SUPPORTING GNSS/SBAS DEVELOPMENT AND IMPLEMENTATION FOR AFRICA DEVELOPMENT
EU/AFRICA Partnership on Satellite Navigation

BUILDING TOGETHER SATELLITE NAVIGATION SERVICES FOR AFRICA
EGNOS AFRICA JOINT PROGRAMME OFFICE (JPO)
Space-based positioning, navigation, and timing systems are currently used in a wide variety of applications. Their economic benefits have been growing year by year with the introduction of new applications.

The development of satellite navigation in Africa is an overarching objective of African Union Space and Policy Strategy and the AIM Strategy 2050 for seas and oceans adopted in 2016 by the 26th Africa Union Summit and is embedded in Agenda 2063 Flagship Programmes.

It is fully in line with the world trend where 4 global navigation systems and 8 regional SBAS will be available.
Overview of the Global Navigation Satellite System (GNSS)

GNSS allows users with compatible receiver devices to determine their position, velocity and local time by processing signals from satellites in point positions within space. GNSS signals are provided by a variety of satellite positioning systems including global (core constellation) systems (e.g. USA’s GPS and Russia’s GLONASS), Satellite Based Augmentation Systems (e.g. Europe’s EGNOS) as well as ground and aircraft based augmentation systems, as illustrated below.

SBAS System Overview

GNSS Global Systems, when used alone, have a number of limitations; most importantly they cannot be used for applications that have stringent requirements in terms of accuracy (less than 10 meters), integrity, continuity and availability. To overcome this limitation, SBAS, one of the existing augmentation systems, provides error correction information via geostationary satellites to users of the primary GNSS system services. SBAS complements GNSS system performance to improve accuracy, integrity, continuity and availability, making it compliant with the stringent requirements of specialised applications such as the operational requirements set by the International Civil Aviation Organization (ICAO) for use during the most critical phases of aircraft flight, in particular final approaches. SBAS has been implemented or is undergoing implementation in several parts of the world. WAAS (US), EGNOS (Europe), MSAS (JAPAN) and GAGAN (India) are in operation while SDCM (Russia), KASS (South Korea) and BDSBAS (China) are under development and deployment. In addition, there are ongoing initiatives such as Australian SBAS and SBAS ASECNA. At this level, the overall coverage of SBAS is growing.
2.3 SBAS SYSTEM: THE CASE OF EGNOS

TECHNOLOGY BASED ON EGNOS

The European Geostationary Navigation Overlay Service (EGNOS) consists of various components: (I) Ranging and Integrity Monitoring Stations (RIMS) that receive satellite signals and send this information to (II) the Mission Control Centres (MCCs). Correction messages are generated to improve signal accuracy and provide information on the status of the satellites (integrity). (III) Navigation Land Earth Stations (NLES) receive the correction messages and upload the data stream to geostationary satellites which then transmit the data to users. As a result, EGNOS allows users to determine their position down to 1-2 meters compared to the 5-10 meters presently guaranteed by GPS alone.

2.4 EGNOS RANGE OF SERVICES

There are three EGNOS services that are currently provided in Europe and these are:

- The EGNOS Open Service (OS) available to any user equipped with an EGNOS-enabled receiver and operating within the EGNOS Open Service area. It is intended for non-safety critical applications.

- The Safety of Life Service (SoL) which has a committed performance that is tailored to safety critical transport applications, especially aviation. The use of this service is subject to regulatory requirements such as certified SoL SBAS receivers.

- The EGNOS Data Access Service (EDAS), a commercial data service which provides access of EGNOS data, to authorised users through a ground-based transmission network. Ultimately, it is envisaged that EDAS will add value to a range of multimodal applications in the professional GNSS market and related research and development (R&D) activities.

2.5 SBAS BENEFITS

IN THE AVIATION SECTOR

Aviation is the main driver of SoL service. SBAS provides the accuracy, integrity, service continuity and availability needed to rely on GNSS navigation for all phases of flight; from en-route through Category I equivalent approach (i.e. LPV 200). Also ADS-B1 will benefit from SBAS as a position source with more accuracy and higher integrity, especially for airport surface movement.

