item 1: Tests and studies results analysis for GNSS Implementation
Impact of ionospheric effects on GBAS L1 operations

(Prepared by Ricardo Elias Cosendey and Alessander de Andrade Santoro)
(Presented by Mario Sergio Corbelli)

Summary

This paper presents the Brazilian GBAS Implementation Project status and intends to update the GNSS-TF about the tests that are being carried out by DECEA, FAA and UNIVAP at Rio de Janeiro Int'l Airport regarding the procedure criteria development and ionospheric impact on the GBAS performance.

1.0 INTRODUCTION

1.1 As the result of the SBAS flight trials carried out in 2002/2004 in Brazil and presented in the Final Report of RLA/00/009 (GNSS Augmentation Tests), the ionosphere effect over the GPS (SBAS) signal did not guarantee NPA approaches with vertical precision requirements (APV) in Brazilian airspace. Since then, Brazilian Government is working with FAA in a LAAS Test Prototype (LTP) at Rio de Janeiro International Airport.

1.2 Brazilian LTP is a result of a large cooperation project between DECEA/FAA and intends to collect data in order to support a future GBAS implementation, considering the particular ionospheric environment in Brazil, the capability to provide CAT I/II/III precision approaches integrated with an enroute SBAS System, a positive cost-benefit analysis and the necessity to capacitate Brazilian technicians in the certification process and data analysis.

1.3 The GBAS is expected to provide, initially, CAT I precision approach, future Terminal Area Procedures (TAP) and Position, Velocity and Time information suitable for use in a Performance Based Navigation (PBN) airspace and other applications.

1.4 GBAS provides this service in a Terminal Area and can support multiple operations in that airspace volume.

2.0 LAAS TEST PROTOTYPE (LTP) CONFIGURATION UPGRADE

2.1 The GBAS prototype existing in Rio de Janeiro International Airport was upgraded by a FAA team from FAATC (FAA Technical Center) between August 21st and 31st.

2.2 The upgrade consisted of:

a- Ground Station:

- Software change to a DO-246C compliant format including TAP broadcast capability;
- Instalation of one TAP approach (curved with vertical guidance) to RWY28 at Rio de Janeiro Int´l, which was successfully tested. Two more TAP approaches were installed to support approaches in Santos Dumont Airport (runways 20L and 02L) but they need some adjusts to work correctly.
- Change of failing components such as power supplies, receivers, amplifiers and fiber converters.

b- Airborne equipment

- Implementation of change 25 to MMR GNLU-930, providing the airborne capability for flying TAP.
- Wiring reconfiguration in the MMR rack in order to comply with the new software.

2.3 To support the data analysis by DECEA technicians GRAFNAV software was acquired and an introduction to the software operation was presented by the FAA team.

2.4 A GBAS monitoring station will be installed at Santos Dumont airport to collect data transmitted from the VDB at Rio de Janeiro Int´l airport.

3.0 DATA COLLECTION STATIONS

3.1 Five additional Data Collection Stations were strategically distributed around Rio de Janeiro in order to collect daily ionospheric data information that will allow studies about the scintillation observed in low-latitude region and evaluate the impact over GBAS corrections.

3.2 Data are being continuously collected from those reference stations and sent to the FAA Technical Center in Atlantic City for processing and analysis. The processing of these data is expected to be useful in the study and evaluation of the impact caused by ionospheric anomalies in the GPS signals received by GBAS in the equatorial zone.

3.3 As an ionosphere threat model doesn’t exist for regions around the geomagnetic equator, it is really necessary to support the LAAS study with experimental activities in order to improve the knowledge about how ionosphere really can impact the Local-Area Augmentation System.

4.0 DECEA AND UNIVAP IONOSPHERE DATA COLLECTION COOPERATION PROJECT

4.1 In order to improve the GBAS development in Brazil, DECEA has initiated a cooperation project with the Research Group on Solar Physics from UNIVAP (Universidade do Vale do Paraiba), an university located in Sao Jose dos Campos (Sao Paulo).

4.2 This university has expertise in ionosphere analysis and will support the research of its influence over GBAS system, by a continuous monitoring of the ionospheric activities during the flight tests.

4.3 UNIVAP will use an all-sky imager with fisheye lens and filters to record pictures, in real time, of the ionosphere behavior during flights.

4.4 The All-Sky imaging system is capable of detecting the photon emissions of the atomic oxygen (OI 630 nm; transition 1D - 3P) originating from an altitude of about 270 km. The images of the OI 630 nm emission are obtained by using a combination of a fish-eye lens, interference filter and CCD detector. Since the OI 630 nm emission depends on both height and electron density of the ionospheric F-layer, the dark portions in the image shown in Figure 01 indicates regions stretching from north to south (aligned along the geomagnetic field lines) of very low ionospheric densities or also known as ionospheric plasma bubbles.

