



**International Civil Aviation Organization  
South American Regional Office**

**THIRD WORKSHOP/MEETING OF THE SAM IMPLEMENTATION GROUP (SAM IG/3)  
REGIONAL PROJECT RLA/06/901**

**Lima, Peru, 20 to 24 April 2009**

**Agenda Item 3: Implementation of performance-based navigation (PBN) in the SAM Region**

**CONSIDERATIONS ON THE MONITORING OF THE ABAS BASED AIR NAVIGATION  
OPERATIONS PERFORMANCE**

(Working paper presented by the Secretariat)

**SUMMARY**

This working paper describes considerations given regarding the provision of a ground system for the monitoring in real time of GPS satellites in ABAS operations, as well as the functions of RAIM.

**Reference:**

Notes on GNSS Monitoring (Prepared by the ICAO CNS Section for the Air Navigation Commission (ANC)).

**1. Background**

1.1 GNSS based air navigation operations require systems verifying the integrity of the signal in space in the global positioning systems (GPS). In this regard, to guarantee the GPS signal's in space integrity parameters, for en-route, non precision approach and terminal area ABAS based air navigation operations, there is a GPS receiver with a Receiver Autonomous Integrity Monitoring (RAIM) system.

1.2 An aircraft equipped with certified GPS receivers with RAIM (TSO C129a, E/TSO-C146) comply with the monitoring of the precision, integrity and continuity parameters specified in Annex 10, Vol. I, Table 3.7.2.4.1 – *Signal in space performance requirements*, for en-route, terminal en-route and non precision approach operations.

1.3 For the monitoring of the performance parameters indicated in the above paragraph, some air navigation services providers have taken under consideration the implementation of an independent ground in real time monitoring system. In this respect, many States have enquired regarding the need or not of implenting these type of systems, taking into consideration the functions of RAIM.

## 2. **Analysis**

2.1 With the aim of providing guidance to States on ABAS based air navigation operations performance monitoring, the ICAO Air Navigation Commission (ANC) requested the Air Navigation Bureau (ANB) to elaborate a clarifying note on the subject, considering that the monitoring requirements regarding the status of the air navigation aids, including GNSS, are found in Annex 10, Volume I.

2.2 The note was prepared and presented to the ANC, which considered that same be included in the ICAO web page, under the PBN Section ([www2.icao.int/en/pbn](http://www2.icao.int/en/pbn)). The **Appendix** to this paper presents the information elaborated.

## 3. **Analysis**

3.1 The Meeting is invited to:

- a) Take note of the information presented;
- b) Analyze the considerations provided on ABAS based operations monitoring performance presented in the Appendix to this working paper and formulate a conclusion in this regard; and
- c) Analyz any other considerations in this respect which the Meeting might consider necessary.

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ICAO requirements for status monitoring of radio navigation aids, including GNSS, are provided in Annex 10, Volume I. The requirements have recently been updated (Amendment 83 to Annex 10, applicable on 20 July 2008). In particular, section 3.7.6 of Volume I, which contained specific requirements for GNSS status monitoring, has been deleted. GNSS requirements are now included in the following general Standard addressing provision of information on the operational status of radio navigation services (Annex 10, Volume I, 2.8.1):

*“Aerodrome control towers and units providing approach control service shall be provided with information on the operational status of radio navigation services essential for approach, landing and take-off at the aerodrome(s) with which they are concerned, on a timely basis consistent with the use of the service(s) involved.”*

This Standard refers to approach control service only (as opposed to ATC service in the whole airspace) and the previous requirement (pre-Amendment 83) to provide information “without delay” is replaced by a more open requirement to provide information “on a timely basis consistent with the use of the service(s) involved”.

With specific regard to the requirement to provide status monitoring for ABAS operations, the official interpretation of the standard is provided in ICAO Document 9849 (GNSS Manual), para. 5.6.5.7:

*“A decision on whether or not to develop a status monitoring and NOTAM system for ABAS operations should be made by taking into account the nature of ABAS approvals. In many cases ABAS operations are predicated on having a full complement of traditional NAVAIDs available for back-up when ABAS cannot support service.”*

Even when status monitoring and NOTAMs need to be provided, there is no requirement to have a real-time ground based status monitoring system. NOTAMs can be based on the status information that is provided by the satellite operator and can be obtained by the State authorizing the operation, as can the information on scheduled outages. Additional real-time information to ATC could be provided by pilots reports based on status information provided by the avionics.

More generally, real time monitoring of GNSS performance is an ABAS (or SBAS/GBAS/GRAS) function and no real time monitoring to ATC is required to ensure safe operations.

A State could use an independent real-time ground based system as one resource-intensive way to provide status information to ATC, but in that case, a number of issues may arise. Specifically for Basic GNSS (ABAS) systems, that is systems equipped with aircraft based augmentation system based on RAIM (Receiver Autonomous Integrity Monitoring), the key issue with generating NOTAMs based on a real-time status monitoring system is the fact that all the following factors can differ between aircraft:

- the receiver RAIM algorithms of different receivers can be different;
- the satellites in view can be a different set;
- the receiver mask angle can vary;
- integration with other sensors/aids (DME/DME, baro, inertial) may or may not be available to the navigation system;
- by definition, status monitoring system cannot provide scheduled outage information, and hence even a State operating such system ultimately needs to rely on information provided by the GNSS operator.

It should be recognized that use of ground-based monitoring tools to provide real-time information to ATC may have some “psychological” advantages insofar as the air navigation service provider may feel more in control of the situation. However, this perception should not obscure the following facts:

- RAIM availability is user specific (as discussed above) and cannot be generalized;
- monitoring per se does not change anything – it is just information which cannot be projected forward (it is not a prediction);
- conflicting status information between ground-based status monitoring and avionics could create a human factors issue insofar as pilots would have to decide which source to trust;
- if, in order to resolve the conflict, pilots were asked always to trust the avionics in case of conflict, the ground-based system would be effectively proven to be useless;
- if, on the other hand, the ground based system information should be made to prevail, integrity and/or availability could be affected depending on whether the ground-based system overestimates or underestimates the quality of the signals at the aircraft’s location and the capabilities of on-board navigation system.

Thus, in addition to being resource-intensive, the use of a ground-based monitoring system to provide real time information to ATC is potentially problematic insofar as it could conceivably worsen the actual performance of the overall navigation system, without providing any improvement with respect to the on-board monitoring capabilities provided by ABAS.

Finally, notwithstanding these considerations, it is noted that Annex 10, Volume I, 2.4.3 contains Recommended Practices addressing recording and retention of GNSS data, for which the use of a ground-based monitoring system is of course an option. A possible alternative (which has been adopted by at least one State) would be to make use of existing national geodesy/surveying networks (if available).

Additional uses of ground-based monitoring systems include monitoring and archiving of GNSS data to support historical data analyses and establish technical familiarity and confidence in GNSS core constellation performance.