International Civil Aviation Organization
CAR/SAM Regional Planning and Implementation Group (GREPECAS)
First Meeting of the Communications, Navigation and Surveillance / Air Traffic management Subgroup (CNS/ATM/SG/1)
(Lima, Peru, 15-19 March 2010)

Agenda Item 4: Review of pending matters of the ATM/CNS/SG, ATM/COMM, CNS/COMM, and the respective Task Forces, for their consideration in the work programme of the CNS/ATM Subgroup

Combined use of SBAS and GBAS to minimise problems in the ionosphere during precision approaches

(Presented by Spain)

SUMMARY

SBAS and GBAS systems permit SoL operations, but are affected by problems caused by the ionosphere. The combination of both will minimise such problems in GBAS systems responsible for CAT I (and in the future CAT II/III) operations.

References:

- ICAO Annex 10; and
- Project RLA/03/902 – SACCSA.

ICAO Strategic Objectives:	*A - Safety* *D - Efficiency*

1. Introduction

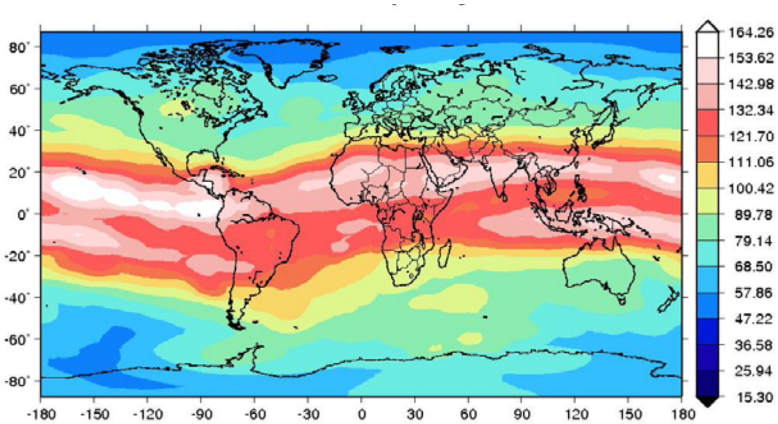
1.1 Currently, there are two augmentations for SoL operations. One is SBAS, that permits the attainment of APV 200, and the other is GBAS, that permits the attainment of CAT I, and, in the future, CAT II/III. The combination of both augmentations would result in a robust system against ionosphere disturbances, providing warnings of such disturbances and sufficient lead time to adjust traffic and take timely measures to minimise the impact.

2. Discussion

2.1 The implementation of GNSS systems entails using and combining all of its elements which, starting with the GPS reference constellation, provide augmentations and functionalities to meet ICAO requirements. That is the reason for adding the RAIM function to airborne receivers and ABAS, SBAS and GBAS augmentations.

2.2 The purpose of all these augmentations is to meet one of the most important parameters in the definition of SoL systems: system integrity, without which it would be difficult to obtain aeronautical approval for precision operations.

2.3 However, this will be more or less easy (or difficult), depending on the latitude in which the flight is taking place. In the CAR/SAM Regions, things are more complicted due to the effects of the ionosphere on most part of both Regions (mainly between 20º N and 20º S starting at the geomagnetic equator).

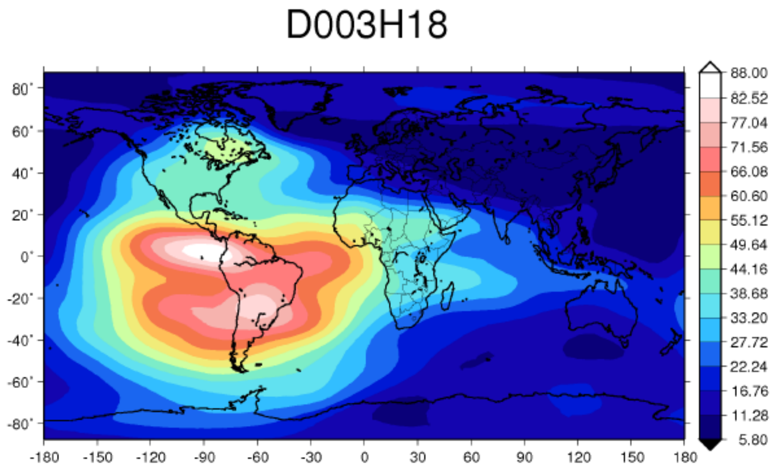


2.4 Currently, both Regions are implementing programmes for the development/implementation of SBAS (regional project) and GBAS (national projects) systems. Both systems seek to improve GPS services and ensure integrity, one (SBAS) at regional level, with services that provide APV 200, and the other one (GBAS) at local level, with services that initially reach CAT I but that are evolving to CAT II/III.

