ICAO

Twenty-Third Meeting of the AFI Planning and Implementation Regional Group (APIRG/23)

(Virtual - 24, 25 and 26 November 2020)

Agenda item 4: Other Air Navigation Issues

4.1. Industry initiatives and other air navigation matters

"SBAS for Africa & Indian Ocean" development status

(Presented by XXX on behalf of ASECNA Member States)

(Prepared by ASECNA)

SUMMARY

SBAS benefits are today widely acknowledged by airspace users. In the AFI region, where these benefits are viewed to be much more important than in any other part of the world, a growing number of airspace users are interested in the use of SBAS services, and some are calling for expediting their deployment.

The "SBAS for Africa & Indian Ocean" (A-SBAS) programme, recognised by ICAO under Annex 10, primarily aims to provide autonomously airspace users with operational SBAS services from 2024, with a progressive coverage of the continent. These services are intended to support en-route, APV-I and CAT-I operations, to enhance PBN and ADS-B operations for all phases of flight. This paper presents the development status of this programme, and progress of the dialogue with airspace users regarding the adoption of the services.

The meeting is invited to:

a) note the growing interest of airspace users in SBAS operations in the AFI region, as well as the significant progress made in the development of the "SBAS for Africa and Indian Ocean"

a) note that the restriction to operations is not justified due to lack of SBAS equipment and no costs related to SBAS being imposed directly or indirectly to airspace users who do not use such technology and

b) Recommend :

   i. expeditious completion of the dialogue to accelerate the provision of SBAS services in the AFI region, based on the "SBAS for Africa and Indian Ocean" and any other initiative that may emerge, to enable interested users to take advantage of the benefits as soon as possible;

   ii. Speedy conduct of the continental CBA SBAS study, to facilitate decision-making for the adoption of SBAS by the community of potential users

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

1. INTRODUCTION

1.1 Airspace users increasingly integrate SBAS in their navigation strategy, based on their own assessment of the positive benefit/cost ratio. SBAS services are in exponential development in the world, and avionics solutions are more and more available at lower cost. It is largely recognised that, in 2030, SBAS will be the baseline navigation system, as GPS is today.

1.2 A growing 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 safety, efficiency, and environmental benefits as soon as possible.

1.3 The "SBAS for Africa & Indian Ocean" provides a unique opportunity to respond to this need. This programme, recognised by ICAO for SBAS services provision in Africa under the SBAS provider identifier n°7 as per the provisions of the Annex 10, is under development for the benefit of the AFI Region. It primarily pursues the autonomous provision of SBAS services from the 2024 time-horizon to enhance navigation and surveillance operations, and to meet airspace users' requirements in this regard.

1.4 This initiative is also a key enable to the operationalisation of the Single African Air Transport Market (SAATM) and is part of the implementation the African Union Space Policy and Strategy, which call for an indigenous continental level navigation augmentation system for Africa. The initiative is also developed within the framework of the Africa-EU Strategic Partnership.

2. FEASIBILITY OF SBAS IN AFRICA

2.1 By providing both horizontal and vertical geometric guidance, without local ground infrastructure, and offering lower minima down to 200 feet as for ILS CAT-I, SBAS services provide an efficient solution for precision approaches everywhere every time, while enabling improvement of RNAV routes availability and flexibility.

2.2 SBAS services performances can be affected by the perturbation of core constellations signals due to the ionosphere, especially in the equatorial region where it has a specific dynamic compared to high and mid- latitudes.

2.3 In this context, feasibility studies were performed from 2011 to 2015, to characterise the ionosphere and optimise the SBAS correction algorithm for the African equatorial region.

2.4 With the support of the French Space Agency (CNES) and of the European Space Agency (ESA), a dedicated network of GNSS stations, so-called SAGAIE, was deployed to collect and process real GNSS data from core constellations.

