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EUROCONTROL policy on GNSS in Europe

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Abstract - This paper summarizes the EUROCONTROL policy on GNSS for Navigation applications in the civil aviation domain. This policy is based on a gradually increasing reliance on Satellite navigation that has as the final goal its use as sole service, to the extent that this can be shown to be the most cost beneficial solution and if it is supported by successful safety and security analyses. The vision for implementing this policy is based on the combined use of at least two constellations with signals in more than one frequency band. User receivers will process signals from different GNSS constellations in combination with augmentations (e.g. ABAS, GBAS or SBAS depending on individual business cases and the phase of flight). This vision is in line with the "Common aviation Community position on GNSS" endorsed by the members of the EUROCONTROL Provisional Council.

Keywords: GNSS, ABAS, GBAS, SBAS.

INTRODUCTION

EUROCONTROL is the European Organisation for the Safety of Air Navigation. This civil and military Organisation which currently numbers 38 Member States has as its primary objective the development of a seamless, pan-European Air Traffic Management (ATM) system.

EUROCONTROL has had a long involvement in GNSS matters at European and international level. The EUROCONTROL policy on GNSS is part of a multi-modal strategy in Europe, through co-operation with the European Union (EU) and the European Space Agency (ESA), and contributes to the global vision for aviation, to be achieved through co-operation with ICAO, the FAA and other international partners

EUROCONTROL is contributing to the development of GNSS applications addressing technical, operational, economic, institutional and legal matters in coordination with key European and international stakeholders.

OBJECTIVES

This GNSS policy:

- Aims to establish a common vision among all aviation stakeholders in Europe to jointly proceed towards a successful transition to GNSS.
- Sets policy guidelines on GNSS for the SESAR implementation phase.
- Includes specific policies for SBAS and GBAS.
- Provides a more consolidated position with respect to the need for the Galileo SoL service in aviation.
- Describes some principles related to the transition towards GNSS.

GNSS POLICY: THE VISION FOR THE USE OF A MULTI-CONSTELLATION AND MULTI-FREQUENCY GNSS IN 2020+.

This EUROCONTROL policy on GNSS is based on a gradually increasing reliance on Satellite navigation that has as the final goal its use as sole service, to the extent that this can be shown to be the most cost beneficial solution and if is supported by successful safety and security analyses. The vision for implementing this policy is based on the combined use of at least two constellations signals coming from more than one frequency band. User receivers will process signals from different GNSS constellations in combination with augmentations (e.g.

ABAS, GBAS or SBAS [1] depending on individual business cases and the phase of flight).

There are still uncertainties in different aspects (e.g. technical, economic,..) that may affect this vision depending on how the GNSS context evolves. In particular, in the absence of a GNSS pricing policy for aviation from the EU, it is assumed that a service fee will be levied for the EGNOS and the Galileo SoL services. The existence of a service fee is seen as being detrimental for the acceptance of these services in aviation and it is recommended that these services will be provided for free to aviation as a public utility.

There is no GNSS solution that fits all user sizes and all Air Navigation Service Providers (ANSPs). Each aviation stakeholder will chose the GNSS solution that can meet their operational and safety requirements in the most cost effective way.

The expected evolution of GNSS systems will allow a progressive improvement in terms of user performance and system robustness that will overcome most, if not all, of the current GNSS limitations. This vision is considered to be the optimal scheme in terms of performance, robustness and independence from a single GNSS operator.

Aviation welcomes the agreements on the signals for GPS and Galileo between the US and the EU, in terms of frequency bands and common design that will facilitate interoperability at user level.

Operational framework

For en-route and terminal area:

- A total Performance Based Navigation (PBN) environment will enable improved flexibility of airspace design and increased efficiency of aircraft operations. There are several technical options, or combinations of them, potentially capable of supporting the required specification (i.e. Advanced RNP 1): a free GNSS service provided by at least 50 multi frequency satellites from at least two constellations enhanced at aircraft level (i.e. ABAS based on inertial coupling and/or RAIM functionality), and by EGNOS and the Galileo SoL service. Individual business cases will determine the most adequate solution for each stakeholder.

- A rationalised DME network. A back-up with a dissimilar-technology covering the remaining deficiencies of GNSS (e.g. jamming and solar storms). The progressive reliance on GNSS and the mitigation of all GNSS deficiencies could result in a complete withdrawal of ground navigation infrastructure in the very long term (2030+).

For approach and landing:

- ILS will remain the primary source of guidance for CAT I/II/III operations in major airports. GBAS will increasingly support CAT II/III operations where economically beneficial once enhanced GPS and Galileo become available. It is assumed that all GBAS for CAT I stations will be upgraded to CATII/III stations. MLS may be implemented where it can be justified by a local business case.