Benefits include:

- Provision of vertical guidance for all runway ends as compared to ILS (‘Instrument Landing System) that provides guidance to only one at a time. This improves safety in landing especially in difficult locations or in bad weather conditions

- Straight in approaches with reduction of minima during landing down to 200 feet.

- Phasing out of some current ground-based navigation aid equipment and/or backup to existing Nav aids, VOR, NDB, ILS Cat I, resulting in cost reduction for ANSPs (air navigation service providers) and airport operators

- Route optimisation, advanced arrival, approach and departure procedures (PBN enabler) resulting in cost saving, fuel savings, CO₂ emissions reduction.

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1 Automatic Dependent Surveillance-Broadcast, a satellite based surveillance technology.
In Africa, once the SBAS is operational, there will be no need for additional Navaids infrastructure to be deployed at qualifying airports. As a result, 65% of the aerodromes in Africa that are not equipped with Navaids can benefit from SBAS SoL service. In addition, about 21% of airports/aerodromes equipped with non-precision Navaids and about 14% equipped with ILS can benefit from SBAS as a primary navigation aid or as a backup.

In most studies, the benefits to the aviation sector have been unanimous, ranging from infrastructure cost savings to ANSPs and airport operators to increased efficiency and safety to airspace users. Despite the positive results, there are still ongoing discussions within the aviation sector questioning whether SBAS-related costs and benefits should be prioritised instead of other technologies such as GBAS.

SBAS benefits are not restricted to the aviation sector. Several socio-economic studies have been undertaken to analyse the potential benefit generated to other sectors such as agriculture, road, rail, maritime, UAV, surveying and mapping, as well as in the use of various Location based services.

**IN THE SURVEYING, MAPPING AND GEOGRAPHIC INFORMATION SYSTEM (GIS) SECTORS**

For its availability of services all over the service area, SBAS is anticipated to provide lower cost information for land surveys with an accuracy of better than 2 meters. This means that rural Africa (which stands currently with a mere 10% of surveyed land) is set to benefit from SBAS services. Other sectors projected to benefit from an Africa-wide SBAS service include the mapping and GIS sector, and aerial surveys.

Additionally SBAS contributes to reduction of survey time and overall survey cost due to simplified survey devices and procedures.

**IN THE AGRICULTURE SECTOR**

The mechanisation of agriculture through machinery guidance, biomass monitoring, livestock tracking, harvest and yield monitoring, can increase the capacity of small and large farmers by a factor of up to 50 times, and 10 times respectively. In Europe, by precisely locating tractors and other equipment SBAS has been shown to further enhance efficiency by reducing wastage from the over-application of fertilisers, herbicides and seed wastage during mechanised planting, by as much as 3.55%. SBAS improves on standalone GNSS by as much as 11-15%.

**IN THE MARITIME SECTOR**

SBAS can support the efficiency, safety and optimisation of marine transportation when used in combination with other maritime applications. General navigation (ocean and coastal) and inland water navigation, Search and Rescue, container inventory management, and marine engineering have been identified as the applications that contribute most to the reduction of ship navigation casualties, pollution and optimise security. Using SBAS for container management will improve the efficiency, safety and economic return of port operations.
3.1 CAPACITY BUILDING, A PRE-REQUISITE TO DEPLOYMENT

The SAFIR Project under the Framework Programme “Support to air transport sector and satellite navigation in Africa” involved the set-up, staffing and operation of the Joint Programme Office (JPO) and the set-up and support for GNSS/SBAS Working Sessions (WSs). The 8 WSs, conducted around Africa, involved JPO staff and various African stakeholders and were organised around priority topics including future developments of EGNOS (V32), governance and liability, safety and certification for the deployment of SBAS in Africa, and the SBAS Services Implementation Roadmap.

The Action “Support to EGNOS in Africa, which started in 2016 reinforced the capacity building with the organisation of 9 additional workshops, all targeted at decision makers in the RECs with a view to appropriating the technology and mastering the institutional, economic and financial aspects of its implementation. This culminated in the submission of the first Preliminary Programme Proposal for the Eastern Africa SBAS Module, during the Kampala workshop held in April 2018.