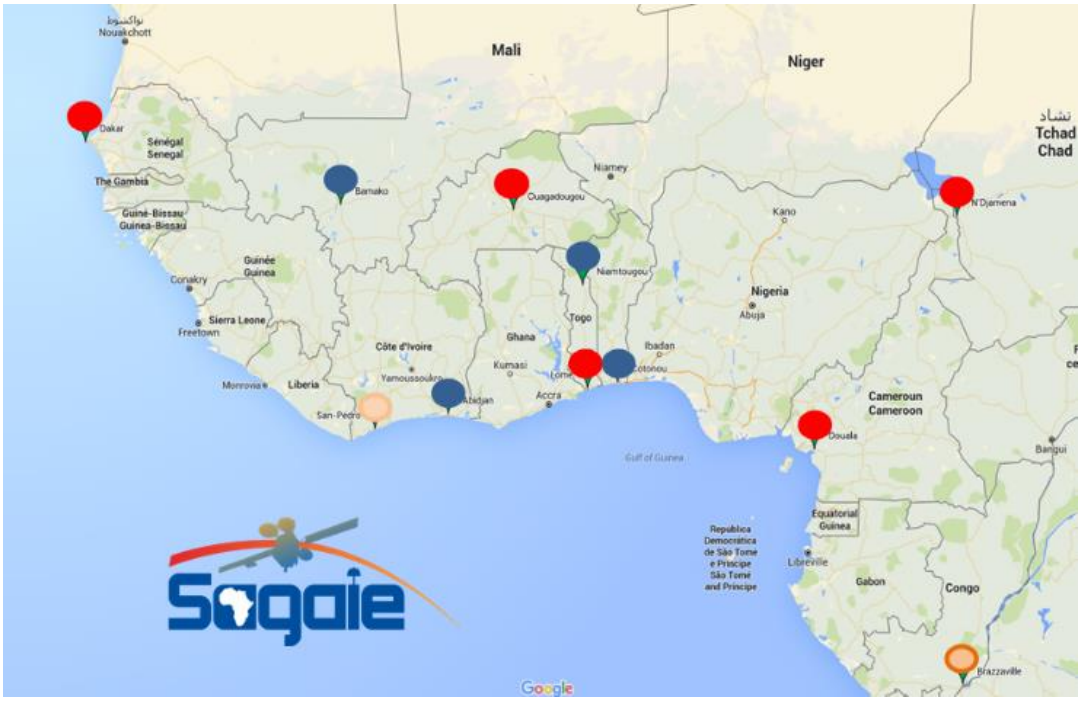

Figure 1: SAGAIE network of GNSS stations

2.5 The studies undertaken included analysis of scintillations, plasma's bubbles and Total Electronic Content to characterise the physical phenomena of the equatorial ionosphere, and SBAS emulation using a representative test platform and an advanced tuning of SBAS correction algorithms and processing set.

2.6 The studies demonstrated the feasibility of SBAS services provision in compliance with corresponding SARPs contained in ICAO Annex 10, including during high ionosphere activity periods.

2.7 This demonstration positions ASECNA at the cutting-edge of this technology issue in the world.

3. SERVICES PROVISION AND INFRASTRUCTURE

3.1 The "SBAS for Africa & Indian Ocean" primarily aims to provide autonomously Safety of Life (SoL) service for safety critical applications in aviation, to support en-route/NPA (RNP 0.3), APV-1 and CAT-I operations according to three separate services level.

3.2 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 (Dual-Frequency Multi Constellation).

3.3 More specifically, the services provision plan involves three essential steps:

- Provision of a pre-operational service from 2020, in Western and Central Africa, to support field demonstrations
- Provision of mono-frequency (L1) services from 2024, with a potential progressive coverage of the continent, to support en-route down to CAT-I operations
- Provision of DFMC services beyond 2028-2030, to support CAT-I autoland operations and beyond

3.4 The SBAS signal-in-space will be compliant with corresponding SARPs from ICAO Annex 10, and with Minimum Operational Performance Standards (MOPS) published by RTCA (Radio Technical Commission for Aeronautics) and EUROCAE (European Organisation for Civil Aviation Equipment). Thus, it will be interoperable with the other SBAS, ensuring a seamless transition for aircraft flying to or arriving from other SBAS service areas.

3.5 The infrastructure to support such an autonomous services provision will be owned and operated by African stakeholders, as a solution deployed by Africa for the benefit of Africa.

3.6 It will comprise a network of Navigation Reference Stations (NRS), Mission Control Centre(s) (MCC), Navigation Broadcast Stations (NBS), an SBAS wide area transport network, and a space segment composed of one or several geostationary (GEO) satellites.

3.7 The correction messages are calculated by dedicated processing and check-set systems in the Mission Control Centres (MCC), using the GPS and GALILEO constellations data collected by the network of reference stations (NRS) whose geographic distribution allows to optimise the observations of the satellites and the propagation conditions of their signal. The messages are then transmitted via the uplink stations (NBS) to the space segment which in turn broadcast these messages to every aircraft in the service areas.

