

Suporting GNSS/SBAS Development and Implementation for Africa Development

Building together satellite navigation services for Africa

SatNav Africa Joint Programme Office



Funded by the European Union





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Foreword

he development of Satellite Navigation in Africa remains an overarching objective of the African Union Space Policy and Strategy as well as the Africa Integrated Maritime (AIM) Strategy AIM 2050 for seas and oceans adopted in 2016 by the 26th Africa Union Summit. It is also embedded in the Agenda 2063 Flagship Programmes and is fully in line with the world trend where four global navigation systems and nine Regional Satellite Based Augmentation Systems (SBAS) including in Africa will be available.

The "Satellite Navigation in Africa Support Programme-III," which is a continuation of the cooperation initiative between Africa and Europe, is championing the development of Global Navigation Satellite System (GNSS) applications as well as the implementation and adoption of SBAS services across the African continent. It is a component of the Joint Africa-EU Strategy (JAES) on regional integration and trade, aiming primarily at enhancing safety in the domain of civil aviation by the introduction of satellite navigation in Africa based on European solutions EGNOS (European Geostationary Navigation Overlay Service) and Galileo.

The Second Action Plan of the Joint Africa-EU Strategy (JAES) adopted in 2011, following the Tripoli Africa-EU Summit in 2011, included cooperation on satellite navigation as the first step towards the provision of SBAS services in Africa. The Pan-African (PanAf) financial instrument, which is co-funded by the European Commission and ASECNA, has supported since 2016 the Programme 'Support to the JPO".

The new "Satellite Navigation in Africa Support Programme-III" (2021-2024) empowers the Joint Programme Office (JPO) as an entity tasked to coordinate the introduction of GNSS and SBAS based on EGNOS technology in Africa in coordination with regional stakeholders, to increase and expand its work of technical assistance, expertise sharing, awareness raising and capacity building with key stakeholders in order to promote and facilitate the development and use of SBAS and GNSS services in Africa. It provides firstly; the required technical support and capacity building to regional and continental stakeholders in order to accelerate and facilitate the development of the regional initiatives and the integration of SBAS into continental planning and policies and; secondly support the adoption of GNSS services and the development of related-applications across Africa, including those based on European programme Galileo.

With hope that the Africa Aviation industry will recover its former dynamism in the near future despite the economic backslash of COVID-19 Pandemic, GNSS/SBAS technologies and applications are set to bring significant contribution in terms of safety and flight efficiency improvement while contributing to economic and social development in the other economic sectors in Africa

Supporting the use of SBAS in Africa

SBAS implementation in Africa requires efficient coordination within and among countries given the complexity of the Programme and is facilitated by the development of a Roadmap for the implementation of SBAS services in Africa while considering the regional initiatives and new programmes.

The Joint Programme Office (JPO)

The creation of JPO in December, 2013 enabled the setup of a highly specialized Team in the field of Satellite Navigation Services in Africa and a successful African stakeholders' capacity building programme. The JPO is set to play a key role in the implementation of the continental vision on satellite navigation through its full operationalisation under the African Union aegis.

JPO Mission, current and future status

The mission of the JPO is "As a Pan African specialized 'entity', to coordinate and support the implementation of seamless and sustainable satellite navigation solutions in all sectors with aviation as a main driver". As such, the Programme is contributing to economic and social development in Africa, in line with AU Space Policy and Strategy, as well as the Agenda 2063.



JPO Steering Committee Meeting

The Programme Steering Committee Co-Chairs are AUC, EC as the result of the historical foundation of the Programme which is deeply rooted into the Joint Africa-EU Strategy (JAES) regarding cooperation on satellite navigation (back to 2010 in Tripoli Summit and adopted by Heads of State and Government from Africa and Europe). Members include EC, AUC, AFCAC, ACAC, ICAO, RECs (EAC, COMESA, ECOWAS, ECCAS, IGAD, UEMOA, SADC), GSA, ASECNA. The membership was later extended to cover the entire GNSS Community.

