Twenty-Fourth Meeting of the AFI Planning and Implementation Regional Group (APIRG/24)

(Virtual – 2 to 4 November 2021)

Agenda item : Other Air Navigation Initiatives

4.2. Regional and Interregional Activities

Update on "SBAS for Africa & Indian Ocean" (A-SBAS) development

(Presented by ASECNA)

SUMMARY

SBAS benefits are today widely acknowledged by airspace users, especially in the AFI region, where these benefits will be much more important than in any other part of the world. The recent Position Paper on SBAS issued by the Joint User Requirements Group (JURG) confirms further the interest of airspace users in the use of SBAS services, some of them even calling for expediting their worldwide deployment, and especially in Africa, to take timely advantage of the safety, efficiency, and environmental protection benefits.

The "SBAS for Africa & Indian Ocean" (A-SBAS) programme, recognised by ICAO under Annex 10, constitutes an advanced and unique solution to meet these user requirements. This programme primarily aims to provide autonomously airspace users with operational SBAS services from 2025, with a potential progressive coverage of the continent, to support en-route down to CAT-I (LPV-200) operations.

This paper presents the state of development of this programme, especially on the A-SBAS system development status, on the pre-operational service and related field demonstrations, on contribution to standardisation and on the services adoption by airspace users.

The meeting is invited to:

- note the significant achievements of the "SBAS for African and Indian Ocean" programme
- note the position on SBAS taken by the Joint User Requirements Group
- encourage the acceleration of SBAS services deployment and provision to meet requirements of the airspace users already interested
- recommend ICAO to facilitate, following the conclusion of the continental CBA SBAS study, a series of workshops with stakeholders to raise further their awareness on SBAS technology, and services provision and use, from ground and airborne perspectives, and to facilitate thereby their decision-marking on SBAS integration in their navigation strategy

Strategic Objectives	A – Safety, B – Air Navigation Capacity and Efficiency, E – Environmental Protection

1. INTRODUCTION

1.1 The Joint User Requirements Group (JURG), a discussion platform established under the aegis of IATA and A4E, issued on last June 2021 a position paper on SBAS, in which airlines endorsed a position to support the worldwide deployment of SBAS services, especially in Africa, as a key enabler for PBN, with no extra air navigation charges for their use.

1.2 This position acknowledges further the benefits of the use of SBAS, especially in the AFI region where these benefits will be much more important than in any other part of the world. It also definitely confirms the interest of airspace users, some of them even calling for expediting SBAS deployment to take timely advantage of its safety, efficiency, and environmental protection benefits.

1.3 The “SBAS for Africa & Indian Ocean” (A-SBAS) programme, recognised by ICAO under Annex 10, and developed for the benefit of the AFI region within the framework of the African Union Space Policy, constitutes an advanced and unique solution to meet these user requirements.

1.4 This programme primarily aims to provide autonomously airspace users with operational SBAS services from 2025, with a potential progressive coverage of the continent. These services will support en-route down to CAT-I (LPV-200) operations, to improve availability for all PBN routes and flexibility for new and more efficient routes, and to provide an effective solution for ILS CAT-I operations “everywhere every time”

1.5 The services provision overall strategy is to meet user needs with an incremental approach in terms of coverage and performances, considering expendability towards the next generation of DFMC. More specifically, the services provision plan involves three essential steps:

- Step 0: Provision of a pre-operational (L1/L5) service from 2020, in Western and Central Africa, to support field demonstrations
- Step 1: Provision of mono-frequency (L1) services from 2025, primarily in ASECNA airspace with a potential progressive coverage of the continent, to support en-route down to CAT-I (LPV-200) operations
- Step 2: Provision of DFMC (L1/L5) services beyond 2028-2030, to support CAT-I autoland operations and beyond.

1.6 These services are intended to complement existing ILS services, which in the mid-term may not be renewed. More generally, conventional navaids will evolve towards a Minimal Operating Network (MON) to serve as a back-up in case of GNSS outages, to achieve a full capable and resilient navigation infrastructure.