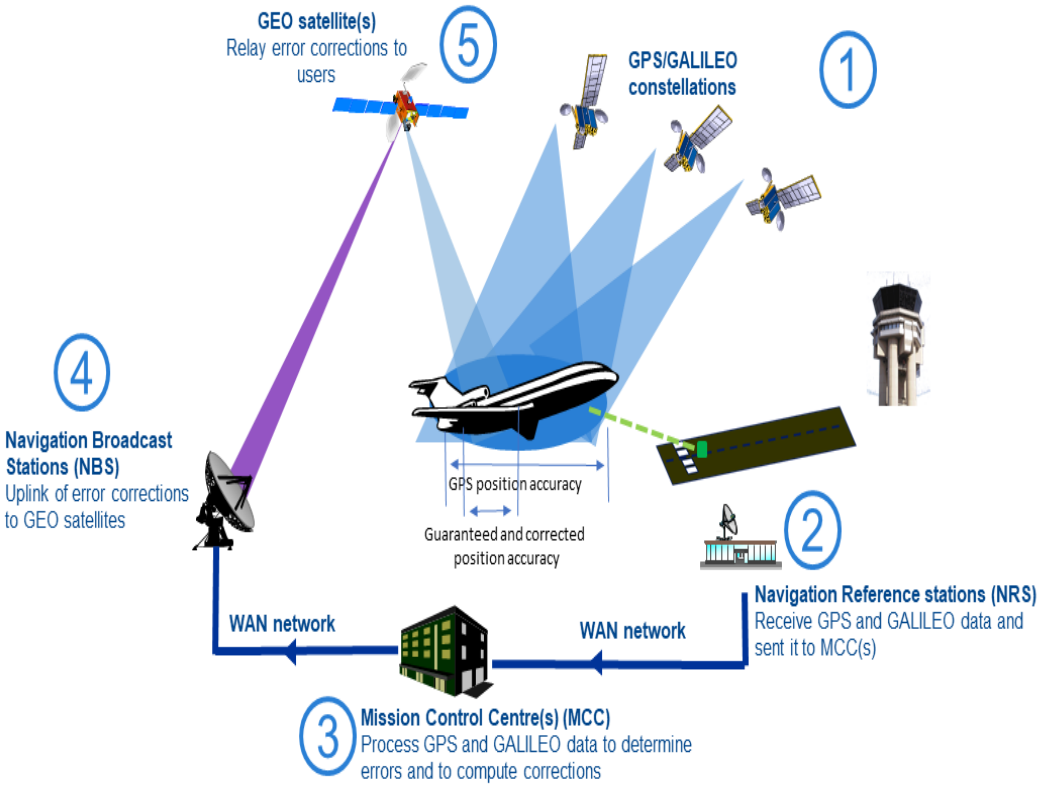

Figure 2: "SBAS for Africa & Indian Ocean" concept

3.8 Regarding L1 services, the achievements of the system development are to date the following:

- The system architecture is fully defined
- 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 deployment plans are developed, as well as the plan of migration towards DFMC

3.9 The next steps will aim to proceed to these development, qualification, deployment, and entry into operations of the system. Critical Design Review (CDR) and Acceptance (AR) are planned in 2022 and 2023 respectively, in view of the entry into operations in 2024.

4. POTENTIAL COVERAGE AND PERFORMANCES

4.1 The potential coverage and performances are now validated with an industrial commitment. The following figures show the achievable performances over the AFI region for the en-route/NPA and APV-1 service levels:

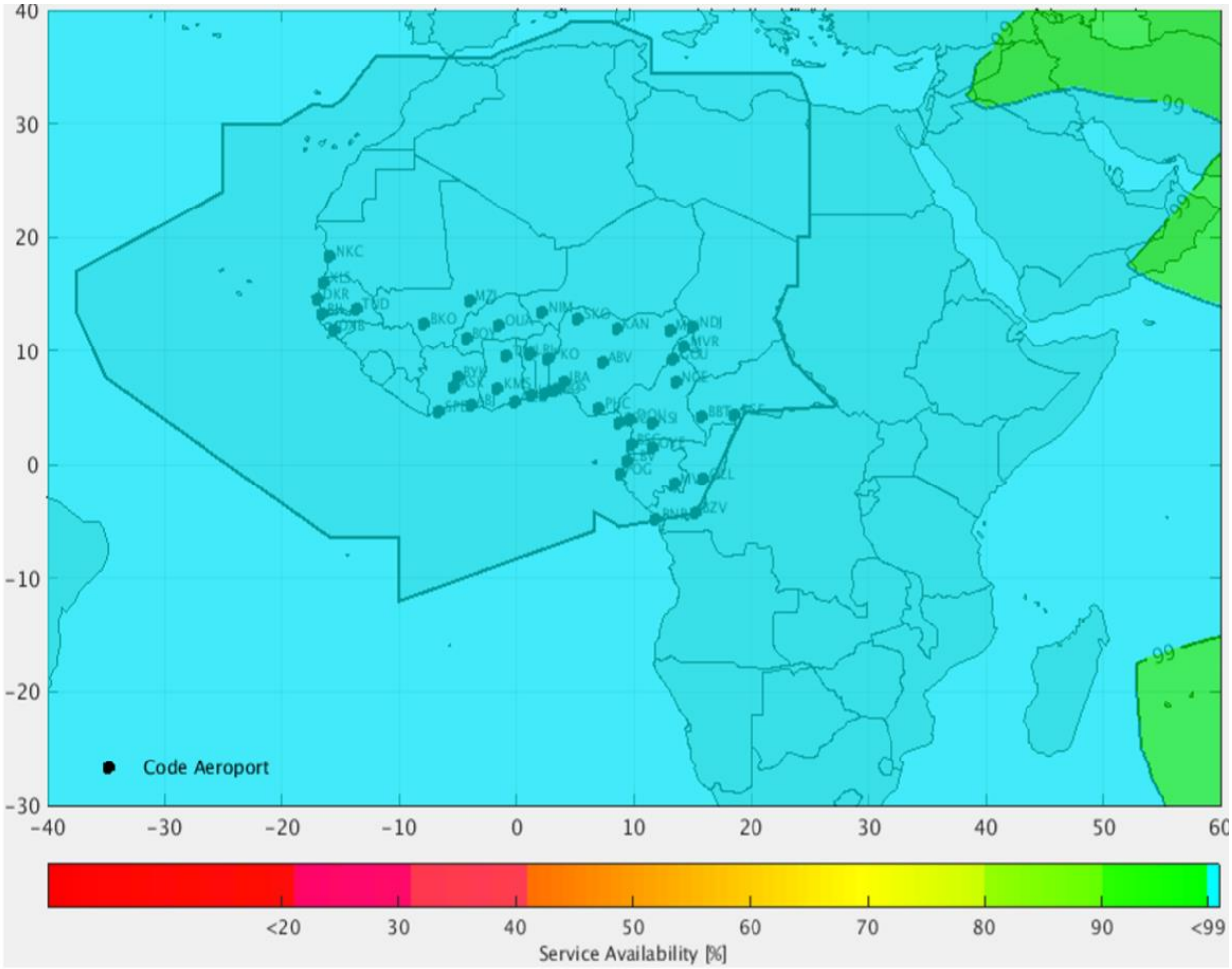

Figure 3: En-route/NPA service availability map

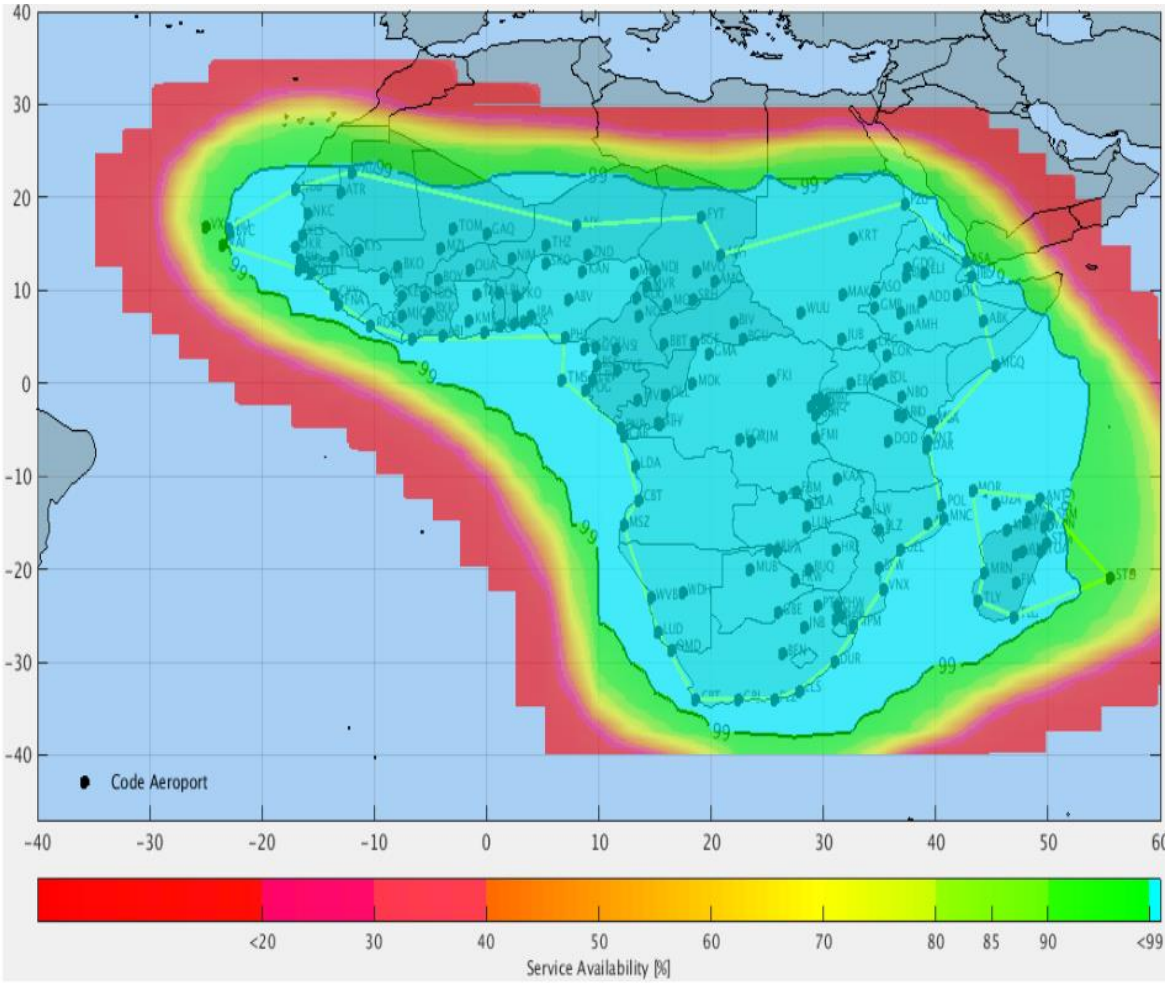

Figure 4: APV-1 service indicative availability map

5. PRE-OPERATIONAL SERVICE

5.1 First essential step of the "SBAS for Africa & Indian Ocean" services provision plan, the SBAS pre-operational service provision is effective since September 2020. It is the first ever SBAS open service to be provided in the part of the globe.