JPO in brief

Programme name	Sat Nav Africa Joint Programme Office	
Sector of activity	Satellite Navigation in Africa	
Regions/countries	All of Africa	
covered		
Target start and end date	December 2013 - 2024	
Vision	Regional implementation of SBAS with the objec- tive of obtaining a Pan-African SBAS	
Missions/Global Objec- tives	Coordinate and support the implementation of seamless and sustainable satellite navigation so- lutions in all sectors with aviation as a main driver.	
Supervisory body	European Commission, African Union	
Affiliated body	Developing infrastructure and providing services with top-down integration, complemented by actions in support of continental planning and development, is the most pragmatic and appro- priate approach, while providing the integrated continental vision the African Union desires. Support for the development of the downstream market for GNSS services, including the develop- ment of key measures to this end, such as the JPO framework and its capabilities, and aware- ness of European space programmes.	
Technical and Financial Partners	European Commission, ASECNA	
Project components	Component 1: Technical support and capacity building for regional and continental actors to accelerate the development of regional SBAS mo- dules and the integration of SBAS into continental policies and planning Component 2: Supporting the adoption and use of GNSS services and the development of related applications and markets in Africa	
Services offered by the sector	Sector 1: Support to GNSS/SBAS services Imple- mentation Sector 2: Support to GNSS/SBAS applications development Sector 3: Support to promotion and communica- tion of GNSS/SBAS services Sector 4: Training and capacity building on GNSS/ SBAS Sector 5: R&D and specific support services (in development)	
Beneficiary organisations/states	African Union (AU), African Space Agency (AfSA), African Civil Aviation Commission (CAFAC), International Civil Aviation Organisation (ICAO), Arab Civil Aviation Organisation (ACAO), ASECNA, Regional Economic Communities - RECs (e.g. ECOWAS, ECCAS, EAC, COMESA, IGAD), National Space Agencies, Civil Aviation Authorities and concerned States. Other actors, especially in non-aviation sectors, may be involved as required and on a case-by-	

The JPO multidisciplinary African Experts Team supports all beneficiaries in Africa through 4 defined strategic intervention domain areas, spanning from GNSS/SBAS services implementation, applications, promotion and communication to Training and capacity building.

JPO current activities

To undertake its mission, JPO Work Programme is guided by the strategic objectives set by its Stakeholders which implementation across the four strategic intervention areas, namely services implementation, applications development, Promotion and communication, Training and Capacity Building while looking for Research and development in the future.

The support to AUC for the assessment of Infrastructure gap and technology across the full range of Positioning, Navigation and Timing Services provides visibility on the way forward in addressing the priorities in the domain in the future. The Programme is all Africa inclusive and main beneficiaries primarily from Aviation have been extended to non-Aviation Communities. More than eleven (11) Regional Institutions including training Organisations have established working arrangements with JPO on GNSS/SBAS. The Programme assures GNSS/SBAS applications advocacy at regional and international fora (APIRG, IWG, etc.)

JPO future activities

The future activities of the JPO are guided by the JPO Action Plan 2021-2024 with focuses on the implementation phase of SBAS in Africa and full integration into continental policies and planning while supporting the much needed adoption and use of GNSS services and the development of related applications and markets in Africa.

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GNSS and SBAS at a glance

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 satellite systems called core constellation systems. The current core constellation systems are USA's GPS, Europe's Galileo, Russia's GLONASS, and China's Beidou. Technologies like DGNSS, RTK and PPP improve the accuracy while ABAS, GBAS and SBAS in addition to improving accuracy provide integrity, a measure of trust in the correctness of the information.

GNSS applications

The use of GNSS position, navigation and timing information depends on operational requirements and encompasses different sectors from Aviation, Maritime, Road, Rail agriculture, consumer Location Based Services, Geoformation to Timing and synchronization as well as Drones and Internet of Things (IoT) sectors.

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. SBAS, one of the existing augmentation systems, provides error correction information via geostationary satellites to users of the primary GNSS system services, making it compliant to the stringent requirements of specific applications such as the operational requirements set by the International Civil Aviation Organization (ICAO) for use during the most critical phases of aircraft flight. SBAS has been implemented or is undergoing implementation in several parts of the world. WAAS (USA), EGNOS (Europe), MSAS (JAPAN) and GAGAN (India) are in operation while SDCM (Russia), KASS (South Korea), BDSBAS

(China) and ASECNA A-SBAS in Africa are under development and deployment.



SBAS and Africa: Ongoing Programmes and initiatives

Facing fast development of SBAS in the world, a number of SBAS initiatives are under development in Africa, with the final goal of having a single African SBAS towards the horizon 2030.



JPO at the Aviation outreach and the ASECNA SBAS Programme Aviation Demonstrations in Lome, Togo.

The ACAO SBAS Initiative

In Northern Africa, ACAO has developed a GNSS policy based on the ICAO GNSS policy, the ICAO regional office and the PIRG GNSS policies and the action plan of the Euro-Med PROJECT 27, leveraging on the presence of the EGNOS geostationary footprint and the coverage of the service area over the African Civil Aviation Organisation (ACAO) region, favorable to the implementation of the SBAS/EGNOS service in this region and is supported by a GNSS training policy, programme and plan, which support states to reach the regional and national Performance Based Navigation (PBN) objective and to ensure the full SBAS coverage of all ACAO states.

