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NAVIGATION SYSTEMS PANEL (NSP)

SIXTH MEETING

2 – 13 November 2020
(VIRTUAL MEETING)

Agenda Item 3: SARPs for GNSS elements and signals (GBAS)

A view on a potential timeline for DFMC GBAS

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SUMMARY

A review of the Job Card NSP.005.02 on DFMC GBAS is due, and this paper discusses some background and proposes possible timelines.

1. HISTORY

ICAO issued the first SARPs for GBAS, supporting CAT I, in 2001. Quite soon afterwards the work to standardize a GBAS concept supporting CAT III started, but it became clear that a straightforward extrapolation of the current concept was not feasible, primarily due to local ionospheric phenomena, for which increased understanding had been gained during the work with the GBAS CAT I standards. A high level concept was conceived in 2007. Then, a detailed concept was developed, distinguishing technical performance categories from operational categories (2009). In 2010, the Baseline Development SARPs (BDS) was published by ICAO, defining GAST (GBAS Approach Service Type) C based on the 2001 ICAO SARPs, primarily supporting CAT I, and a new concept, GAST D, primarily supporting CAT III.

Work continued to validate the GAST D concept proposed in the BDS, and the standard finally became effective in 2018. Since then, work has been ongoing to develop and certify GAST D equipment on ground and on the airborne side. The first aircraft certified for GAST D operations is planned to fly in 2022.

The standardization, development and certification has so far been driven and funded by the industry, partly co-funded by SESAR and some other sources.

2. DEPLOYMENT

Currently, GAST C avionics have been implemented in a significant number of Airbus and Boeing aircraft being operated world-wide. Ground stations are operational in USA, Russia, Australia, Germany, Spain, Switzerland and India, with Japan and China planning to go into operation in the short term.

In order to benefit from the large investments made by the industry, it is seen as necessary to, in the near and medium term, develop the GBAS concept in a way that allows operational and economical benefits to be harvested, partly also to fund research and standardization of future concepts. By implementing concepts such as CAT II operations on GAST C, and CAT II/III on GAST D, operational benefits and experience can be gained, whilst developing new operational concepts and the tools required to support them (SESAR PJ02, VLD). Whilst new technical developments such as GBAS must support current operational concepts to be viable, they also support more flexible and novel concepts, that may provide opportunities for more effective airspace designs and reduced noise and emission profiles. In turn, implementing such new operational concepts are a demanding exercise that may require additional standardization changes, additional tool development and changes in work procedures in several domains. As this development progresses, it may reveal new technical requirements in several domains, including the supporting navigation systems. It is therefore desirable to harvest operational experience with new operational concepts before baselining the next generation navigation systems.

3. CURRENT SITUATION

As mentioned above, the current status is that GBAS GAST C has been deployed to some extent. GBAS GAST D has been validated to be able to support CAT III operations, with the limitation that under severe ionospheric conditions, the siting restrictions may be limiting, in the sense that large airports in areas with demanding ionospheric conditions may have to trade availability against siting distance, or use two GBAS stations to be able to provide GBAS GAST D service to all runway ends.

This siting limitation mainly stems from a potential ionospheric front that may affect the airborne receiver, whilst still being invisible to the ground station until the very last stages of the approach. Implementing dual-frequency monitoring on the airborne side opens up possibilities to detect such conditions, easing the siting restrictions on the ground.

Since 2011, research on a GAST F concept has been ongoing. Currently, a conceptual framework has been developed on the basis of extrapolating the GAST D concept as follows:

- Positioning based on smoothed pseudoranges with fixed smoothing times
- A similar split in performance responsibilities between ground and air
- Identical VHF data link layer, which, on the positive side provides backwards compatibility, the downside being that it is already reaching its capacity limits

The concept currently on the table provides options still to be selected in several domains:

- Iono-free processing versus dual frequency airborne iono monitoring
- Which fallback modes to standardize

The concept has been presented to ICAO and RTCA, but currently, the pros and cons associated with each individual option appear not to be sufficiently clear to make final choices and move forwards. There are performance penalties with each of the options, and selection of any option could limit some future use cases. For example, selection of the IFree option would provide good performance at greater distances from the ground station in an active iono environment, but due to the increase in noise from the IFree processing, achieving CAT III performance at the threshold is likely to require 2 or more constellations.