- APV operations will provide a vertically guided approach to every runway end and allow the discontinuation of conventional non precision approach procedures. There are several technical options based on the use of signals coming from different constellations (e.g. GPS and Galileo) that are potentially capable of supporting APV operations: ABAS based on inertial coupling, EGNOS, Galileo SoL, ABAS based on new RAIM algorithms and BaroVNAV. There are still uncertainties on the final capabilities of these options (e.g. Galileo SoL performance, the actual performance of new RAIM algorithms). These technical options will require procedures with different Decision Heights for the same runway to maintain required safety levels, and individual business cases will determine the most adequate solution for each stakeholder.

This vision for GNSS is considered to be the most cost-effective way of providing positioning and timing information to meet the operational requirements of the Airspace strategy and the SESAR operational concept for the long term (2020+).

The issues related to the complexity of the multi-constellation receiver including augmentations (e.g. ABAS, GBAS or SBAS depending on individual business cases and the phase of flight), will have to be addressed in coordination with appropriate standardisation groups (e.g. EUROCAE/RTCA) with due consideration to performance, safety, robustness and economic aspects.

POLICY ON GBAS

ILS systems are providing a very efficient service today for precision approach and landing operations. It is recognised that there will not be a rapid transition from

NOTE: In Europe the Space Based Augmentation System will be implemented by the European Global Navigation Overlay Service (EGNOS).

ILS to GBAS and that an ILS network will be maintained for the foreseeable future. However, ILS systems are facing some problems in terms of multi path effects, dimensions of the sensitive areas and frequency spectrum constraints that are becoming progressively more difficult to manage. Airports may overcome these problems by implementing GBAS.

GBAS also has the capability to support more advanced operations than those based on the ILS look-alike concept and therefore provide operational benefits which:

- Allow for enhanced flexible approaches in a seamless way, such as high performance RNP approaches and multiple approaches to a single runway (linked to advanced controller aids).
- Increase flexibility of airport runway use by enabling all runways of an airport simultaneously.
- Maintain airport throughput during low visibility operations.
- Increase closely spaced parallel approach availability
- Provide Take Off, departure and missed approach guidance as well as navigation on the airport surface.

The GBAS standard was initially developed as a replacement of ILS and consequently has been designed under the concept of ILS look-alike in order to reduce its cost to the airlines. But that concept has some major limitations and one of them is to significantly limit the benefits that could be obtained exclusively from GBAS, especially at European level where ILS are wide spread.

Notwithstanding the difficulty to justify the business case, the implementation of GBAS can be economically viable and operationally acceptable on a local basis for an increasing number of airports and airspace users based on the progressive development of the following enablers:

Concept of operations: it is expected that the concept of operations for precision approaches and landings will evolve progressively, away from the current ILS look alike concept to an advanced concept [2] due to operational and environmental needs. Other elements needed to enable this concept of operations (e.g. controller tools and autopilot updates) are under development, but their implementation is outside the scope of this policy and dependent on additional factors.

Safety: Safety analysis will provide the adequate assurance level commensurate with the degree of reliance being placed upon the GBAS service and will indicate the dimension and the nature of potential backup services to be retained.

Technical and standardisation aspects: GBAS CAT I stations are considered to be an interim step towards the development of GBAS CAT II/III stations. It is expected that GBAS standards and developments will ultimately support CAT II/III operations based on the combined use of signals coming from different constellations (i.e. GPS, Galileo and GLONASS). Current developments at technical and standardisation level aim at achieving CAT II/III capabilities based on GPS L1 only. In this case, provisions to allow the transition from current developments to a future more robust multi-constellation scheme should be made.

Airborne aspects: Airborne costs are one of the key drivers in the transition from ILS to GBAS. It was initially expected that just a few aircraft would be retrofitted with GBAS equipment but the number of retrofit will largely depend on the retrofit avionic package definition and the associated cost. Regarding forward fit, GBAS cost should be very limited as already most commercial aircraft manufacturers offer GBAS CAT I capability as optional equipment, and some new aircraft will have GBAS as standard equipment.

Operational implementation: GBAS CAT I operational approval will be the first key achievement towards GBAS operations. The GBAS CAT I stations deployed in Europe will allow the GBAS validation activities to progress and operational experience to be gained. This experience will support the development of future GBAS applications such as CAT II/III and high performance RNP operations. Work performed on the GBAS concept of operations has highlighted that significant effort must be made at ICAO level in order to consolidate the concept and to ensure harmonised operations.

The EUROCONTROL policy on GBAS is to support a progressive, harmonised and cost effective transition towards GBAS across ECAC by supporting the development of the above mentioned enablers.