The South Africa SBAS initiative (SBAS-Africa)

This initiative was conducted by the South African National Space Agency (SANSA) in 2016. It involved the deployment of an end-to-end SBAS testbed with a live signal in space to demonstrate the potential benefits of implementing SBAS capabilities in Southern Africa. EGNOS trials carried out involved flight and drone trials, non-aviation trials in Agriculture and Maritime sectors and also trials of the use of SBAS, RTK and Professional Grade Receivers.

The Nigeria SBAS initiative

Nigeria through NIGCOMSAT (the operator/manager of NIGCOM-SAT-1R Satellite with Navigation Overlay Service (NOS)) officially requested in 2018 to join the GNSS Providers' Forum as an SBAS Service Provider with coverage over the African Continent and surrounding Oceans (Atlantic and Indian). In 2020, the NIGCOMSAT SBAS payload was leveraged for ASECNA A-SBAS Programme, demonstrating true intra Africa-cooperation in the domain.

The ASECNA SBAS programme

The ASECNA SBAS Programme - SBAS for Africa and Indian Ocean (A-SBAS), a regional navigation augmentation system involves the implementation of an independent SBAS system in line with Africa Union Space policy of "indigenous system", under a licensed agreement with Europe on the use of EGNOS technology. A signal in Space (SiS), compliant with the ICAO Standards and Recommended Practices (SARPS) and the specifications of Minimum Operational Performance of the RTCA (MOPS) is currently being broadcasted via the Nigerian NIGCOMSAT-1R Satellite for technical trials to build competencies for operations, perform field demonstrations in aviation for aircraft and rotorcraft as well as in non-aviation, including specific new services (PPP, SDAS and Alerting Services).

The SBAS System: The Case of EGNOS

Technology based on EGNOS

The European Geostationary Navigation Overlay Service (EGNOS) consists of various components distributed between space for Geo Satellites and ground segments with Reference Stations, Master Control Centres and Performance Assessment and Check facility Systems, Navigation Land Earth Stations and the Wide Area Network.

EGNOS allows users to determine their position down to 1-2 meters compared to the 5-10 meters presently guaranteed by GPS alone.

EGNOS range of services

EGNOS services are currently provided in Europe and include firstly "The EGNOS Open Service (OS)" for any user equipped with an EGNOS enabled receiver inside the EGNOS Open Service area; secondly "The Safety of Life Service (SoL)" with committed performance tailored to safety critical transport applications, especially aviation and; thirdly "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.

SBAS Benefits

In the Aviation sector

Aviation is the main driver of the SBAS 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 to Category I equivalent approach (i.e. LPV 200).

ADS-B will also benefit from SBAS as position source with more accuracy and higher integrity especially for airport surface movement.

The operational benefits include provision of vertical guidance for all runway ends as compared to ILS (Instrument Landing System) that provides guidance to only one end at a time and therefore enhanced safety at landing especially in difficult locations and/or in bad weather conditions, straight-in approaches with reduction of minima down to 200 feet. Other benefits include optimisation of ground-based navigation aid equipment, route optimization, advanced arrival, approach and departure procedures (PBN enabler), resulting in cost savings, fuel savings, CO2 emissions reduction while providing cost-efficiency for Air Navigation Service Providers (ANSPs) and airport operators.

It is expected that through SBAS SoL availability in Africa, 65% of the aerodromes in Africa that are not equipped with Navaids will benefit from SBAS. 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.

SBAS benefits accrue to sectors beyond aviation and the recent economic studies demonstrate there are significant potential benefits generated to other sectors such as agriculture, road, rail, maritime, UAV, Geomatics, as well as in the use of various location-based services.



In the Geomatics Sector

SBAS is set to provide lower cost information for land surveyors with an accuracy below 2 meters, an opportunity for rural Africa.

With the emergence of new technologies like PPP by satellite, accuracy levels are expected to reach decimetre levels while SBAS would provide larger coverage of areas therefore resolving the current CORS infrastructure gaps in Africa.

SBAS facilitates the use of a regional unified measurement reference system based on WGS84, eliminating problems associated with the use of multiple coordinate systems in Africa.



(Geomatics Photo: ©GSA, ©European GNSS Agency).

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SBAS CORS in Africa

Potential Continental SBAS coverage facilitating the filing of gaps caused by insufficient number of CORS

CORS : Continuously Operating Reference Stations



(Agriculture Photo: ©GSA, ©European GNSS Agency)

In the Agriculture sector

The mechanization 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. SBAS is known to further enhance efficiency by reducing wastage from the over-application of fertilizers, herbicides and seed planting.



In the maritime sector

SBAS can support the efficiency, safety and optimization of marine transportation when used in combination with other vessel maritime applications. General navigation (ocean and coastal) and inland waterway navigation, Search and Rescue, container inventory management, and marine engineering, are some of the applications supported by SBAS.