As mentioned above, adding dual-frequency monitoring on the airborne receiver, provides a possibility to detect and potentially correct for an ionospheric front which only affects the airborne, thereby relaxing siting restrictions for the ground subsystem. Adding also a second constellation provides additional robustness, also primarily against ionospheric disturbances. In areas with severe ionospheric disturbances, several ranging source measurements may have to be rejected by ionospheric monitors on the ground and in the airborne when they are affected by ionospheric gradients. Additionally, during disturbed ionospheric conditions, scintillations are often experienced, causing additional noise or loss of lock on individual ranging sources. In severe cases, a single constellation GBAS concept may suffer from reduction in availability due to ionospheric conditions.

A dual frequency concept could in principle also provide additional robustness against jamming. However, the following considerations should be taken into account:

- Although commercial dual frequency satellite navigation signals are in their infancy, dual frequency jamming cases are already being observed (EUROCONTROL LATO 33 presentation by Aiden Morrison, SINTEF)
- If the GAST F concept is to provide a single frequency fallback mode, this fallback mode has the same siting restrictions as the current GAST D concept since ionospheric anomalies must still be mitigated, limiting the benefits of the new concept compared to GAST D.

It is therefore anticipated that the main benefit of the GAST F concept currently on the drawing board, is increased robustness against ionospheric disturbances.

In order to justify the effort needed to standardize another GBAS concept, and to provide a business case for implementation, especially on the airborne side where the costs for implementing a dual frequency, multi-constellation GBAS is significant taking into account that none of the current GAST C installations can be leveraged on, it should be investigated whether there could be a possibility to extend the use of a new GBAS concept also outside of approach, landing, rollout and take-off operations. One possible operational use of a new concept could be taxi guidance. Also, with the entrance of VTOL and UAV, it could be investigated whether GBAS could meet navigation needs in those domains, in order to ensure that a new high-precision, high-integrity navigation concept being developed will actually have the potential to support new needs emerging in the coming decades. Maximizing the operational benefits in several domains will improve the business case, increasing the success probability with respect to realizing a GAST F concept, not only on the paper of ICAO standards and recommended practices, but also in an operational environment.

Taking into account that the pros and cons of the GAST F options currently on the table seem to be hard to trade off against each other, it is considered of utmost importance for the future business case of a GAST F concept to take into account any potential future operations, currently not being considered for GBAS operations, to evaluate if any of the currently identified options provide significant benefits for any realistic future use, or whether a fundamentally different technical concept, such as for instance carrier phase based navigation, or a different data link should be investigated before making a decision on what the GAST F concept should look like.

Proposed work plan

It is proposed to ensure sufficient time is allowed to investigate future needs and conclude on the final concept to support GAST F, and to gain experience with new operational concepts enabled by GBAS and PBN in general. This provides the possibility to feed back requirements into the development of the GAST F concept. This is seen as necessary in order to maximize the operational benefits of the future GAST F system. Basing a GAST F concept on a pure extrapolation of GAST D is, as explained above, considered to provide limited benefit compared to GAST D, and may therefore not be viable from an implementation point of view.

In order to take into account the considerations above, a work plan could be developed along the following lines:

1. Realize the CAT II on GAST C-concept. With the current situation in the industry, this could realistically be realized in the 2023 timeframe
2. Realize operational use of CAT II /III on GAST D. With delays being incurred by the COVID crisis, this is considered realistic in the 2025 time frame
3. Improve and amend the GAST D concept, including additional signals and constellations in the standards. This provides a possibility to improve performance of the current concept, without imposing a requirement on the airborne to implement dual-frequency signal processing. This effort can benefit from the current work ongoing within SESAR to define GAST F, for instance to define the threat models that need to be considered for Galileo. Taking into account the need to precisely define and gain experience with the threat models, inclusion of additional constellations in the standards is seen as being realistic around 2030. Including corrections for new constellations (Galileo, Beidou and others) in the current GBAS concept will provide valuable experience and insights in the challenges and potentials associated with those additional constellations in the context of GBAS.

In parallel with these developments, GAST F research and investigations must be undertaken, and at the same time, GAST C and GAST D deployments and operational experience will feed back technical requirements, enabling the GAST F standardization to optimize the benefits of the concept being developed.