1.7 The services also include Open Service (OS) to be used by mass-market receivers for general purpose applications. A SBAS Data Access Service (SDAS) is also under development, to provide solutions with enhanced performance for professional use.

1.8 The A-SBAS system development status is to date the following:

- The system missions, including services levels, are endorsed
- The system architecture is defined, and the preliminary design of the system is completed in compliance with the defined architecture
- The progressive services areas and related performances are validated
- The system development and qualification plans are developed, as well as the plan of migration towards DFMC
- The system has been assigned by the U.S Space Force two PRN codes, namely PRN120 and PRN147.
- The system development, deployment and entry into service phases are under procurement, in view of services declaration in 2025
- The pre-operational service provision is effective since September 2020, allowing the conduct of field demonstrations, and of advanced studies in support to the standardisation

1.9 These achievements together with the status of consultations with some airspace users and aircraft manufacturers on the services adoption are presented hereunder.

2. A-SBAS SYSTEM DEVELOPMENT

2.1 The A-SBAS System Requirements Review (SRR) and Preliminary Design Review (PDR) were successfully completed by end of 2020. The baseline system architecture, subject of the preliminary design, is dimensioned for L1 services provision (Step 1), and is evolutive to support extension of the services areas for the different service levels. It comprises:

- A network of Navigation Reference Stations (NRS) deployed at various locations to collect GPS and Galileo signals data, with a fine-tuned geographic distribution to optimise the observations of the satellites and the propagation conditions of their signals. The network is scalable to support incremental service areas extension.
- Two Mission Control Centres (MCC) composed of Navigation Processing Systems (NPS) to compute SBAS corrections and associated integrity bounds, and of Centralised Control Systems (CCS) for system control and monitoring
- A least two Navigation Broadcast Stations (NBS) for the uplink of the signal carrying the SBAS messages to the navigation payload of the GEO satellite(s)
- A wide area transport network to ensure data communication between the various sub-systems
- A space segment composed of GEO satellite(s)

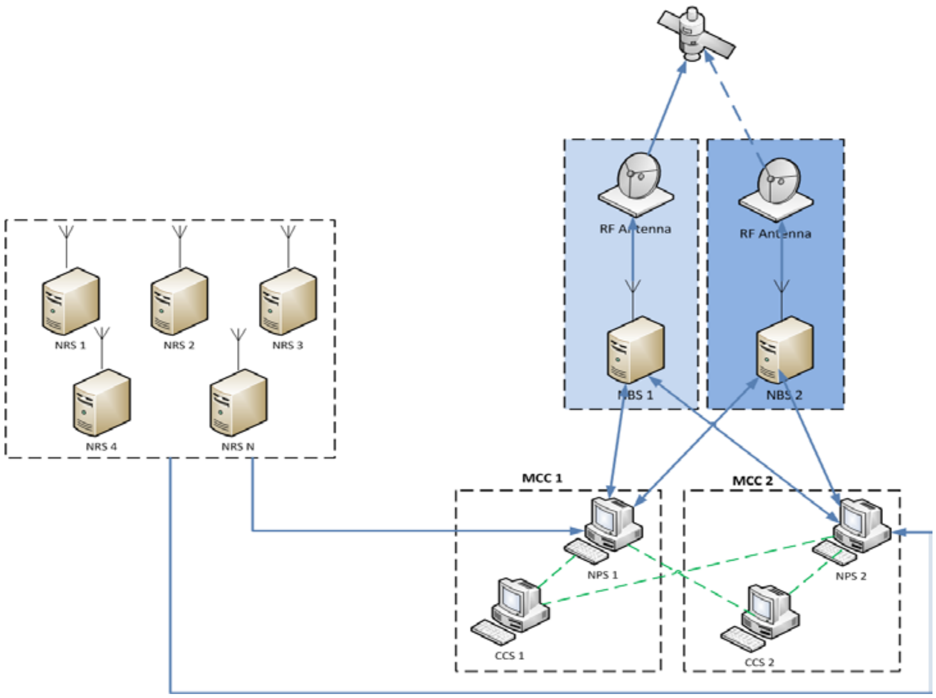

Figure 1 : Minimal architecture overview

2.2 The A-SBAS system is designed to ensure integration of up to three GEOs, with corresponding NBS. It is also expandable to support DFMC services provision with the integration of additional and dedicated NPS, without impact on L1 services.

