INTERNATIONAL CIVIL AVIATION ORGANISATION

Third Meeting of APIRG Infrastructure and Information Management Sub-Group (IIM/SG/3)
Virtual meeting, 12-14 October 2020

Agenda item n°4: Status of implementation of APIRG projects

"SBAS for Africa & Indian Ocean" development status

(Prepared by ASECNA)

SUMMARY

SBAS services are key enablers to an airspace harmonised continuum in Africa, an essential pillar of the operationalisation of the Single African Air Transport Market (SAATM), and to the implementation of the Space Policy and Strategy of the Africa Union which call for an indigenous continental level navigation augmentation system for Africa.

In this regard, the "SBAS for Africa & Indian Ocean" programme, recognised by ICAO under the Annex 10, primarily aims to provide autonomously airspace users with mono-frequency (L1) services from 2024, with a progressive coverage of the continent. These services are intended to support en-route/NPA, APV-1 and CAT-I operations, and thereby to enhance PBN and ADS-B operations in Africa for all phases of flight.

This paper provides an update on the development status of the programme.

The meeting is invited to:

- note the achievements to date of, and to assimilate, the "SBAS for African & Indian Ocean" programme
- consider this initiative as a flagship programme for the benefit of the continent, and give mandate to expedite its development under the aegis of the African Union Commission and of the African Civil Aviation Commission
- support the other initiatives and thoughts to pool resources and to provide in the medium to long term the capabilities for SBAS services provision for the entire African continent

Related ICAO Strategic Objectives	A – Safety, B – Air Navigation Capacity and Efficiency, D – Economic Development
ASBU KPIs and B0 modules	PIA 1 (B0 – APTA), PIA 3 (B0 - FRTO), PIA 4 (B0-CDO)

1. INTRODUCTION

1.1 The use of enabling technologies constitutes a fundamental pillar of the operationalisation of the Single African Air Transport Market (SAATM). Indeed space-based technologies, infrastructure and services, and especially satellite navigation services, provide new and innovative solutions to address today's technical and operational challenges of air navigation over the continent, helping to favour development and growth.

1.2 The so-called "SBAS for Africa & Indian Ocean", recognised by ICAO for SBAS services provision in Africa under the SBAS 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 mono-frequency (L1) services from the 2024 time-horizon to enhance navigation and surveillance operations, and to meet airspace users' requirements in this regard.

1.3 Beyond the SAATM and its Single Sky component, the initiative aims also to contribute to 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. FEASABILITY OF SBAS IN AFRICA

2.1 Satellite navigation, as an enabler to area navigation (RNAV), provides flexibility for new, innovative and more efficient routes, reducing flight time, noise, and CO2 emissions, while increasing flight safety, especially for the arrival and landing phases through precision approaches.

2.2 Core constellations (such as GPS) enable indeed only non-precision approaches, with geometric lateral guidance only, the final approach segment being flown using the CDFA (Continuous Descent Final Approach) technique. Vertical guidance is not provided due to important limitations, mainly for reasons related to observation of satellites. This lack of vertical guidance in an important contributory factor to the risk of CFIT accident.

2.3 Barometric vertical navigation can be used but has known safety and operational performance limitations, due to linkage with QFE setting and non-optimal minima. On its side, although providing both horizontal and vertical guidance, ILS requires local ground infrastructure and is not deployed on all runway thresholds. Only main airports are served by ILS today, and when so, it is mostly only at one runway threshold.

2.4 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.

2.5 This is allowed by the augmented performances offered by SBAS, in terms of availability, continuity and integrity of operations. However, these 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.

2.6 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.

2.7 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.

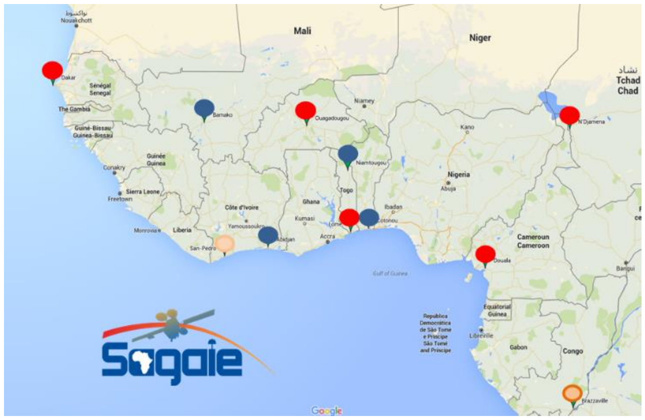

Figure 1: Network of SAGAIE GNSS stations

2.8 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.