Taking into account:

- The need to thoroughly investigate the operational requirements coming from both potential new GBAS users such as UAVs and VTOL operations, and also requirements emerging as advanced and flexible operations are implemented on the basis of PBN and current GBAS concepts
- The need to revisit the current concept with respect to the strategy to extrapolate based on GAST D design choices
- The experience from development of current GBAS concepts in terms of the time it takes to research and standardize new concepts

Based on the assumption that the stakeholders find it useful to revisit the basic GAST C and D design choices and evaluate them against future needs, the following timeline can be derived on the basis of the GAST D experience:

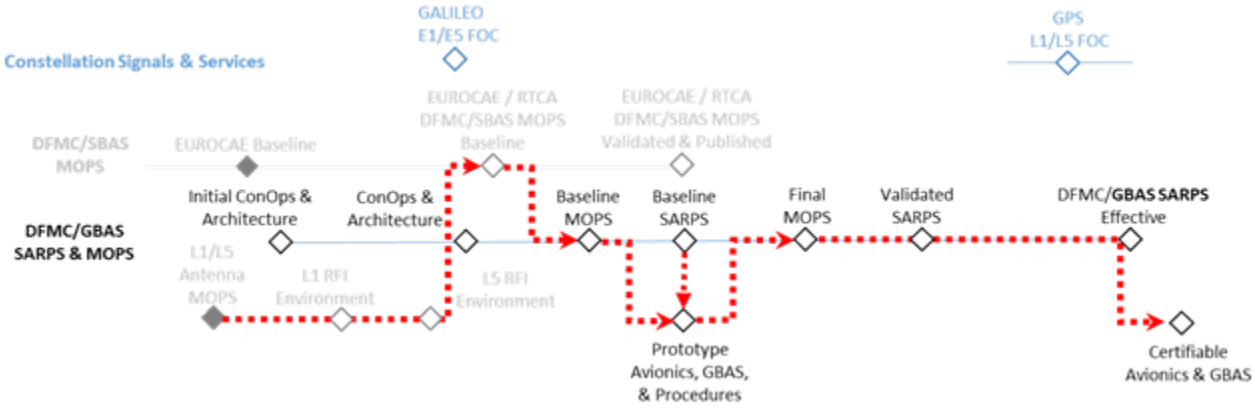
2021-2024	Collect requirements from additional operational contexts, evaluate possible concepts against them, revisiting fundamental GAST D design choices such as smoothed pseudoranges and choice of data link
2024	A high level concept (similar to the level of detail currently proposed by SESAR, with all options selected) agreed in ICAO and RTCA
2026	A detailed concept paper agreed in ICAO and RTCA, similar level of detail as the 2009 GAST D concept paper
2028	A baseline development SARPs for GAST F
2034	A validated GAST F concept ready for proposal to NSP

In the GWG telecon on October 14, there did not seem to be any clear conclusions, however, these are some takeaways:

- A careful review of the concept is needed, with respect to other operational contexts and use cases than the approach, landing, rollout and take-off phases that the current GBAS concepts are standardized for (AI 232)
- The view of the European Commission is that there is a need to target an accelerated timeline compared to the ones above

- Input from RTCA is needed in order to consider the dependencies with the DFMC SBAS MOPS and the future DFMC GBAS MOPS (Jwgs4/WP35)

The following figure illustrates the dependency of the development between RTCA/Eurocae and ICAO activities.



The following draft timeline takes the two first considerations above into account, but must be revised to take input from RTCA into account. It is noted that this timeline is expected to require considerable effort from the relevant stakeholders, and there is uncertainty with respect to the availability of resources, especially in the short term taking the industry's current situation into account. There is therefore some risk associated with this timeline.

2021	**Collect requirements from additional operational use cases, evaluate possible concepts against them**
Q4 2021	A high level concept (similar to the level of detail currently proposed by SESAR, with all options selected) agreed in ICAO and RTCA
Q4 2022	A detailed concept paper agreed in ICAO and RTCA, similar level of detail as the 2009 GAST D concept paper GWG drafting group to start an update package to ICAO SARPs RTCA/EUROCAE to start drafting airborne MOPS
Q4 2024?	A baseline airborne MOPS Prototype airborne implementations for validation
Q4 2025?	A baseline development SARPs for GAST F Prototype ground implementations for validation
2028	A validated GAST F SARPs ready for proposal to NSP

Due to the wide range of options that need to be examined and other uncertainties regarding potential influences of the development time line, the delivery date for the next major GBAS SARPs update should remain TBD until the high level concept has been agreed.

4. DISCUSSION

The meeting is invited to:

a) Note the information presented; and

b) Discuss and provide feedback

— END —