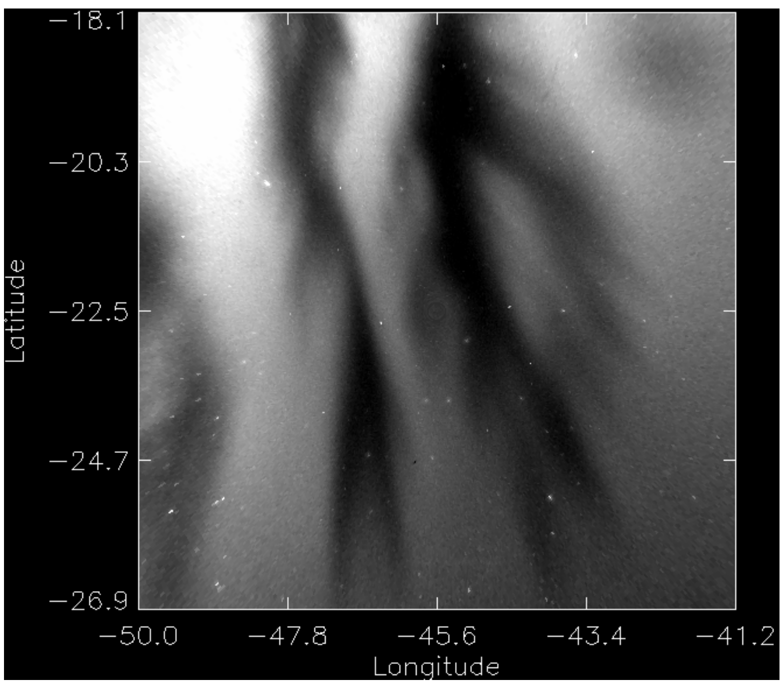

Fig. 01 – Image from ionosphere obtained by UNIVAP with all-sky imager (the dark areas show low concentration – bubbles).

4.5 The lenses allow a 3,400 km visualization diameter with distortions in the image that are corrected by a linearization software.

4.6 After the use of the linearization software, it is possible to visualize the ionosphere behavior in layer with a geographic map (Fig. 02).

Fig.02 – Linearized ionosphere all-sky imager picture over a geographic map.

5.0 FLIGHT TESTS

5.1 Flight tests will be conducted in order to collect data to support the GBAS implementation in Brazil, by identifying the ionosphere impact on GBAS signals and developing a Brazilian Ionosphere Threat Model that can help implementations in all geomagnetic equatorial zones.

5.2 Two kinds of flight will be done: ionosphere data collection and approaches to several runways in Rio de Janeiro.

5.3 The initial ionosphere data collection flight happened during the last week of September, between 20:00 and 23:00h, in Rio de Janeiro, and consisted of a squared path with two sides aligned W/E at an altitude of 9,000 feet.

5.4 During the flight the UNIVAP group recorded the ionosphere activity with the all-sky imager and the data collection stations recorded continuously the GNSS signals.

5.5 The objective of this flight was to obtain a reference of ionosphere behavior during its stable phase to compare to the high activity phase (from October to March) when new flights will happen to collect data.

5.6 All data collected will be used to identify the possible influence of ionosphere disturbances in GBAS signal and to develop the Brazilian Iono Threat Model.

5.7 The objective of the approaches to runways in Rio de Janeiro Terminal Area is to gather data in order to support the criteria for development of air navigation procedures, including those to adjacent airports.

5.8 These flights consist of straight in and TAP approaches to Rio de Janeiro Int'l Airport and Santos Dumont Airport. A truthing system in the aircraft allows the position error evaluation used to calculate the system accuracy.

5.9 Using all the data collected either on the ground and airborne, the university experts can study the ionosphere impacts, under the orientation of aeronautic authorities, and suggest the lines to be researched, in order to guide the future implementation.

5.10 All the data collected will be available to support other States researches through request to Brazilian Government.

6.0 CONCLUSIONS

6.1 Brazil is considering the implementation of a future GBAS facility network mainly to improve some terminal areas capability, as well as to manage the conventional navaids obsolescence in a cost beneficial manner.

6.2 The goals of the tests are to guarantee that GBAS can work properly in the peculiar Brazilian ionosphere environment and to acquire knowledge about the system's behavior in the geomagnetic equator zone in order provide guidance material to support future implementations in other similar regions around the world.