

ELEVENTH AIR NAVIGATION CONFERENCE

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**Agenda Item 6 Aeronautical navigation
: issues**

FEASIBILITY ASSESSMENT OF GNSS-BASED CATEGORY II/III APPROACH AND LANDING AND AERODROME SURFACE OPERATIONS

(Presented by the Secretariat)

SUMMARY

This document presents the results of an assessment by the Global Navigation Satellite System Panel (GNSSP) of the on-going work on GNSS capable of supporting Category II/III approach and landing and aerodrome surface operations. The document, which was developed at the request of the ICAO Air Navigation Commission (ANC), reviews challenges associated with the development of an all weather operations capability using GNSS ground-based augmentation system (GBAS). It also attempts to predict time frames when GNSS capable of supporting Category II/III and surface operations can be in place. Recognizing the potential benefits of GNSS service in support of these operations, the paper confirms that ICAO should progress development work in this area.

Action by the conference is in paragraph 5.

1. INTRODUCTION

1.1 Users and service providers may avoid some costs and gain benefits by having a single system that can provide guidance in all phases of flight. For low-visibility operations in particular these benefits include potentially reduced infrastructure and operator costs, new procedures, flexible siting requirements and provision of airport surface guidance.

1.2 The ground based augmentation system (GBAS) is the GNSS augmentation system being standardized to support all categories of precision approach and landing operations. A number of States are engaged in developing and acquiring GBAS equipment to support Category I approach and landing operations. Research and development is ongoing in several States to evolve these systems to support Categories II and III, and aerodrome surface operations.

1.3 The level of performance obtained from GBAS is dependent upon the architecture chosen to support the operation. For example, greater accuracy and/or robustness can be obtained from the use of dual frequency both on the ground and on the aircraft. This architecture choice directly affects the achievable schedule and technical risk of a given architecture.

2. PRECISION APPROACH AND LANDING

2.1 General

2.1.1 The current Standards and Recommended Practices (SARPs) for GBAS provide augmentation to the core satellite constellations of GLONASS and GPS and support Category I precision approach. Galileo will be added to the core satellite constellations and its local component will be standardized as an amendment to the GBAS SARPs at a later date. Additional ranging sources such as ground-based ranging sources may be included in the standards in the future.

2.1.2 A goal of GBAS development to support Category II/III operations is to enable the evolution of the basic Category I architecture to Category III minimizing changes to the basic architecture. Backwards compatibility with existing Category I avionics is a requirement.

2.1.3 Another fundamental goal for GBAS supporting precision approach is to be “ILS-look-alike.” Although this term can vary greatly in meaning it implies, in general, that GBAS should be designed to minimize the impact on the aircraft implementation, flight crew procedures, operations, air traffic control, aircraft certification, charting, NOTAMs, etc. Regardless of how well GBAS meets this goal of transparency with ILS, it must meet the same safety standards as ILS.

2.2 Category I GBAS

2.2.1 ICAO SARPs for GBAS capable of supporting Category I operations became applicable on 1 November 2001 as a part of Amendment 76 to Annex 10. In November 2001, RTCA completed minimum operational performance standards (MOPS) for various configurations of airborne equipment (RTCA/DO-253A). The European Organization for Civil Aviation Equipment (EUROCAE) is currently updating their multi-mode receiver (MMR) MOPS to include GBAS (ED-88). In early 2003, EUROCAE completed the first issue of MOPS for ground equipment (ED-114).

2.2.2 Although there are currently no operational approvals using SARPs-compliant GBAS, there is a significant amount of GBAS activity within the aviation community. Several States have prototypes of Category I GBAS systems and are gaining experience in siting, testing, and using the system. At least three ground equipment manufacturers are developing SARPs compliant systems. Some States have procurement programs and at least one State plans to install some GBAS systems to support Category I precision approach and landings using GPS with an initial operational capability planned for 2006.

2.2.3 At least three avionics vendors are pursuing equipment development and at least one vendor has a prototype SARP compliant MMR installed in a test aircraft. At least two aircraft manufacturers are integrating equipment into their production aircraft. Several States are working on technical certification activities. At least two aircraft operators have a program to integrate equipment into their fleet.

2.3 Category II/III GBAS

2.3.1 Development of SARPs for GBAS to support Category II/III approach and landing operations is under way. The development of the high level requirements is in progress. The SARPs are expected to be completed circa 2008. The key issues for the evolution of Category I systems to Category III are outlined below.

Performance requirements development

2.3.2 The GNSS signal-in-space performance requirements for Category I are defined in Annex 10, Volume I, Chapter 3, 3.7.2.4. The requirements are for accuracy, integrity (including the time-to-alert and alert limits), continuity, and availability. These requirements will be extended to include Category II/III performance.

2.3.3 EUROCAE and RTCA are concurrently developing requirements for Category II/III. Previous efforts have focused on deriving high-level requirements for the navigation system error characteristics using the Annex 10 ILS standards and airborne EUROCAE/RTCA MOPS requirements.

2.3.4 However, there are indications that this type of derivation of the requirements may be overly restrictive due to the different error characteristics of ILS and GBAS. Analyses by two aircraft manufacturers indicate that the guidance quality and accuracy provided by Category I GBAS may be sufficient to conduct autolands for transport category aircraft. As a result, EUROCAE, RTCA, and GNSSP are also considering new methods of deriving the detailed navigation system requirements, while achieving the same integrity and continuity risk levels specified for ILS. If these alternative methodologies can be matured and validated, fewer changes may be needed to extend Category I architectures compliant with the SARPs to support Category II/III operations. Depending upon the final performance requirements, a second, protected, civil frequency may be necessary to conduct Category II/III with sufficient continuity performance. Performance benefits which can be obtained using dual frequency satellite information, such as the improvement in the removal of ionospheric errors, may be needed to achieve the levels of accuracy and integrity needed for Category III operations.