2.9 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.

2.10 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.

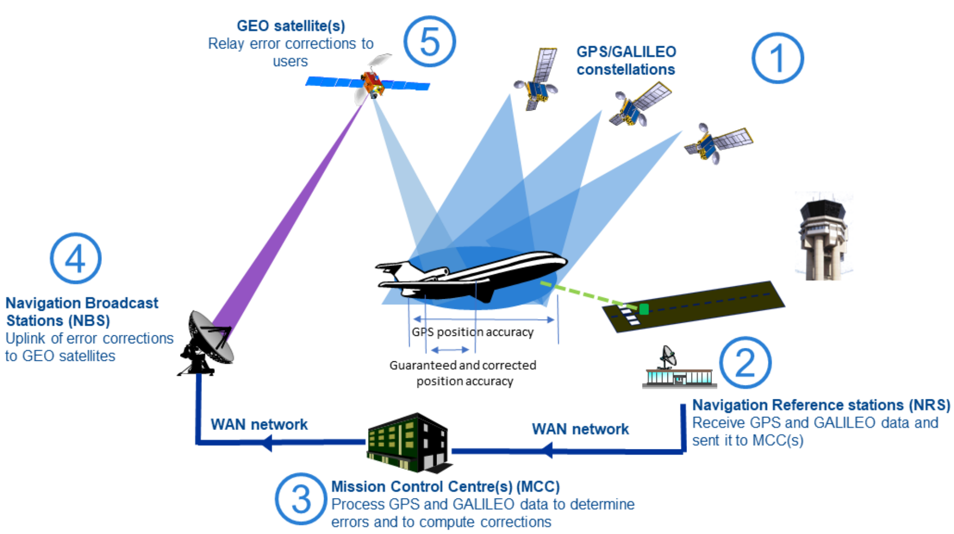

Figure 2: "SBAS for Africa & Indian Ocean" concept

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.

4.2 The following figures show some achievable performances over the AFI region for the en-route/NPA and APV-1 service levels:

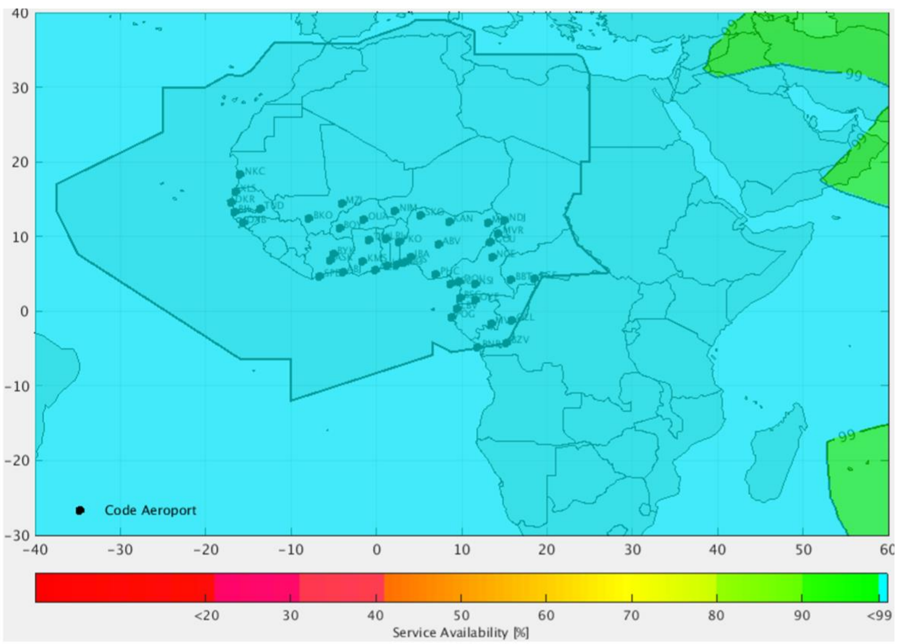

Figure 3: En-route/NPA service availability map

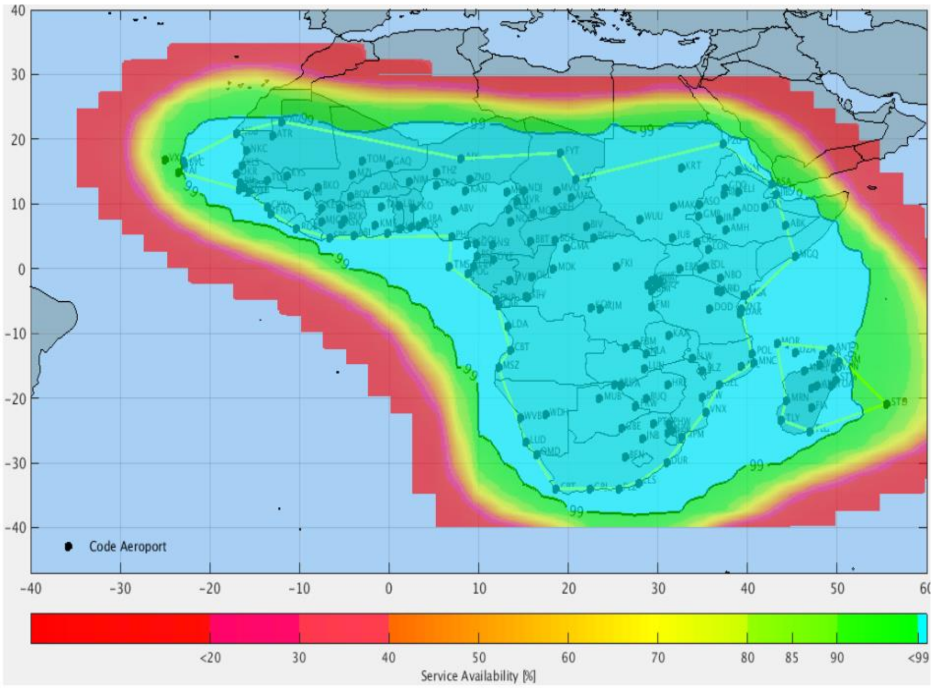

Figure 4: APV-1 service indicative availability map

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 technical trials, to build competencies for operations and to undertake 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. Demonstrations in the field of Precise Point Positioning (PPP) and Emergency Warning Services to populations (EWS) will also be undertaken.

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.

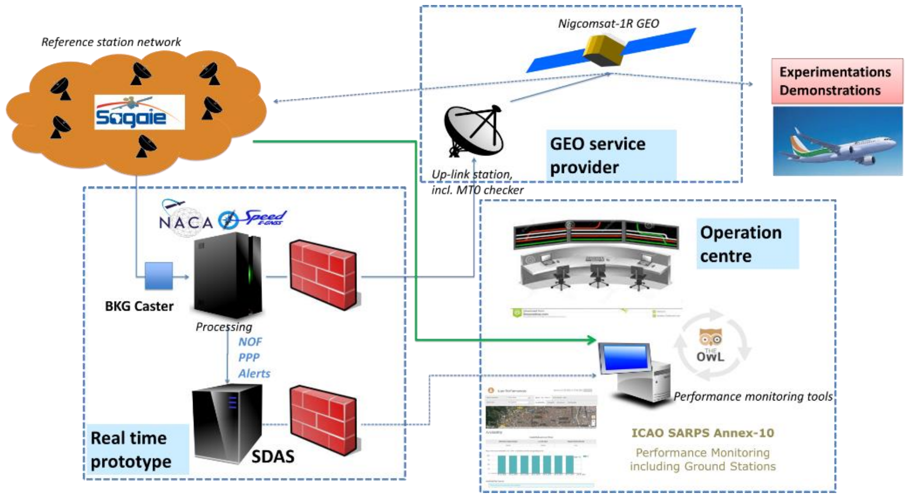

Figure 5: Pre-operational system architecture

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:

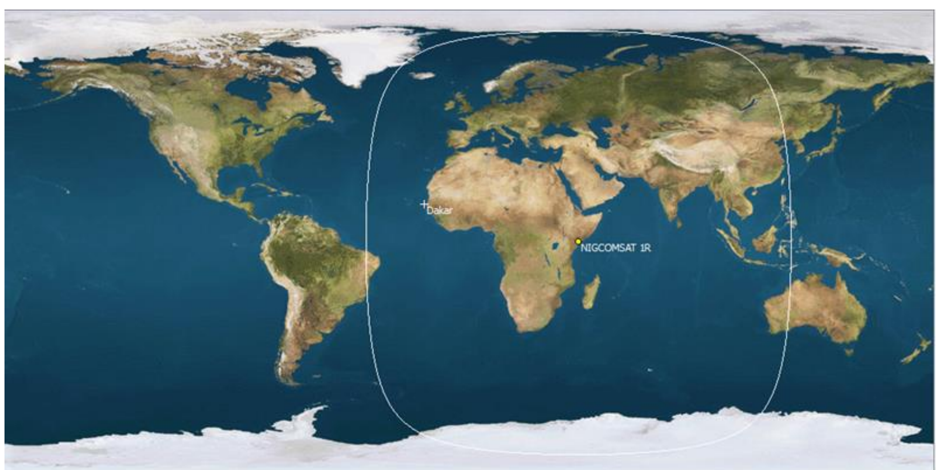

Figure 6: Nigcomsat 1-R GEO coverage (PRN 147)