2.3 The L1 services areas for the 2025 timeline and the related performances, validated with an industrial commitment, are the following:

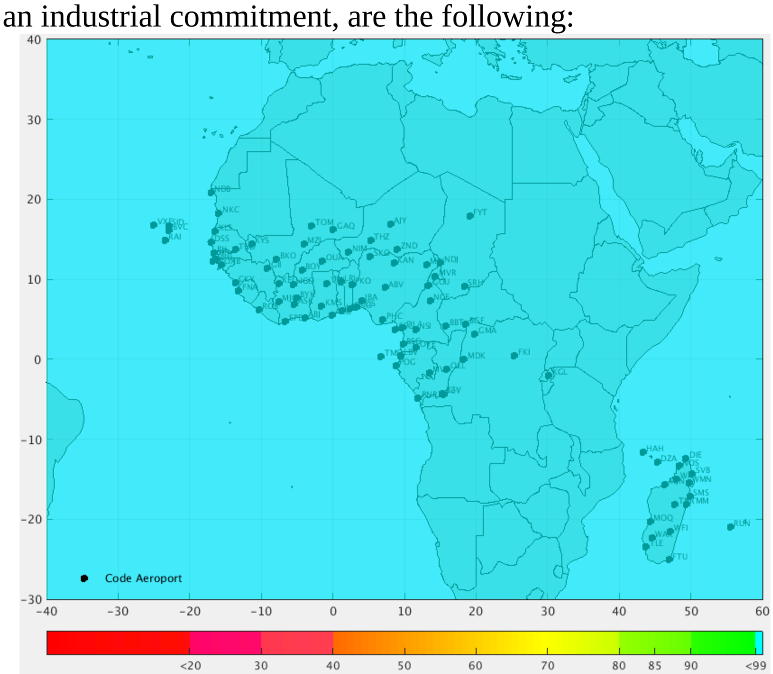

Figure 2: En-route/NPA availability performance (2025)

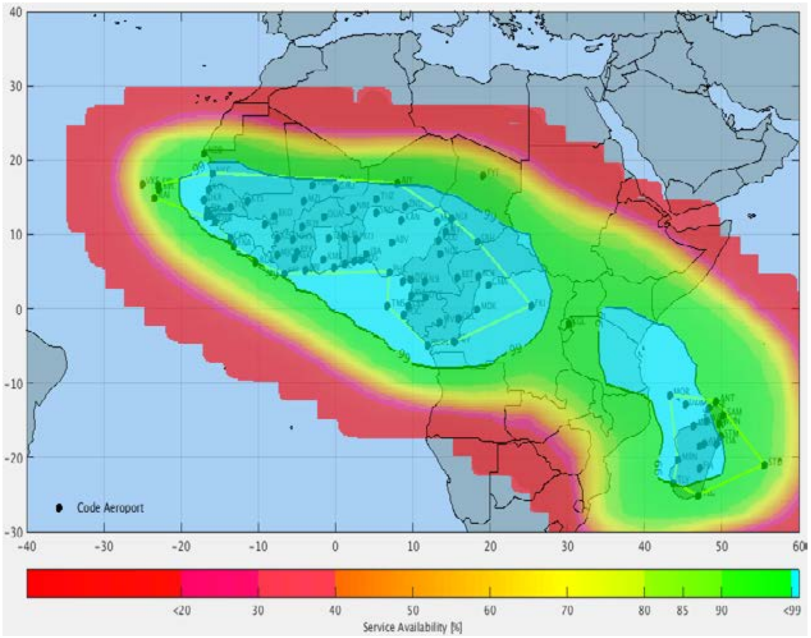

Figure 3: APV-1 availability performance (2025)

2.4 A-SBAS has been assigned by the U.S. Space Force two PRN codes, namely PRN120 and PRN147: https://www.gps.gov/technical/prn-codes/L1-CA-PRN-code-assignments-2021-Jun.pdf

2.5 These codes are required for the broadcast through the GEO satellites of the SBAS signal-in-space. More general information on PRN codes can be found here: https://www.gps.gov/technical/prn-codes/

2.6 The next steps will aim to proceed to the development, deployment, qualification, entry into service and initial operations of the A-SBAS system. The industrial activities in this regard are under procurement with a scheduled start in early 2022, in view of completion by 2025 to issue services declaration.