Signal-in-space integrity

2.3.5 Determination that the GBAS ground sub-system complies with the signal-in-space integrity requirements is a significant challenge. The same methodology used to design GBAS and demonstrate its compliance to the Category I requirements is being applied to the more stringent Category II/III requirements. Since both the integrity risk and the time-to-alert requirements are more stringent, design changes are likely. Efforts are underway to examine the extension of the monitors designed to support Category I and to identify other ramifications on existing ground system designs.

Continuity

2.3.6 For ILS, the signal-in-space continuity requirement to support Category III is a factor of four times more stringent than for Category I. Some experts consider this to be a challenging difference if applied to the GBAS because the effects of satellite constellation geometry and satellite outage characteristics become a more significant factor in meeting the tighter requirement. Continuity outages that are caused by satellites geometry or their failures can be minimized by using additional ranging sources.

2.3.7 A factor identified at RTCA as a risk area for achieving the required continuity for Category III operations is a potential degradation in performance due to ground multipath when the aircraft is very close to/on the ground and decreasing in speed. This may be a significant issue for code-based systems which is currently under investigation. Transitioning to the use of carrier-based measurements is being investigated to see if it can mitigate this degradation.

2.3.8 Coverage of the VHF data broadcast (VDB) for aircraft on the runways is another concern for Category III operations. Multiple VDBs can be sited around the airport to provide the aircraft receives with a usable signal; however, there are operational issues still to be addressed with such a solution.

Availability of service

2.3.9 Studies are currently underway to understand what levels of availability can be achieved for various architectural options (such as the core satellite constellation(s) used and the use of single or dual frequency measurements) as well as for different assumptions on the performance requirements. There are two competing goals in the selection of the architecture and the performance requirements: to maximize availability and to minimize complexity and cost while maintaining at least the current level of safety.

2.3.10 If Category II/III requirements can be met with a single frequency, a second frequency may be used to provide a redundant service in case the first frequency is unavailable, for example due to interference. Multi-frequency Galileo is expected in the 2008 time frame. A second frequency for GPS for safety-of-life applications is expected to be available in the 2015 time frame.

2.3.11 Ground-based ranging sources, also known as airport pseudolites or APLs, were proposed for a Category II/III architecture as an alternative to the increased number of satellites to improve overall service availability. RTCA developed a preliminary APL signal specification in 1998, which has been retained in their subsequent updates to the signal-in-space interface control document (RTCA DO-246B). Since that time, some States have progressed the development of APLs and are engaged in prototyping and flight test activities.

2.3.12 Although the technical maturation of APLs is progressing, concerns remain regarding siting issues on the airport, integrity monitoring for the pseudolite ranging signal, and compatibility with non-participating airborne GNSS receivers. Some experts express reservations with pursuing APLs development considering the continued expansion of and additions to the core satellite constellations. For example, the use of multiple core satellite constellations, such as GPS and Galileo, may obviate the need for APLs in some areas. Ultimately, the need for APLs depends upon the need for high availability GBAS systems and the satellite geometry shortfalls at the particular airports where GBAS is to be implemented.

Software issues

2.3.13 The software contained in a GBAS system is larger and, in some cases, supports more critical functions than the software of terrestrial navigation aids. This, in and of itself, is a concern for some experts. Software development becomes more complex and requires more time as the level of critically increases. Even if the guidance quality of a system designed to support Category I operations could support a Category III landing, the software level would have to be commensurate with the increased criticality of the Category III operations.

3. SURFACE OPERATIONS

3.1 In 1998, RTCA concluded that both the SBAS and GBAS architectures have utility in providing guidance and surveillance for surface operations. Development and demonstration work is being carried out in Europe, Japan, and the United States. Efforts encompass service for both aircraft and airport vehicles and include differential-GNSS architectures beyond those currently included in the SARPs. Current efforts at RTCA are targeted at identifying how the current GBAS equipment can support surface applications, particularly situational awareness.

3.2 Current studies in ICAO are focusing on the application of GNSS as a position sensor in support of Advanced Surface Movement Guidance and Control (A-SMGCS).

4. CONCLUSION

4.1 Some GNSS experts predict that by the year 2015 when multiple fully populated, multi-frequency, core satellite systems are operational, GBAS supporting Category II/III and surface operations will be technically possible. Some GNSS experts predict that service may be achievable as early as 2010, depending on the GBAS architecture selected and performance requirements, such as availability.

4.2 The final outcome of the development of the performance requirements and standards will largely determine the complexity of the future GBAS architecture which can support Category II/III approach and landing operations and when it will be generally available. While the final complexity of the future GBAS architecture is not yet known, the potential benefits outlined in paragraph 1.1 above justify continued work on the resolution of technical and operational issues involved.

4.3 Evaluations are being conducted to determine the surface applications that GBAS can support.

5. ACTION BY THE CONFERENCE

5.1 The conference is invited to take account of the conclusions in this paper in developing proposed amendments to the ICAO strategy for introduction and application of non-visual aids to approach and landing (Annex 10 — *Aeronautical Telecommunications*, Volume I — *Radio Navigation Aids*, Attachment B) and to the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750).

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