3.2 ROLL-OUT THROUGH A MODULAR APPROACH

Several possible approaches were considered for the deployment of SBAS in Africa including a single African SBAS system. The outcome of the assessments of the possible approaches, taking into consideration on-going SBAS initiatives, i.e. MEDA region, ASECNA States, and the Republic of South Africa, recommended that a modular approach be followed as a guideline with the final target of having an interoperable SBAS system in Africa.

“The modular approach” is based on the deployment of SBAS infrastructure by a group of countries (modules) within their own agreed timeframe and is seen as a preliminary phase towards the long term target of a single pan-African SBAS system. The implementation uses a phased/incremental approach.

Two main possible scenarios are considered for the implementation of SBAS in Africa under the modular approach as follows:

- **An autonomous scenario** where stakeholders own the infrastructures and provide the SBAS Signal in Space (SiS) and services in their geographical boundaries.
- **An extension scenario** where the Signal-in-Space is provided by an external core SBAS system, extending its coverage area by added ground infrastructures.

Altogether, the 4 Modules in Africa will support and complement the Continental Framework which is being coordinated throughout AFCAC/AUC.

3.2.1 STRATEGY FOR BUILDING MODULES

**Use of the existing EGNOS initiatives as starting points**

Ongoing SBAS initiatives in Africa, MEDA region, ASECNA, and Republic of South Africa, can be used as building blocks for regional modules.

**Creation of modules**

The strategy foreseen for the establishment of modules is to make use of already existing regional groupings such as Regional Economic Communities (RECs) and other organisations. Their institutional and decision-making structures can be used to organise States for the creation of modules including assessment of the feasibility of the system (at economic, financial and technical levels) through preliminary studies (impact analysis/Cost Benefit Analysis and technical feasibility) in the modules to facilitate decision making.

**Optimising costs and time**

In order to reduce implementation costs, sharing of assets (GEO Satellite, Processing Centers, RIMS (Reference and Integrity Monitoring Stations), NLES (Navigation Land Earth Stations)) between modules is strongly recommended. Furthermore, there should be integration of EGNOS with existing related infrastructure systems, including VSAT networks and existing African SBAS geo-stationary satellites.

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2 EGNOS second generation based on Dual Frequency Multi Constellation (DFMC).
3.2.2 Possible SBAS Modules for Africa

Considering the role of RECs in regional integration matters and the impact of ongoing SBAS initiatives in Africa, the following four possible modules have been proposed in the recent roadmap for the roll-out of SBAS.

- **Module 1**: North African module
- **Module 2**: West and Central African module
- **Module 3**: Eastern African module
- **Module 4**: Southern African module

3.2.3 African Ionosphere Conditions

One of the drivers for adopting the modular approach is the varying ionospheric effects on GNSS signals exhibited in different regions of Africa. Regions outside sub Saharan Africa such as the MEDA region and the Republic of South Africa, where propagation of SBAS signals is not severely affected by the ionosphere, can exploit the current SBAS technology (Mono-frequency SBAS) to achieve the service performance required by users. Other regions however would have a degraded performance with this type of SBAS technology. To mitigate this shortfall, a more robust SBAS technology based on Dual Frequency Multi Constellations (DFMC) is in its final development stage with an operational target date of 2023. Regions already using Mono-Frequency EGNOS GPS L1 services could then migrate to this new technology. This transition should go hand in hand with required change of user receivers to support the upgraded functionalities.

3.3 Targeted EGNOS Services for Africa

The targeted services at this stage are driven by aviation, a sector in which only 14% of African airports are equipped with ILS.

The following levels of service are expected to emerge in Africa:

<table>
<thead>
<tr>
<th>Mono-Frequency EGNOS GPS L1 services</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Service GPS</td>
<td>2022</td>
</tr>
<tr>
<td>Safety of Life NPA GPS</td>
<td>2023</td>
</tr>
<tr>
<td>Safety of Life NPA+APV1+LPV200 GPS</td>
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In the aviation sector, the SBAS safety of life services will be used as a means of navigation for a specific operational use (LPV procedures) as well as for timing. The certification of the service provider is a critical step for the use of the signal in space. However, in Africa, one of the major challenges is the absence of common institutional, regulatory, and certification frameworks to address the multi-national nature of the SBAS services provision. According to JPO analysis, certification of ANSPs will be required in most of the African States by the time SBAS/EGNOS is implemented. Currently, most of the African States by the time SBAS is implemented. As a result, JPO developed a framework for certification of the SBAS service provider for consideration by stakeholders. SBAS stakeholders including Space Agencies, CAAs (Civil Aviation Authorities), ANSPs, RSOOs, AFCAC and ICAO will play a major role in the certification process of the SBAS service provider in Africa.