3. A-SBAS PRE-OPERATIONAL SERVICE

3.1 First essential step of the A-SBAS services provision plan (Step 0), the SBAS pre-operational service broadcast is effective on L1 since September 2020, with full compliance to ICAO SARPs and RTCA DO-229 MOPS provisions.

3.2 The L1 signal-in-space is generated and broadcasted from a test-bed infrastructure composed of:

- the network of SAGAIE GNSS stations, heritage of the SAGAIE project of ionosphere characterisation, completed by additional stations
- a representative system prototype using advanced correction algorithm and processing set, optimised for the ionospheric conditions in Africa

- an uplink station deployed in Abuja (Nigeria) and the navigation payload of GEO satellite NigComSat-1R, operating under the PRN 147.

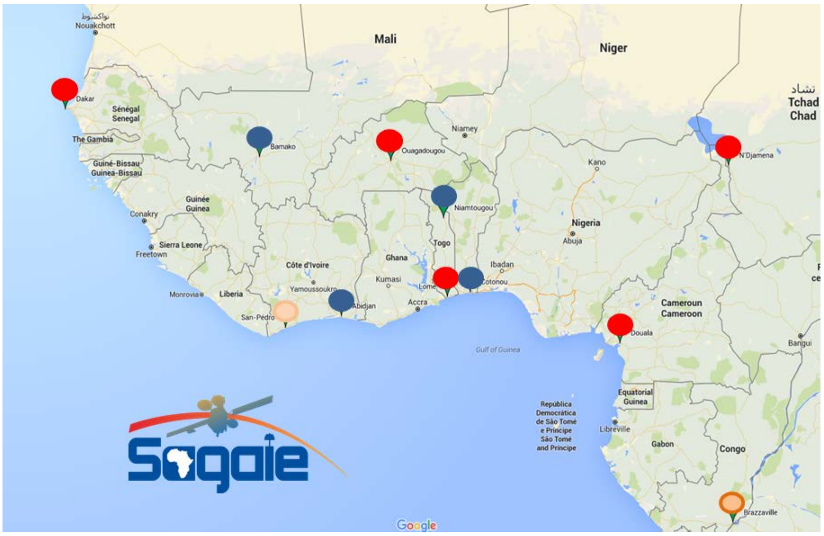

Figure 4: Extended SAGAIE network

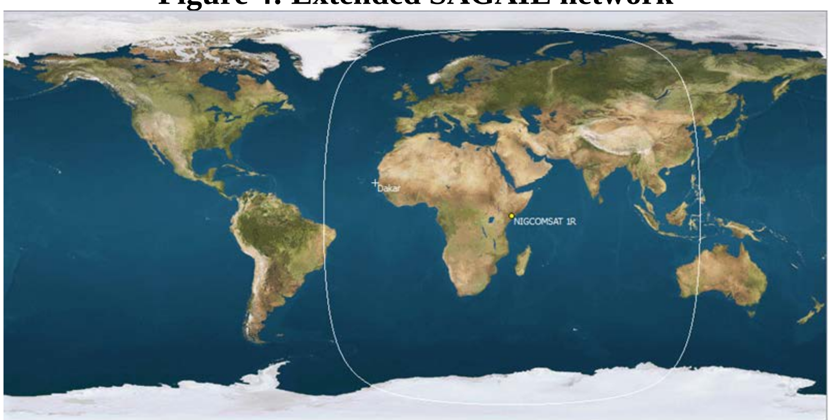

Figure 5: NigComSat-1R coverage area

3.3 The observed performances for the APV-1 and OS service levels are very good, considering the limited network of the GNSS stations:

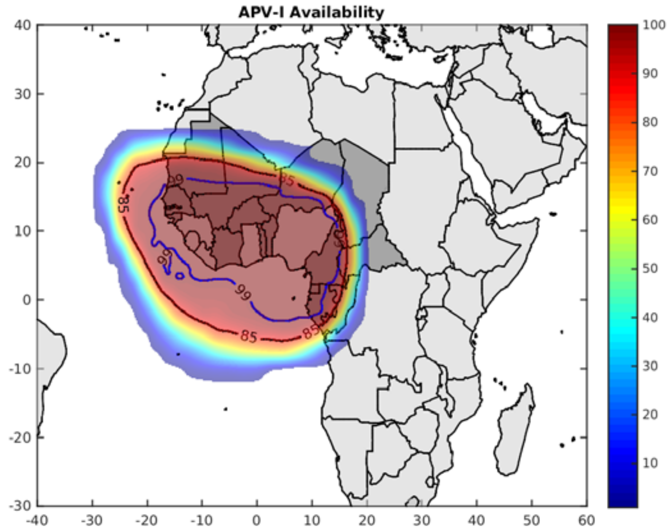

Figure 6: Pre-operational APV-1 service availability

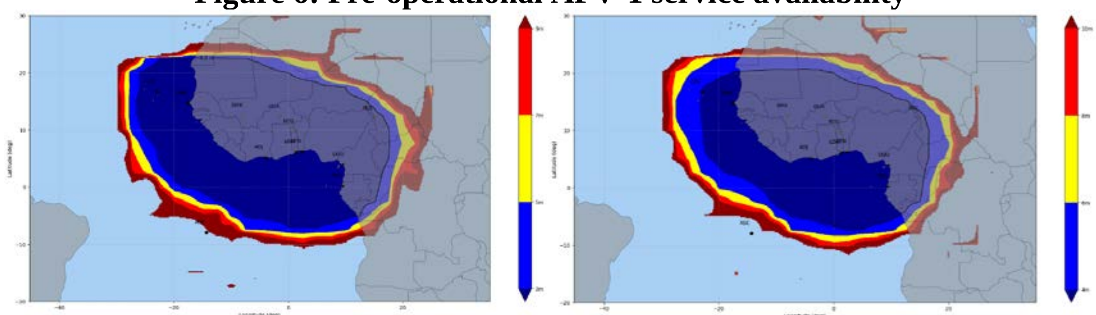

Figure 7: Pre-operational OS service availability (left: horizontal accuracy 3m@100%, right: vertical accuracy 4m@100%)

3.4 The testbed also broadcasts an L5 test signal to deliver preliminary ancillary services on this channel.

4. A-SBAS FIELD DEMONSTRATIONS

4.1 Exploiting the pre-operational APV-1 service on L1, a series of 5 flight demonstrations was carried out on 27th January 2021 at Lomé-Tokoin airport (DXXX, Togo) by means of the ASECNA ATR42-300 aircraft, equipped for the occasion by specific receiver and navigation display, to fly the approach and landing LPV procedure designed for RWY 22.

Figure 8: ASECNA ATR42-300 aircraft

Figure 9: Flight deck equipped with navigation display for SBAS demo flight

4.2 These demonstrations showed in real configuration the technical performances of the signal and validated the testbed from an end-to-end perspective.