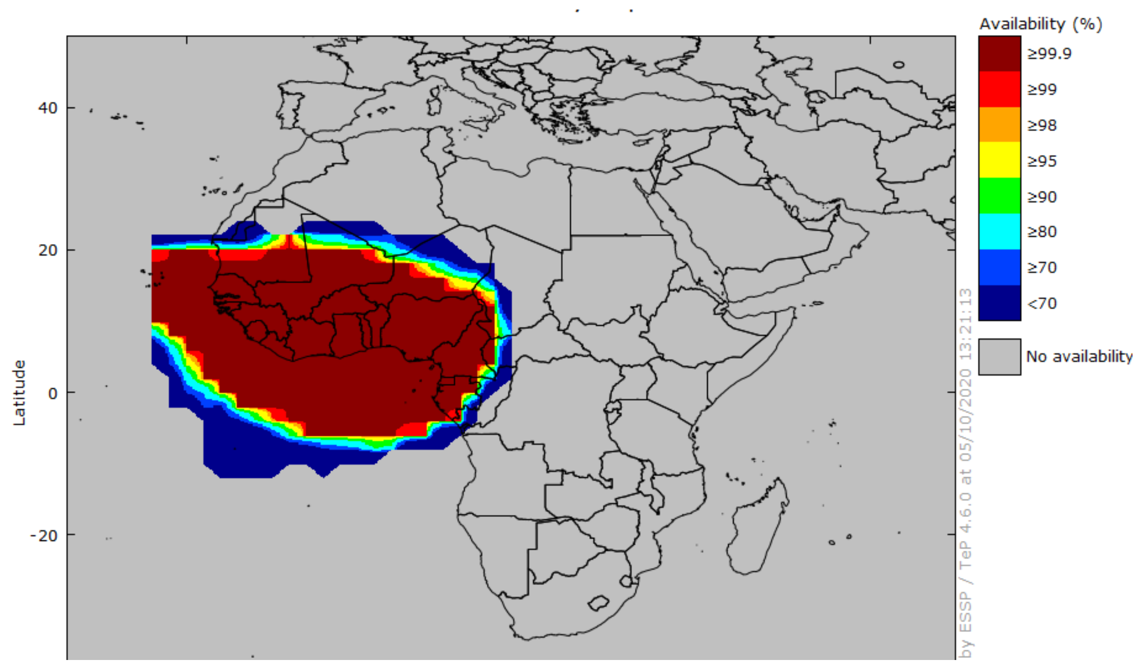

Figure 7: Pre-operational APV-I service availability (30 September 2020)

5.5 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. WAY FORWARD

6.1 The flow of history heads towards SBAS introduction over the world as baseline operations, as GPS is today, and the “SBAS for Africa & Indian Ocean” aims to ensure that the AFI region is not left behind thereof.

6.2 “SBAS for Africa & Indian Ocean” constitutes a fully-fledge African initiative developed for the benefit of Africa, and need to be further developed in coordination with AFCAC and under the aegis of the African Union.

6.3 From a planning perspective, SBAS shall be positioned as a high priority of the AFI GNSS strategy, and its introduction shall be expedited to improve air navigation services safety and efficiency and to respond to airspace users’ requests. This would not be in contradiction with the need impact analysis requested by APIRG conclusion 19/29, as this analysis shall consider the SBAS initiatives under development, as requested by the African Union Ministerial Specialised Technical Committee TTIEET.

7. ACTION BY THE MEETING

7.1 The meeting is invited to:

- note the achievements to date of, and to assimilate, the "SBAS for African & Indian Ocean" programme
- consider this initiative as a flagship programme for the benefit of the continent, and give mandate to expedite its development under the aegis of the African Union Commission and of the African Civil Aviation Commission
- support the other initiatives and thoughts to pool resources and to provide in the medium to long term the capabilities for SBAS services provision for the entire African continent