5.2 Its main objectives are to carry-out signal tests and technical trials, to build competencies for operations and to perform with partner airlines (ASKY, Air Côte d'Ivoire, Air Senegal, Air France, Emirates …) field demonstrations in the aviation domain for aircraft and rotorcraft, to showcase the benefits of the future operational safety-of-life SBAS services. Aircraft demonstrations scenario will focus on flying RNP to LPV transition procedure for arrival and RNP APCH (down to LPV minima) approach. Rotorcraft demonstrations will aim to fly a low-level route (LLR) and a "Point-in-Space" (PinS) approach.

5.3 This early service is based on the broadcast of a test signal-in-space, from a pre-operational infrastructure deployed with the support of the Thales Alenia Space company and of Nigcomsat LTD. This infrastructure is composed of the SAGAIE GNSS stations network, a demonstrator, an uplink station and the GEO satellite NigComSat-1R.

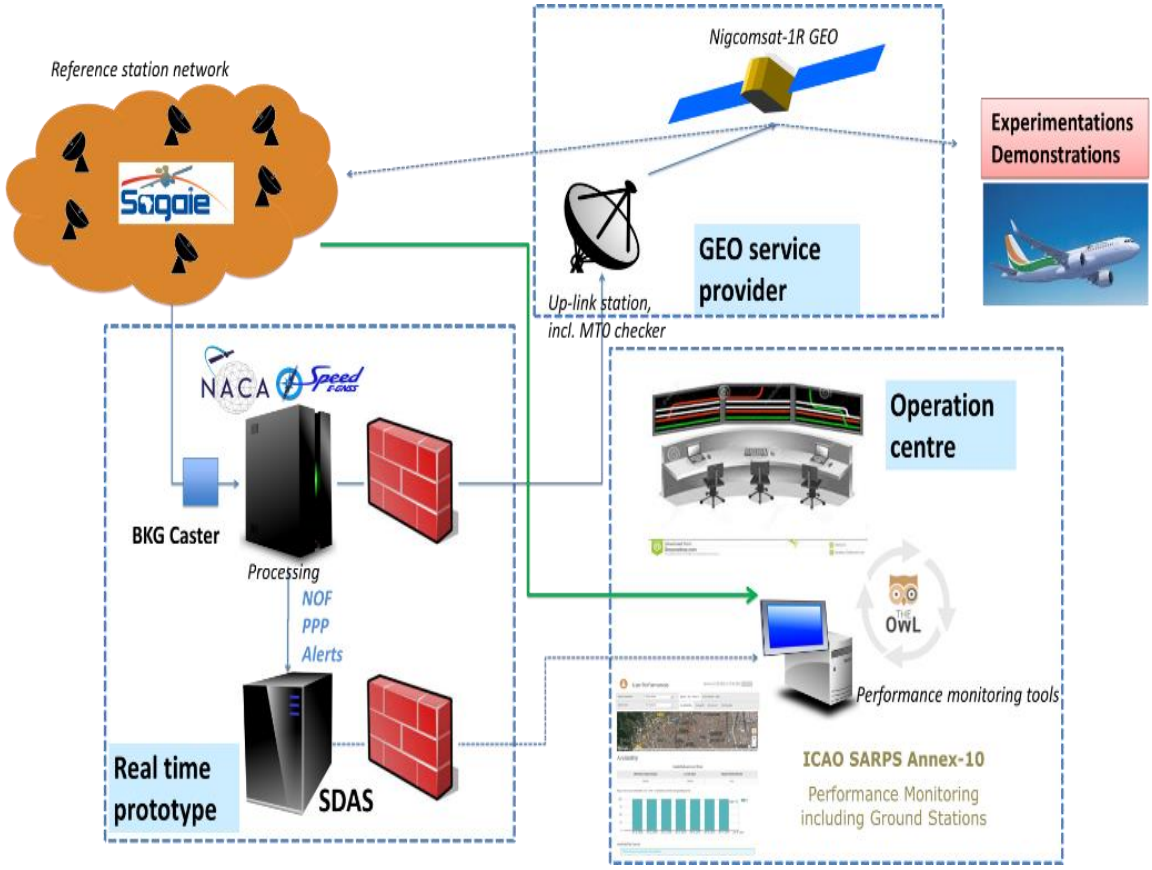

Figure 5: Pre-operational system architecture

5.4 The signal-in-space is compliant to the ICAO SARPs and to the RTCA DO-229E MOPS. It includes a message type MT0 to prevent any use for safety critical applications, including any use by aircraft equipped with certified SBAS receivers. It is visible in the whole Africa and Indian Ocean, up to the West Australian coast, and in Europe, as per the coverage area of the NigComSat-1R satellite:

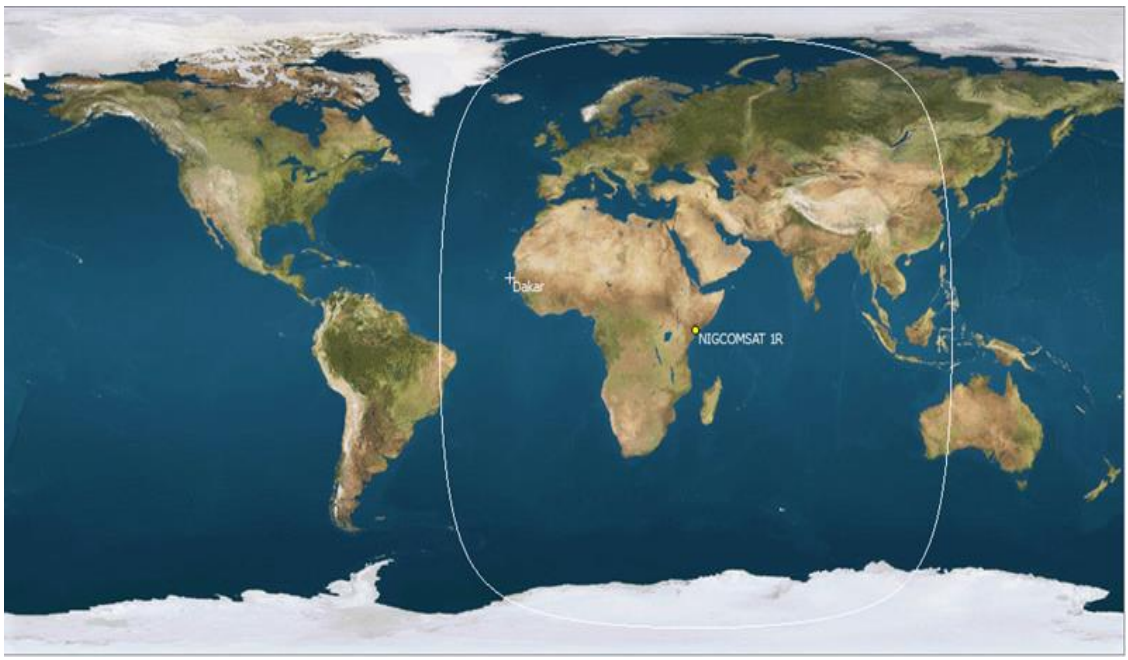

Figure 6: Nigcomsat 1-R GEO coverage (PRN 147)

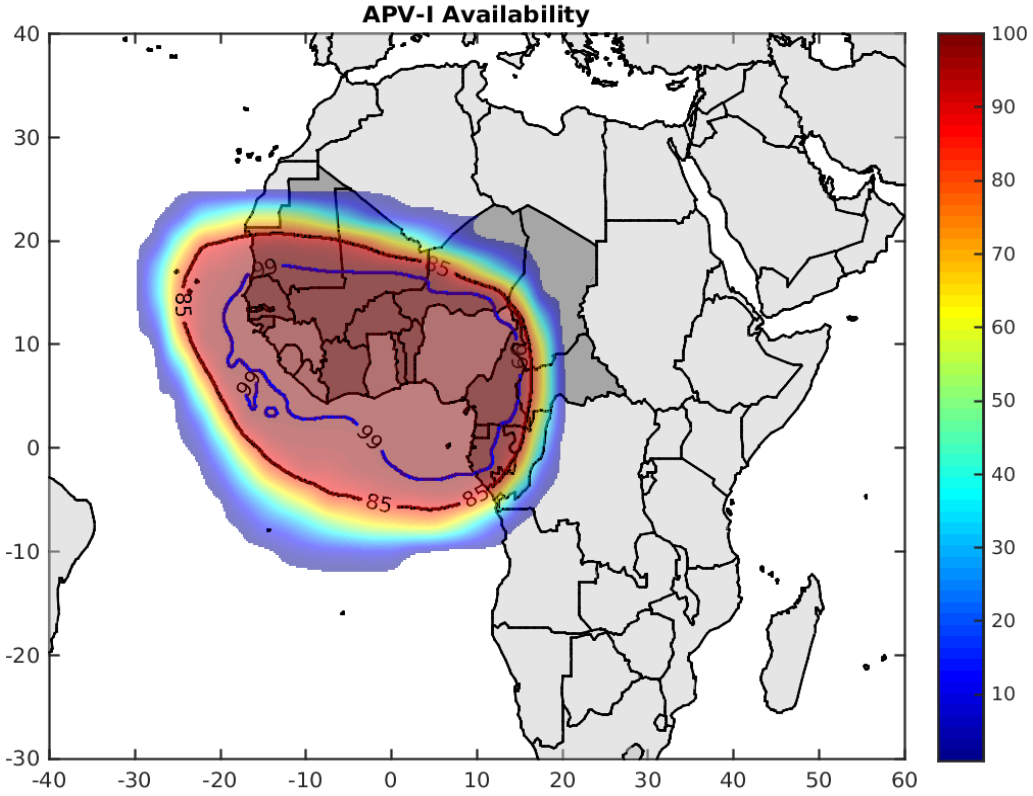

Figure 7: Pre-operational APV-I service availability (5 October 2020)