4.3 The recorded flight path for the above landing scenario is the following:

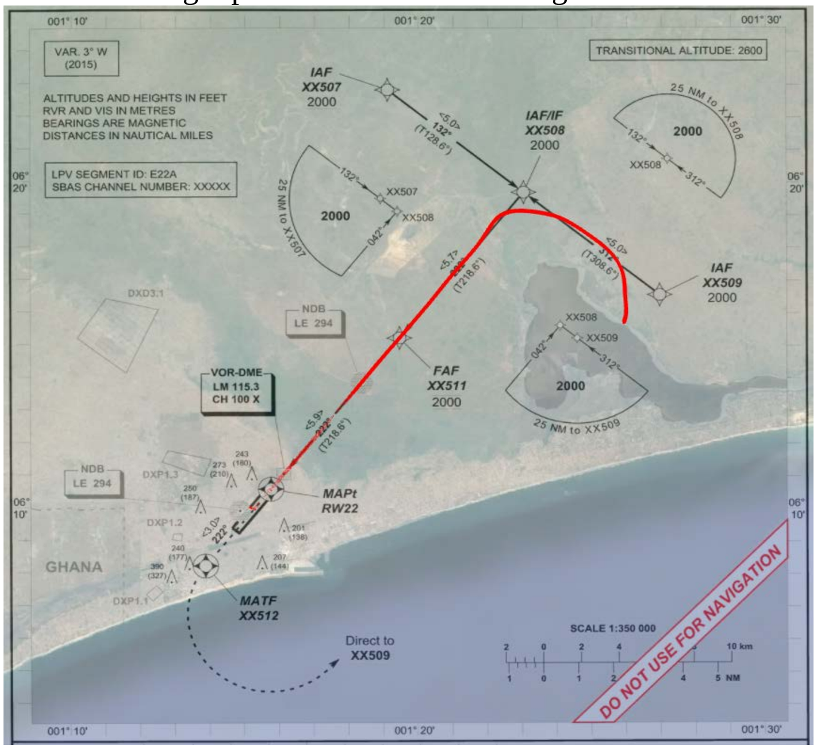

Figure 10: Recorded flight path vs. procedure chart

4.4 These results confirmed on the field the quality of the pre-operational signal on L1, and thereby the adequacy of the developed ionospheric models and the overall efficiency of the advanced correction algorithm and processing set.

4.5 Beyond technical validation, the demonstrations also provided the opportunity to showcase on the field the benefits of SBAS operations, in terms of safety improvement, operational costs reduction and environmental protection. VIPs and pilots from ASKY and Air Côte d'Ivoire, embarked for the occasion, provided very positive feedbacks in this regard. A video clip on these demonstrations is available here:

https://www.youtube.com/watch?v=UGz4xPxTYaU

4.6 A second series of demonstration was successfully carried out on 2nd June 2021 between Douala and Kribi in Cameroon with an AS365 N3 rotorcraft of Heli-Union. The rotorcraft performed a low-altitude two-way demonstration flight along a low-level route (LLR) linking two point-in-space (PinS) approaches (with LNAV an LPV minima) to the Douala airport and a point near the oil platforms off the Kribi coast.

Figure 11: Heli-Union AS365 N3 rotorcraft

Figure 12: Flight deck with external navigation display for SBAS demo flight

4.7 Good feedback of this demonstration flight was delivered by the rotorcraft operator and pilots with respect to the capability to perform all weather conditions operations.

4.8 Finally, two demonstrations on ancillary services (beyond aviation) were successfully performed on July 7 and 8, 2021 at Brazzaville (Congo), with the pre-operational A-SBAS L5 signal providing SBAS open service.

4.9 The first one concerned the Emergency Warning Service (EWS) via satellite and showed the system's ability to broadcast a warning message via the A-SBAS signal to mobile phones, without requiring a terrestrial network. This service sends an emergency message to the populations concerned, providing information on the type of danger and instructions to be followed.

4.10 The second one was related to the Precise Point Positioning (PPP) application with close-to-market prototype user terminal and entailed the transmission of GNSS corrections based on the A-SBAS pre-operational signal.

5. SUPPORT TO STANDARDISATION

5.1 The A-SBAS test-bed capability allows the conduct of advanced technical studies, which supports the standardisation efforts at ICAO, EUROCAE and RTCA levels, with a unique and valuable contribution due to its specific geographic position.

5.2 The flagship study undertaken in this frame is the assessment of the robustness of certified (i.e. MOPS compliant) airborne receiver against ionospheric scintillations. The data collected through the testbed are used to feed MOPS receivers with signals impacted by severe scintillations, and to assess the performances of the computed positions. The initial outcomes of this study, still on going, shows that GPS signals are properly processed by the receivers despite the adverse conditions, and that A-SBAS corrections will significantly improve the performances.