3.4 Certification of the SBAS Service Provider
SBAS implementation in Africa requires efficient coordination within and among countries given the complexity of the Programme. To facilitate the coordination during the implementation of SBAS in Africa, JPO has developed the Roadmap for the implementation of SBAS services in Africa based on European technology for consideration, approval, and adoption by African States. JPO also develops preliminary programme proposals with Module Stakeholders in support of decision making for the creation of each Module.

4.1 THE JOINT PROGRAMME OFFICE (JPO)

The creation of JPO enabled the setup of a highly specialised team in the field of Satellite Navigation Services in Africa and a successful African stakeholders’ capacity building programme. JPO commenced operations in December, 2013, in Dakar (Senegal) through the SAFIR Project and the continuity of its activities was ensured through continuous Africa-Europe cooperation on funding and overseeing the programme. After five years supporting African initiatives in various domains of satellite navigation, the JPO aims at playing a key role in the implementation of the continental vision on satellite navigation through its institutionalisation within the African Union space framework.

4.1.1 JPO CURRENT AND FUTURE STATUS

JPO was set up at this initial stage towards its institutionalisation as the pan-African instrument in charge of supporting and coordinating the development of GNSS/EGNOS in Africa and the provision of related services.

JPO consists of a nominal team of ten experts, coming from different African countries and regions, competitively recruited. The establishment of the coordination entity (JPO) will be a major stepping stone of Africa in the operationalisation of Africa/EU partnership as its finalisation will ensure harmonised, safe and cost effective introduction of EGNOS SBAS in Africa.

The governance of the JPO is assured by a Steering Committee, made up by representatives of EC, AUC, AFCAC, ACAC, ICAO, RECs, (EAC, COMESA, Ecowas, ECCAS, IGAD, UEMOA, SADC), GSA, ASECNA.
4.1.2 JPO Current Activities

To undertake its mission, JPO initially develops a Work Programme at each phase of the Programme and which is driven by the strategic objectives set by its Stakeholders. To date, JPO has established working arrangements through 7 MoUs (EAC, IGAD, COMESA, ECCAS, AATO, ACAC, CRASTE-LF), has conducted 9 workshops (Kigali, Dar-Es-Salam, Brazzaville, Kinshasa, Conakry, Abuja, Kampala, Dakar, and Nairobi); finalised a Preliminary Programme Proposal for the implementation of the Eastern Africa SBAS Module (Technical, Institutional, and Economic studies, roadmap) to support the decision-making process; and supported AUC and AFCAC on the institutionalisation of the JPO and other technical studies and strategy.

JPO technical studies encompass both ground and space segment systems as well as applications in various sectors in aviation and non-aviation. Present in most of international GNSS/SBAS fora such as IWG, ESSP, and ITU, JPO continues to raise awareness and be present at regional and continental meetings to play advocacy for GNSS/SBAS and related applications.

4.2 The SBAS Services Implementation Roadmap

The roadmap prepares the basis for the programme implementation, building a consolidated technical baseline shared among the partners and ensuring the relevant political and financial supports. It provides the timeline to stakeholders for coordinated activities and gives the different phases for the programme implementation.

The roadmap also supports the stakeholders in the introduction of harmonised, safe and cost effective SBAS services through:

- The definition of a political and institutional coordination framework for SBAS based on the modular introduction of EGNOS services as well as the definition of the strategy for SBAS implementation and the funding mechanism;
- The definition of the implementation phases (from the phase of initiation to the deployment phase);
- A user adoption process.

The final goal is a single African SBAS.

4.1.3 JPO Future Activities

The future activities of the JPO will be guided by the JPO Action Plan 2018-2020 with the focus on: (I) supporting the process of establishing modules and ongoing SBAS initiatives in Africa, (II) institutionalisation of JPO, and (III) development of a coordination framework for SBAS implementation and exploitation in Africa. The range of support activities encompasses assistance for strategic, technical and economic, legal and institutional studies, training, workshops and seminars, and awareness campaigns.