5.5 Considering the limited network of basic GNSS stations, and even if the solar cycle is currently is at a low point, the observed performances of this pre-operational service are very good, confirming in the field the adequacy of the ionospheric models and the efficiency of the advanced correction algorithm and processing set which have been developed.

5.6 Followed by the international community, the provision of the pre-operational service is major step forward in the development of satellite navigation in Africa.

6. USE OF SBAS SERVICES

6.1 SBAS benefits are today widely acknowledged by airspace users, thanks to the global expansion of SBAS services over the world. An important number of airlines have integrated or plan to integrate SBAS in their navigation strategy, based on their own assessment of the positive benefit/cost ratio.

6.2 The use of SBAS services indeed provides various benefits to airspace users for all phases of flight, from en-route down to approaches, through the enhancement of PBN and ADS-B operations, significantly improving flight safety and efficiency.

6.3 A recent cost-benefit analysis (CBA) undertaken by ASECNA in conjunction with the EGIS-AVIA company, and with the support of the EGNOS-Africa Joint Programme Office (JPO), has assessed the profitability of the use by airlines of SBAS services in the AFI airspace, over the 2025-2045-time period.

6.4 This study focused on the profits for airlines, and did not cover the air navigation services providers, airport operators, and States and citizen perspectives.

6.5 It assessed the overall net profits as the difference between the present value of the benefits (of use of SBAS services) and the present value of costs (of acquisition of SBAS capability), the ratio between the net profits and the costs to emphasise the return on investment, and the payback period as the length of time the users recover their initial investment.

6.6 Conservatively, the quantified benefits only include:

- Reduction of the risk of Controlled Flight Into Terrain (CFIT)
- Reduction of delays and diversions
- Reduction of flight time through:
  a) Elimination of the operational practice of landing at the opposite QFU
  b) Optimisation of approach trajectories
  c) Optimisation of en-route trajectories in ADS-B airspace

6.7 All the other benefits, such as increased options for alternate runways, lower fuel load requirements, increased dispatch reliability, elimination of the pre-flight requirement to ensure GPS availability using RAIM prediction tools and increased runway throughput were not considered for the quantification.

6.8 The quantified costs covered:

- SBAS airborne equipment acquisition, integration and installation
- Flight crew training, and operational/technical documentation
- Certification