POLICY ON SBAS

EGNOS is the European implementation of its spaced based augmentation and is expected to be certified according to the Single European Sky (SES) regulations by 2009/2010. EGNOS can provide operational benefits to different categories of airspace users (e.g. General Aviation, Helicopters, Business jets, Regional Airlines) offering a cost-effective option to meet PBN requirements and supporting LPV operations at runways not equipped with ILS. The EUROCONTROL ECIP (European Convergence and Implementation Plan), includes a

specific objective (NAV 08) aiming at enabling the implementation of approach procedures with vertical guidance using EGNOS in five European States (France, Germany, Spain, Italy and Switzerland). EUROCONTROL is contributing to the operational validation of EGNOS according to aviation requirements. EUROCONTROL is supporting the development of enablers required for the operational introduction of EGNOS and is coordinating activities at European level.

EGNOS LPV approaches are expected to provide 250 ft minima and an ILS look-alike approach capability on most European runways. In a second step it is expected to evolve toward a Cat I equivalent capability (200 ft minima). This evolution will be similar to the WAAS evolution to 200 ft minima, implemented in 2007 in the US.

However, EGNOS provides little performance benefit to first level commercial aircraft (i.e. equipped with RNP approach and BaroVNAV systems). Most of the airlines do not plan to invest in equipping their aircraft with EGNOS and are against paying for this service. IATA requires that whenever States are providing geometrical vertical guidance (i.e. LPV) at a certain airport, that such procedures must be complemented by BaroVNAV procedures if BaroVNAV capable aircraft are operating into these airports. Airspace users are not collectively willing to pay for EGNOS services and the major air transport airlines request that EGNOS related costs shall not be allocated to airspace users not equipped with EGNOS.

In the long term, the overall added value of an augmentation system like EGNOS will depend on the level of performance achieved by ABAS solutions in a multi-constellation, multi frequency GNSS environment. Nevertheless, EGNOS will improve the overall robustness of GNSS and can be used as a GPS monitoring tool for States. In particular, the availability of the ionospheric model broadcast by EGNOS could be a very valuable mitigation to cope with some of the effects of solar activity on GNSS signals, which is one of the major technical obstacles to the sole service concept.

Individual business cases will determine the suitability of EGNOS for each aviation stakeholder. If there are no significant operational benefits that can be exclusively obtained from a service for which a fee will be charged, ANSPs and airspace users will choose other options (e.g. a GNSS service provided by at least 50 multi frequency satellites from at least two constellations enhanced by a new RAIM algorithm [3]).

Current uncertainties about EGNOS in terms of date of its operational introduction, life-time, institutional issues and charging policy are impeding some ANSPs and airspace users to take their business decisions.

There are already SBAS receivers available that are certified for aviation use. It is expected that progressively all new GNSS aviation sensors and receivers available in a multi-constellation era will be SBAS compatible. The pioneer EGNOS users need to have guarantees that the lifetime of the service would allow them sufficient time to amortize their investment. ANSPs have the elements to start preparing the operational implementation of EGNOS based procedures in their airspaces, but they do not have the necessary inputs for their business decisions.

EUROCONTROL recommends that EGNOS signals should be provided for free as a public utility. In this context, the aviation community welcomes the EC proposal to the EU Council and Parliament to fund all EGNOS operational cost with EU funds for an initial period of 6 years. Nevertheless it has to be mentioned that the proposed period is determined by the EU financial perspective (until 2013), that is inconsistent with the aviation life-cycles.

The prompt completion of the system, the certification of its Service Provider and the clarification of the uncertainties about its charging policy, liabilities regime and life-time have to be achieved as a matter of urgency..

UPDATED POSITION OF THE EUROPEAN AVIATION COMMUNITY ON THE GALILEO SAFETY OF LIFE SERVICE

During the consultation process for the Galileo Mission Requirements Document (MRD), EUROCONTROL, representing the aviation community in Europe, questioned the need for the Galileo Safety-of-Life Service. In view of this EUROCONTROL decided to undertake specific studies to analyse:

- The extent to which aviation navigation applications rely upon a single data source.
- The provision of global versus regional integrity services
- Integrity services required for the specific stringent operations,
- Capabilities of RAIM in the future environment of enhanced GPS and Galileo.

These studies consider a wide cross-section of users to ensure that all their requirements are considered.

One of the current mission requirements for the Galileo service is to support Approach procedures with Vertical Guidance (APV) operations worldwide based only on this service. Considering safety, performance and independence from single operator aspects, it can be concluded that the aviation community does not intend to use Galileo signals alone, in nominal conditions. Aviation

will use Galileo signals in combination with signals from other constellations like GPS, and augmentations (from space, ground or the aircraft) as appropriate.