Establish a coordination framework for SBAS Services introduction in Africa to ensure harmonised implementation and seamless SBAS services provision

Establish SBAS modules in Africa

Implement and exploit the SBAS system in the modules

User adoption

Roadmap High-Level Objectives
The SBAS multi-sectoral applications make it important to involve all stakeholders across Africa in the implementation process. Although the modular implementation approach has been recommended, states’ role in the decision-making process should not be overlooked. Regional and specialised international organisations are expected to play a major role in coordinating states when dealing with technical and policy issues related to the implementation of SBAS in Africa.

**AUC/AFCAC ROLES**

AUC (African Union Commission) through the AU is a co-signatory of the Africa-EU Strategic Partnership, hence has the ultimate ownership of the programme for SBAS implementation in Africa. AFCAC, as the AU specialised agency responsible for civil aviation, has a major role to play concerning technical, legal, and institutional issues related to aviation applications and EGNOS implementation in Africa. Aviation is the main driver of the SBAS SoL service. AFCAC is supervising on behalf of AUC the conducting of a continental CBA study and strategy on the implementation of SBAS in Africa.

**GSA**

The European GNSS Agency (GSA), as the entity in charge of the exploitation and development of EGNOS, has the mission of expanding EGNOS services outside of the ECAC region. GSA is working closely with JPO to ensure EGNOS V3 will meet African requirements. In this respect, JPO supports GSA for technical aspects such as potential RIMS locations in Africa.

**RECs**

Regional economic communities have a central role in the creation of the modules under their geographic scope, addressing the critical issue of sustainability of SBAS implementation. The following RECs are considered as key policy actors in the creation of the modules in Africa: UMA / ACAC for Module 1; ECOWAS and ECCAS for Module 2; EAC, IGAD, COMESA, and CEN-SAD for Module 3; SADC and COMESA for Module 4.

**OTHERS: ICAO, ANSPs, CAA, USER COMMUNITIES**

Considering that ICAO PBN drives GNSS and SBAS uptake, ICAO guidance and its involvement during the consideration of technical matters is crucial. For ANSPs (air navigation service providers), aerodrome operators, and Aviation Training Organisations (ATOs), they have crucial inputs on the exploitation of the SBAS system. States through the CAAs have the oversight and regulatory functions making them major partners in the implementation process. All user communities benefit from safe and reliable services making them natural partners in the decision-making and implementation processes.
Looking ahead to EGNOS in the near future

The Africa-EU strategic partnership on satellite navigation adopted by Heads of State and Government of Africa and Europe is an opportunity for Africa to benefit from satellite technology, like other regions of the world, and to develop and streamline its competences in GNSS and SBAS technology with a view to becoming a global player in the field of satellite navigation services.

Completion of the support to capacity building programme, as a prerequisite for the development and introduction of SBAS services in Africa, marked an important milestone in the operationalisation of the Africa-EU strategic partnership regarding the introduction of satellite navigation in Africa. The required competences to address GNSS and SBAS multi-domain technologies and multidisciplinary skills requirements have been made available through the programme, therefore enabling Africa to move forward with the next phase of the implementation of satellite navigation services.

In 2017 we witnessed an increased interest in SBAS and new impetus through the AU STC of Lomé Ministerial Meeting on 13-17 March, which recognised the capacity built in key African organisations by the JPO and progress made by EGNOS in Africa Programme. It was recommended that the AUC conduct a cost-benefit analysis and develop a strategy, including institutionalisation aspects, for states, through the Sub-Committee in charge of transport of the STC-TTIIET.

JPO will ensure Aviation and non-Aviation user communities are involved in its support and coordination activities throughout the Continent to foster the economic and social development expected through use of satellite navigation systems and applications.

As a pan-African instrument in charge of satellite navigation and services coordination and support, JPO is looking forward to States’ commitment and full support in finalising its institutionalisation, as it is undergoing a thorough transformation of its mandate with expansion of its activities on all GNSS services and applications. As a result, the appropriate re-branding of the programme will be considered alongside the institutionalisation process.
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