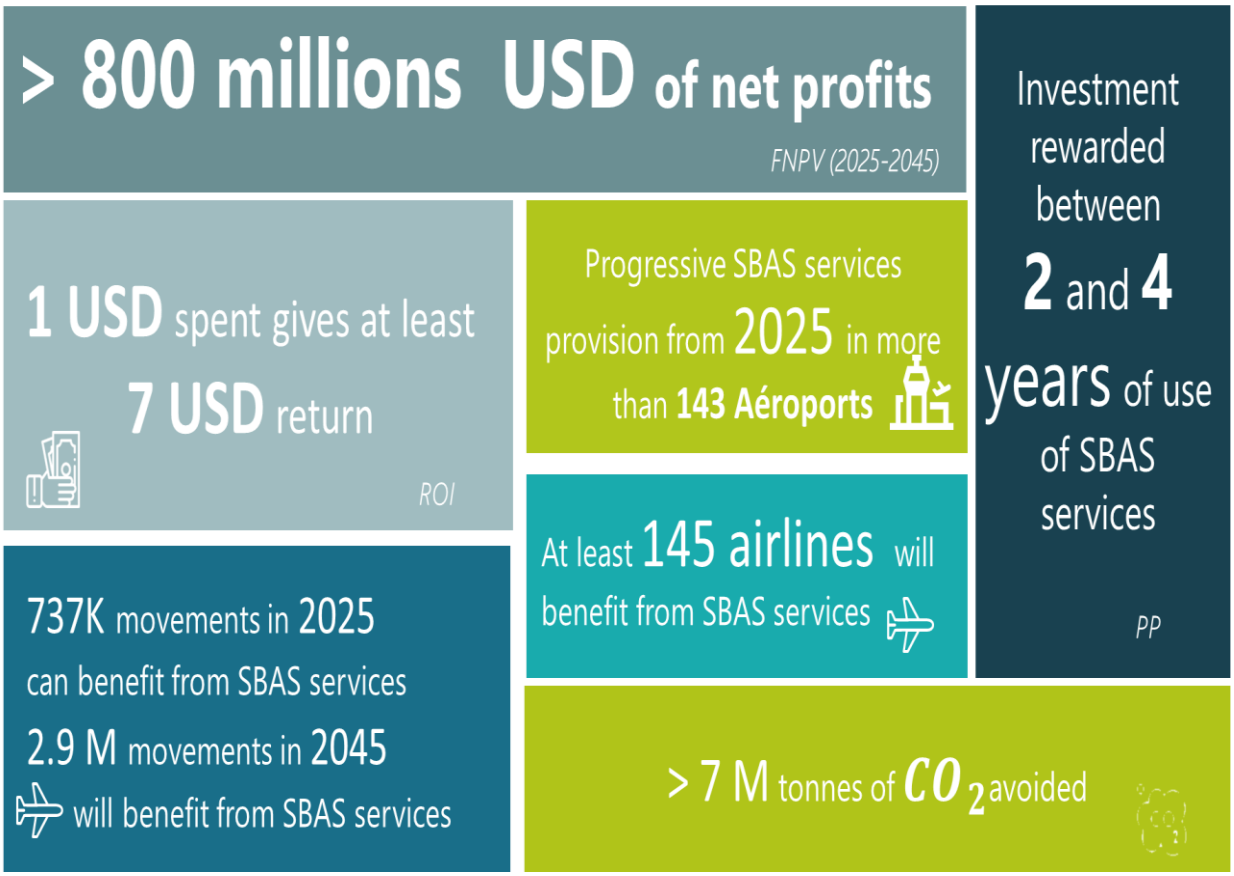

Figure 8: Outcomes of the SBAS CBA study for airlines

6.9 The study shows conservatively that the net profits for airlines generated by SBAS operations in the AFI region will be higher than 800 million USD. During the same period, more than 7 million tonnes of CO2 emissions will be avoided.

6.10 In terms of global return on investment, use of SBAS services will produce a net profit for airlines higher than 7 USD for each USD spent. As regard to the payback period, the initial investment of airlines to acquire the SBAS capability will be recovered between 2 and 4 years after starting the use of the services.

6.11 These outcomes were reviewed with partner airlines such as ASKY, Air Côte d'Ivoire, Air Senegal and Air France.

7. ADOPTION OF SBAS SERVICES

7.1 SBAS benefits are nowadays widely acknowledged by airlines, which integrate increasingly SBAS in their navigation strategy. SBAS services are in exponential development in the world, and avionics solutions are more and more available at lower cost.

7.2 Several airlines operating in the AFI airspace, such as ASKY, Air France and Qatar Airways, are not only interested in SBAS services, but are also calling for expediting their deployment to improve the safety and efficiency of air navigation over the continent.

7.3 Other airlines are also assessing the possibility to adopt SBAS, considering the growing number of airborne SBAS solutions offered by aircraft at very acceptable costs. In this frame, some African airlines, such as Ethiopian Airlines for their A350 fleet, has already acquired the SBAS capability.

7.4 The trend of aircraft SBAS solutions is indeed very positive, including as a consequence of the US ADS-B mandate and of the PBN regulation in Europe.

7.5 It is expected that the number of forward-fit or retrofit SBAS avionics will significantly increase in the next years. SBAS capabilities are today available in forward-fit (standard or as customer option) and in retrofit in the Airbus A220 and A350, ATR 42 and 72, Embraer ERJ-135-140-145-170-175-190-195 and Bombardier Q-Series and CRJ, to name just a few of them. SBAS solutions for the A320/A330, A380 and B737 will be available in the short term. From 2025-27, it is expected that all new aircraft will offer SBAS capabilities.

8. WAY FORWARD

8.1 The flow of events is directing towards SBAS introduction over the world as baseline operations, as GPS is today.

8.2 A growing 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.

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

8.4 Regarding potential users not yet interested, there is no penalty imposed by SBAS operations, as existing navigation services will continue to be delivered and no mandatory equipage will be applied. To facilitate decision-making for adoption of SBAS by these users, the conduct of the continental CBA study is to be expedited.

9. ACTION BY THE MEETING

9.1 The meeting is invited to :

a) note the growing interest of airspace users in SBAS operations in the AFI region, as well as the significant progress made in the development of the "SBAS for Africa and Indian Ocean"

b) recommend :

- accelerating the provision of SBAS services in the AFI region, based on the "SBAS for Africa and Indian Ocean" and any other initiative that may emerge, to enable interested users to take advantage of safety, efficiency and environmental benefits as soon as possible, as existing navigation services continue to be delivered to uninterested users, to which no SBAS mandate should be applied,
- no unjustified restriction to operations due to lack of SBAS equipment and no costs related to SBAS being imposed directly or indirectly to airspace users who do not use such technology.

c) recommend speeding up the conduct of the continental CBA SBAS study, to facilitate decision-making for the adoption of SBAS by the community of uninterested users.