RAiSG-2 – Working Paper 1

The Provision of GNSS Status Information and NOTAMS

Submitted by Eurocontrol

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<td>Recent experience with GNSS NOTAMs in both the US and Europe have highlighted the difficulties of applying solutions that are compliant with the current ICAO provisions. The FAA has recently moved away from the provision of GNSS NOTAMs based on service models due to the inability of such models to predict the actual outages experienced by users. In Europe there have been similar difficulties in the prediction of the impact of EGNOS service degradations.</td>
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1. Introduction

A concept for GNSS NOTAMs has been developed over the past few years in consultation with Navigation and AIS stakeholders. This document was considered close to maturity and was undergoing a final review in the AIS/SWIM Team of Eurocontrol at the end of 2011. At the same time the EGNOS service experienced some availability degradations in part of the service area due to a combination of events including increased ionospheric activity.

The ESSP provided information about the service degradations to those States with whom they had bi-lateral agreements in order to warn them of potential availability reductions at locations where LPV procedures were already published. The resulting information requested by the regulatory authorities to be made available to users was not consistent with the GNSS NOTAM concept.

This situation has forced Eurocontrol to reconsider the GNSS NOTAM concept and to widen the debate to discuss the provision of GNSS outage information to both users and ATC. This paper discusses the need for the provision of such information and the means that are available for generating it. It also reviews the current ICAO requirements based on the lessons learned from initial EGNOS operations.

2. History

2.1. At the start of GNSS based navigation

The provision of GPS outage information was first addressed in the run up to the introduction of B-RNAV back in 1998. This is when GPS started to be used in European airspace and it was considered necessary to inform users of predictable unavailabilities of GPS RAIM. Eurocontrol achieved this by making available the Augur service. Augur is a web-based tool and did not provide NOTAMs.

At around the same time the first GPS approaches were published in Germany. As well as RAIM availability predictions supporting B-RNAV Augur also included outage predictions for GPS approaches. The DFS felt that this was not sufficient and decided to generate NOTAMs to inform users of possible GPS RAIM unavailabilities. This is the way the FAA was doing things at the time. The DFS set up their own GPS RAIM NOTAM system. – The prediction tool being used was an adapted version of the one that had been developed by the Volpe NTSC for the FAA.

Other European States began implementing GPS based Approaches much later. France began around 2005 and the UK in 2010. Now in 2012 around 12 ECAC States have GPS based approaches. Some of these States decided they wanted GPS RAIM NOTAMs and came to an agreement with DFS, others, such as the UK accepted the use of Augur.

2.2. The arrival of EGNOS

More activity in this area was stimulated by the development of EGNOS. Here there were two issues. NOTAMs and ATC Interface. A lot of energy has been expended discussing these points. The EGNOS development started in the early 1990s and the declaration of service was made in 2011. The EGNOS system design included an ATC Interface that was aimed at providing System Status Information to ATC but there was no clear operational concept at that time as to how such information would be used. For the initial LPV implementations it was agreed that ATC did not require any information about the EGNOS system.

In around 2006 Eurocontrol launched a study to look at what was really needed in terms of NOTAMs for EGNOS. This resulted in a list of requirements for a GNSS NOTAM Tool based around the use of a service volume model of the EGNOS system. There had been discussion about whether or not a NOTAM was needed because there were those who preferred the web-
based, Augur-like solution but in the end there was a push from several ANSPs to have the predicted EGNOS outages available in the form of NOTAMs so the debate was closed.

3. ICAO requirements

The ICAO requirements can be found in several ICAO Annexes, including Annex 10, 11 and 15. The exact text of these requirements is reproduced in Appendix A.

- Annex 11 addresses the provision of navigation service status information to ATC.
- Annex 15 is the requirement for the provision of NOTAMs
- Annex 10 reproduces the ATC status requirement from Annex 11 and provides guidance on GNSS NOTAMs.

The Annex 15 and 11 requirements were developed before GNSS when the status of navigation aids was very straightforward to describe. Essentially they were either on or off. GNSS is much more complex and is a time varying system where the performance depends on many different factors. The ability to predict the performance of GNSS is based on models and is not an exact science. The situation is further complicated by the fact that different avionics configurations will achieve different performance from the same navigation service. It should be noted that proposals have been made to the ICAO Navigation Systems Panel to modify the Annex 10 requirements with respect to the provision of GNSS status information to ATC (See RAISG2/IP13). The ICAO PBN Study Group is also addressing Navigation Service Monitoring requirements in the new version of the PBN Manual (see RAISG2/IP14).