2.5 However, both systems face the same problem: the ionosphere. The effects vary from mild interference in the reception of the L1 signal, to loss of such signal or code delays, causing significant disturbance in the services. As a result, both systems can only issue a flag activation message and stop providing the service for which they have been designed.

2.6 SBAS systems permit en-route, terminal area, approach, and landing operations up to APV 200, which makes it especially suitable for low-traffic airports where GBAS would not be profitable, or where GBAS installation could be a problem because of the terrain. On the other hand, GBAS systems are suitable for high traffic airports that require CAT I or higher operations.

2.7 Things work in a different way when determining the effects of the ionosphere, since SBAS is based on a network of reference stations whereby it can detect the arrival of, and track a disturbance (disturbances go from east to west, and in the case of bubbles, their size is approximately 1000 KM N/S by 100 KM E/W). GBAS provides local detection based on the four antennae of the station, whereby it can detect, but not anticipate, the disturbance, due to lack of "far field monitoring". When the disturbance is detected, and if the effects are severe, flags are activated and the precision landing operation is interrupted.



2.8 Consequently, both systems work properly, but having a lead time to anticipate a problem is different from "facing" the problem without prior notice. The difference is that if we anticipate a problem, we can adjust traffic and organise operations for its arrival, but if we are faced with the problem without any warning, it is like when the ILS suddenly fails, only that, in this case, it affects several runways at the same time (remember that GBAS can serve several runways).

2.9 In this respect, the GBAS and the SBAS deal with the ionosphere in a different way. With SBAS, the processing centre calculates some corrections and the associated integrity. With GBAS, it is assumed that the ionosphere does not change "much" between the reference station and the user, and, in order to provide integrity, a statistical behaviour is assigned to that change (ionosphere gradients). The GBAS is entirely valid in an intermediate ionosphere, since nominally, the ionosphere behaves well and is unlikely to "misbehave". Accordingly, GBAS assumes a maximum possible gradient (or equivalent) in order to ensure integrity. This implies a loss of availability, since a Stanford University model (ionosphere threat model) is used instead of a real-time gradient estimate; that is, it applies a maximum ionosphere gradient. In the CAR/SAM Regions, this could be valid for Cat I, where some margin is available and maximum values can be used. In this sense, a study--if possible independent in nature--would be essential to see if the model can be really used in the area involved (AENA is conducting a study of this type for the Canary Islands). The study should comprise several stations in the vicinity of each GBAS station (with an approximate separation of 50km) during a long period of time that includes a solar maximum. However, in the case of CAT II/III, we may say, *a priori*, that this "maximum" model is not valid, since there seems to be no availability margin, and the SBAS (or real-time ionosphere monitor) is clearly more useful for monitoring the ionosphere.

2.10 How can this be solved? If an SBAS system is available, we can know what is happening hundreds of kilometres to the east of our airport, since, thanks to the reference station network, we can monitor extensive areas (a whole region). This allows us to anticipate a ionosphere disturbance sufficiently in advance as to take action to mitigate its impact on traffic. Obviously, when it reaches our airport, the disturbance will affect the GBAS, but since we were warned of its arrival, we will have time to take measures (for instance, advise aircraft that precision operations will be cancelled for a given period of time and that they will have to conduct NPA or Baro-VNAV operations) and structure the airspace around the airport based on these operations, thus avoiding a collapse.

2.11 Consequently, in the various projects currently underway in the CAR/SAM Regions, it would be advisable to consider SBAS and GBAS iteration, taking into account their mutual impact, in order to find a timely solution to ensure the highest possible level of service under any circumstances.

3. **Suggested action**

3.1 The Meeting is invited to:

a) take note of the information provided in this working paper;

b) include the independent study of GBAS ionosphere models for their use in the CAR/SAM Regions;

c) analyse the implementation of the solution shown, and take it into account in national GBAS plans and SBAS project activities; and

d) consider participating in the regional SBAS project (SACCSA in the case of the CAR/SAM Regions) and in national GBAS projects, in order to create awareness of this type of solution.

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