It should be noted that standardization fora (e.g. ICAO, EUROCAE) have however indicated that combined constellation receivers should avoid unnecessary complexity, which would increase costs in avionics design, testing and installation. In this respect, it is assumed that at least the first generation of combined constellation receivers will be limited to dual constellation receivers (e.g. GPS and Galileo); this is the current working assumption of EUROCAE and RTCA.

The mismatch between the aviation operational concept and the current requirements for Galileo would result in an over-dimensioned and costly infrastructure considering that aviation intends to use Galileo in combination with other GNSS elements. Moreover, aviation needs should not be considered as the only driver for the development of the Galileo Safety of Life (SoL) service.

The preliminary results of on-going studies on the capabilities of future RAIM algorithms in a multi constellation and multi frequency GNSS environment, indicate the potential for RAIM to support standalone APV operations with GNSS vertical guidance, or at least the potential for alleviating the requirements (and design costs) of ground integrity channels (like Galileo SoL). These preliminary results will have to be consolidated considering in particular the performance of a RAIM based solution in degraded modes (e.g. loss of one frequency or loss of one constellation).

The aviation community awaits the prompt availability of the Galileo Open service as a key element of the new GNSS environment, but with elements available now, the aviation community can not derive exclusive operational benefits from the Galileo SoL and therefore strongly questions its need particularly if a service fee would be levied for it.

It is suggested that that the Galileo SoL requirements for aviation should be reviewed considering a multi constellation operational concept and the availability of regional, local and aircraft based augmentations.

This exercise would result in a better apportionment of requirements to Galileo resulting in a more cost efficient way of providing the robustness and performance levels (in nominal and degraded modes) as required by aviation. In parallel a trade-off based on operational and economic aspects would indicate the extent to which ground based navigation aids can be phased out based on the performance and robustness that Galileo will bring to GNSS.

TRANSITION TOWARDS GNSS

To take full advantage of the GNSS capabilities, a cost effective transition towards GNSS will be pursued driven by operational requirements with due consideration to safety, technical, security, economic and legal factors. GNSS implementation will be based on cohesive benefit-driven technical choices backed by realistic system development plans and political commitments.

As there is already an effective navigation infrastructure throughout Europe and the costs to airspace users of transitioning to a new system are high, the transition towards a future GNSS will take a long time.

There will be a progressive reliance on GNSS as performance and robustness will increase, the final goal being its use as sole-service for all phases of flight, to the extent that this can be shown to be the most cost beneficial solution and is supported by successful safety and security analyses.

Costs of transition to new navigation systems and concepts are mainly driven by the airborne installation costs and when installation/retrofitting/certification costs outweigh operational benefits evolutions are postponed to the availability of new aircraft.

There will be many aircraft equipped with GPS receivers (with Aircraft, Ground or Space based augmentations) before certified multi-constellation receivers become available. Considering the amortization of the investment made, these receivers will not be updated to multi-constellation GNSS receivers if the retrofitting cost outweighs operational gains.

In the case of GBAS, once equipment and standards are developed to support precision approach and landing in CAT II/III conditions, it will provide a viable alternative to ILS while offering a number of technical and operational advantages. A transition to GBAS from ILS may be enabled through updates of the aircraft's Multi-Mode Receiver, which is becoming standard equipment on all large aircraft.

The inclusion of multi-constellation GNSS receivers within the *'SESAR avionic package'* could be a cost effective scheme to combine the navigation updates with technological updates needed for surveillance or communication applications in one-shot.

ACKNOWLEDGMENTS

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REFERENCES (footnotes)

[1] The SESAR Programme (the Single European Sky ATM Research Programme) is undertaking actions to

move towards an efficient global and integrated Air Traffic Management system defined and supported by all its stakeholders.

[2] The precise definition of the advanced concept of operations is under development. The main principle of this concept is to allow a more flexible transition from an FMS-based approach (RNAV/RNP) to a (short) GBAS approach, taking advantage of the GBAS-inherent system characteristics to overcome operational limitations of ILS. This may include, but is not limited to:

- shortening the straight part of the approach to the operationally required minima (aircraft stabilization);
- optimising capture flight paths (constant descent profiles);
- use the capability of GBAS to provide high-integrity, high accuracy position information in the terminal area (Positioning service);
- exploit the capability to provide multiple, concurrent, approaches to the same runway (different angles or thresholds to more efficiently perform wake vortex separation);
- investigate the ability to perform capture at multiple points more efficiently (no risk of false captures) with the help of arrival managers.

[3] Results of on-going studies carried out by EUROCONTROL and other entities shows that RAIM is a promising technique to provide vertical guidance in nominal and degraded conditions (e.g. multiple failure and loss of one frequency). Technical feasibility is still to be fully confirmed.

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