4. SBAS NOTAM service

4.1. The current EGNOS NOTAM service

A prediction model was developed and this is used by the EGNOS service provider to issue NOTAM proposals to the NOTAM offices of individual States (NOFs). The inputs to this model are the status of the GPS satellites and the status of the EGNOS infrastructure. If there is a change in status of any of these two things then the impact on the service can be predicted. The prediction is made for a list of airports where EGNOS-based procedures are published (LPV or LNAV/VNAV where the use of EGNOS is acceptable) and NOTAM proposals are sent to the appropriate NOF through their preferred interface (AFTN or EAD).

The message in the NOTAM is of the form: **EGNOS IS NOT AVAILABLE FOR LPV**

Note that the above is different from what the FAA were doing. FAA used to send NOTAMs with the form: **WAAS LPV Unreliable**

The difference between the two approaches is that a WAAS unreliable NOTAM does not stop the pilot from flying the procedure once he arrives at the aerodrome if the service is available.

For Europe it was decided to provide a NOTAM which was clearer and which meant that if the system were declared not available the pilot cannot plan to use it.

4.2. Recent Experience with EGNOS

In October 2011 EGNOS suffered reduced availabilities in parts of the service area caused by a combination of factors such as increased ionospheric activity and the way EGNOS processes the measurements from their monitor stations. The degradation was linked to ionospheric activity so it was approximately predictable that it would repeat on a daily basis and reductions in availability
were likely. However, the outages due to this issue were not predictable using the model used in the NOTAM tool so no NOTAMs were issued.

The EGNOS service provider issued a warning of the degraded services to the States having an EGNOS Working Agreement in place and potentially impacted by the degraded EGNOS performance. These warnings were in the form of a technical note with coverage maps showing where the lower availabilities were likely.

The French NSA was not satisfied with this solution as it was seen as not being readily accessible to all of the user community. The NSA expressed a preference for a process where the EGNOS Service Provider would contact the NOF directly who could then issue a NOTAM warning on the potential for lower availabilities but not forbidding flight planning EGNOS based-operations. What format such a NOTAM should take is currently under discussion. It may be appropriate to use something similar to the FAA WAAS Unreliable NOTAM.

4.3. What the FAA is doing about WAAS

The FAA has considerable experience with the WAAS system which has been operational since 2003. Initially they provided a predictive NOTAM service based on a Service Volume Model similar to the one being used by ESSP. This Predictive NOTAM system that used to provide airport specific NOTAMs was removed from service early in 2011. The predictions were not sufficiently accurate and would not predict outages that were due to ionospheric storms.

Experience with WAAS performance has shown that the availability of an LNAV service is 100% over the service area and the LPV service, even with the occasional outages caused by geometry and ionospheric storms has met requirements over the long term. WAAS performance is monitored offline to verify that the above assumption remains true.

Currently for WAAS there are no predictive NOTAMS. There is a set of pre-defined NOTAM templates for specific extreme events:

- Geo failure
- Operating on single Geo
- Scheduled events that remove the entire WAAS service
- Extreme Storm detector trips
- SE757 IGPs with high GIVEi

The impact of each event has been analysed in advance and a fixed set of NOTAM templates have been developed to be sent when and event occurs.

5. GPS RAIM NOTAM and status information service

5.1. What EUROCONTROL is doing about GPS RAIM

In addition to AUGUR service provided on the web several States have requested GPS RAIM outages to be made available in the form of NOTAM. Augur now has this capability built in and it can be provided on request.

5.2. What the FAA is doing about GPS RAIM

NOTAMs are no longer issued by the FAA for GPS RAIM outages. Users should check RAIM availability on the internet or with their own receiver manufacturer tools.

If for example, the GPS constellation were to degrade below 23-24 primary orbit slots occupied with healthy satellites, advisory information might be issued to pilots or have them verify RAIM availability.
availability at their planned destinations. They are also working to specify requirements for a more accurate prediction tool for both GPS RAIM and WAAS based on what can be predicted, how reliably, and to what degree of accuracy and timeliness to have operational relevance. If such a tool is developed, it will output Non-NOTAM (graphical) aeronautical information similar to the RAIM prediction tool, (www.raimprediction.net)

6. Conclusions and Recommendation

Experience with the implementation of RNP APCH operations in both Europe and the US indicates that traditional methods for providing navigation aid status information and NOTAMs cannot be directly applied to satellite navigation services. The prediction of the impact of a particular service degradation is very difficult and can vary depending on the user so one model is not suitable for all.