5.3 The outcomes are also used in contribution to the development, by ICAO NSP and MET panels, of guidance to flight crew on the operational use of Space Weather (SW) GNSS advisories (issued by the ICAO SW Information Centres).

5.4 They also support the development of DFMC MOPS by EUROCAE and RTCA, and the on-going update of the GNSS Manual (Doc. 9849) by the ICAO NSP.

6. A-SBAS SERVICES ADOPTION

6.1 A-SBAS services provision, as other SBAS in the world, will not introduce any extra air navigation charges, in line with the airlines' expectation reminded in the JURG position paper. The community of users not yet interested in the use of A-SBAS will not be penalised by SBAS operations, as existing navigation services will continue to be delivered and no mandatory equipage will be applied.

6.2 As part of the user adoption process, an Outreach event on "SBAS in aviation in Africa" was organised, in conjunction with the SatNav in Africa Joint Programme Office (JPO) on 28-29 January 2021, in the wake of the Lomé flight demonstrations. This event, held virtually, gathered more than 450 participants from all over the world, representing more than 30 airlines, key aircraft/avionics manufacturers (Airbus, Boeing, Embraer, ATR, Collins Aerospace, CMC Electronics), civil aviation authorities, SBAS providers (FAA, European Commission, …) and other aviation stakeholders. It was very successful with regards to its objective to develop a multilateral dialogue to accelerate user adoption and penetration of SBAS services, even beyond Africa. It also showed that avionics solutions are more and more available at lower cost, and that a growing number of airlines are adopting SBAS.

6.3 In the same vein, a set a business/economic studies on the use of A-SBAS services are on-going with partner airlines. A recent CBA developed with Air France, with the support of the SatNav in Africa JPO, assessed the business opportunity related to their future SBAS operations in sub-Saharan Africa with very positive results in terms of net profits and return of investment. In addition, individual business cases were developed with two individual African airlines, in cooperation with the Development Agency of the African Union (NEPAD). The outcomes were also very promising. As part of this exercise, two African-based financing institutions were approached and showed an interest in principle to be involved in the financing of African airlines equipage.

6.4 Bilateral consultations are also on-going with aircraft manufacturers, such as Airbus and Boeing, and with avionics manufacturers, such as Collins Aerospace, with the aim to boost the development of avionics solutions, especially in terms of retrofit either through Service Bulletin or Supplemental Type Certificate, as new aircraft are now expected to be standard fitted.

6.5 From an environmental protection perspective, a comprehensive and end-to-end C02 emissions assessment was performed for the development, provision and use of SBAS services, with a very positive result of a net reduction of a least 140 000 tons of Co2 per year over the 2025-2045 period. More information on this assessment can be found in ASECNA WP "Carbon footprint assessment as part of the implementation of CNS / ATM projects".

7. WAY FORWARD

7.1 The flow of history heads towards SBAS introduction over the world as baseline operations. An important number of airlines operating in the AFI airspace are interested in SBAS services, and some of them are even calling for expediting their deployment to take advantage of their benefits as soon as possible.

7.2 The "SBAS for Africa & Indian Ocean" provides a unique opportunity to respond to this need, and its development should be encouraged, as for any other SBAS initiative which may emerge in the continent.

7.3 To facilitate the stakeholders' decision-making on SBAS integration in their navigation strategy, a series of workshops to raise further awareness, from both ground and airborne perspectives, on SBAS technology, services provision and use thereof, should be organised following the conclusion of the continental CBA SBAS study.

8. ACTION BY THE MEETING

8.1 The meeting is invited to:

- note the significant achievements of the "SBAS for African and Indian Ocean"
- note the position on SBAS taken by the Joint User Requirements Group
- encourage the acceleration of SBAS services deployment and provision to meet requirements of the airspace users already interested
- recommend ICAO to facilitate, following the conclusion of the continental CBA SBAS study, a series of workshops with stakeholders to raise further awareness on SBAS technology, and services provision and use, from ground and airborne perspectives, and to facilitate thereby their decision-marking on SBAS integration in their navigation strategy