The provision of NOTAMs indicating predicted GNSS unavailabilities has been abandoned by the FAA and is under discussion in Europe. GNSS outage information is provided through web-based services such as Augur and the FAA RAIM prediction site.

It is proposed that the current ICAO provisions may not be appropriate for GNSS and should be reconsidered. The requirements in Annex 10 and 11 requiring ATC to be provided with status information is being questioned.

In conclusion, it is recommended that the RAiSG take the action:

- to re-assess the operational needs for GNSS status information and NOTAM and review the ICAO provisions with the objective to propose changes to the ICAO documents.
Appendix A – ICAO Requirements for NAVAID status information

Annex 15

5.1.1.1 A NOTAM shall be originated and issued concerning the following information:

c) establishment or withdrawal of electronic and other aids to air navigation and aerodromes/heliports. This includes: interruption or return to operation, change of frequencies, change in notified hours of service, change of identification, change of orientation (directional aids), change of location, power increase or decrease amounting to 50 per cent or more, change in broadcast schedules or contents, or irregularity or unreliability of operation of any electronic aid to air navigation, and air-ground communication services;

5.1.1.5 NOTAM notifying unserviceability of aids to air navigation, facilities or communication services shall give an estimate of the period of unserviceability or the time at which restoration of service is expected.

Annex 11

Information on the operational status of navigation services

7.3.1 ATS units shall be kept currently informed of the operational status of radio navigation services and visual aids essential for take-off, departure, approach and landing procedures within their area of responsibility and those radio navigation services and visual aids essential for surface movement.

7.3.2 Recommendation.— Information on the operational status, and any changes thereto, of radio navigation services and visual aids as referred to in 7.3.1 should be received by the appropriate ATS unit(s) on a timely basis consistent with the use of the service(s) and aid(s) involved.

Note.— Guidance material regarding the provision of information to ATS units in respect to visual and non-visual navigation aids is contained in the Air Traffic Services Planning Manual (Doc 9426). Specifications for monitoring visual aids are contained in Annex 14, Volume I, and related guidance material is in the Aerodrome Design Manual (Doc 9157), Part 5. Specifications for monitoring non-visual aids are contained in Annex 10, Volume I.

Annex 10

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.

Annex 10 Attachment D – Guidance Material

6.2.4………..each State is responsible for ensuring that SBAS meets the requirements of Chapter 3, 3.7.2.4, within its airspace, and that appropriate operational status reporting and NOTAMs are provided for its airspace.

6.2.6 Before publishing procedures based on SBAS signals, a State is expected to provide a status monitoring and NOTAM system. To determine the effect of a system element failure on service, a mathematical service volume model is to be used. The State can either obtain the model from the SBAS operator or develop its own model. Using the current and forecast status data of the basic system elements, and the locations where the State has approved operations, the model would identify airspace and airports where service outages are expected, and it could be used to originate NOTAMs. The system element status data (current and forecast) required for the model could be obtained via a bilateral arrangement with the SBAS service provider, or via connection to a real time “broadcast” of the data if the SBAS service provider chooses to provide data in this way.
Appendix B – FAA NOTAMs for WAAS

If all Geos fail then the NOTAM says: WAAS NOT AVAILABLE
Individual GEO failures will only affect coverage in certain areas.
There are two templates available to cater for specific Geo outage scenarios:

- Failure of CRE-138 and CRW-135 (impact to Alaska)

WAAS Signal may not be Available North of a line defined as 6800N14000W to 5400N16000W

- Failure of CRW-135 (impact Western Alaska)

WAAS Signal may not be Available North of a line defined as 7000N15000W to 6400N16400W

Scheduled events that remove the entire WAAS service for a short time are NOTAMed as follows:

WAAS NOT AVBL WEF YYMMDDhhmm-YYMMDDhhmm

These are events such as a scheduled NLES switchover during single-Geo operations which leads to a 5 minute service outage over the entire coverage area.

Extreme Storm detector trips

The WAAS system has a built-in detector for extreme ionospheric storms. The NOTAM is valid for 8 hours.

WAAS VNAV/LPV minima not available WEF Year, Month, Day, hour, minutes

SE757 IGPs with high GIVEi

When Increased ionospheric activity is causing more than a certain number of IGPs to have a high GIVEi

WAAS VNAV/LPV/LP MINIMA MAY NOT BE AVBL