Other sectors

SBAS applications in the road sector include road usage control, vehicle e-tolling among others; in the rail sector with increased situational awareness and trains safety, maintenance and asset management; in Location Based Services with smartphone and personal tracking applications and wearables, Drone applications for parcel delivery and urban air mobility, in agriculture for lite spraying and remote sensing as well as infrastructure monitoring





Roll-Out of SBAS in Africa

The SBAS Services Implementation Roadmap

The initial roadmap developed served as the basis for the programme implementation and for use by stakeholders in the introduction of harmonized, safe and cost effective SBAS services through the definition of a political and institutional coordination framework for SBAS and the implementation phases.

Stakeholders role in the implementation of SBAS in Africa

The SBAS multi-sectoral applications make it important for involvement of 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 specialized international organizations 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 AU which is a co-signatory of the Africa-EU strategic Partnership and has the ultimate ownership of the programme for the SBAS implementation in Africa.

AFCAC, as the AU specialized 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 considering that Aviation is the main driver of SBAS SoL service.

GSA-EUSPA

The new European Union Agency for the Space Program (EUSPA) which taking over European GNSS Agency (GSA is now managing the use of the Copernicus Earth observation satellite system, the Governmental Satellite Communications (Govsatcom) program, and monitoring of the Earth's near surroundings in addition to the exploitation and development of EGNOS and has the mission of expanding EGNOS services outside of the ECAC region.

RECs

Regional Economic Communities have a central role in the uptake of SBAS in their respective regions under their geographic scope, addressing the critical issue of sustainability of SBAS implementation. The following RECs are considered as key policy actors in Africa: ACAO for Northern Africa ECOWAS and ECCAS for Western and central Africa; EAC, IGAD, COMESA, and CEN-SAD for Eastern Africa; SADC and COMESA for Southern Africa.

Others: ICAO, ANSPs, CAAs, Training Institutions, Space Agencies, user Communities

Considering that ICAO PBN drives GNSS and SBAS uptake, ICAO guidance and its involvement during the consideration of technical matters is crucial. ANSPs, Aerodromes operators, and Aviation Training Organisations (ATOs), 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.

National Space Agencies also play an important role in the GNSS value chain including in the upstream market segment as well as raising awareness in the downstream segment.







JPO at Association of African Aviation Training Organisation (AATO) Meeting ((Accra, Ghana, 28-30 October 2019)

Capacity building, a pre-requisite to deployment

The deployment and use of GNSS/SBAS for aviation required strategic continental wide planning with capacity building as a pre-requisite to enable a collective response to the highly demanding operational and regulatory challenges and the required capacity for the exploitation of the system and further PBN implementation phases.

Human capital development remains a priority which is acted through various working Sessions across the Continent and cooperation agreements with regional economic communities, Association of Aviation Training Organisations and specialized GNSS training institutions such as the two Africa Regional Centres for Space Science and Tech Education in Morocco and Nigeria but also Universities with vested interest in GNSS such as Makerere University-Uganda or UFR Thiès Senegal, etc.

Roll-Out through a regional approach

The assessment of different approaches for the deployment of SBAS in Africa with consideration on-going SBAS initiatives, i.e. MEDA region, ASECNA States, and the Republic of South Africa, recommended that a regional approach be followed as a guideline with the final target of having a single or an interoperable SBAS system in Africa.

The regional approach is based on supporting the decision making for deployment of SBAS infrastructure by a group of countries within their own agreed timeframe with the longer-term target of a single Pan African SBAS system. The implementation is therefore driven by the continental policy objective while using a phased/incremental approach.

Two main possible scenarios are considered for the implementation of SBAS in Africa under this approach and include an autonomous scenario or an extension scenario where the Signal-in-Space is provided by an external core SBAS system.

Altogether, the 5 AU Regions in Africa through the RECs will be supporting and complementing the Continental Framework which is being coordinated throughout the AUC.

Strategy for SBAS initiatives in Africa

Ongoing SBAS initiatives and Programmes in Africa, MEDA region, ASECNA (A-SBAS) and Republic of South Africa, as well as from Europe (EGNOS) may be used as building blocks for the SBAS deployment in Africa.

The sharing of assets (Space and Ground Segments) between regions is strongly recommended for optimisation of implementation costs while the continental vision shall build on existing SBAS infrastructure and other related CNS infrastructure systems.

Possible SBAS Modules for Africa

In addition to the overall continental undertaking by AUC, the RECs play a key role as interfaces to States through their own institutional and decision- making structures for consideration of SBAS in their regions based on the assessment of the feasibility of the system both from technical economic and financial aspects.

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



- North African
- West and central African
- East African
- South African





Figure 2: Photo 4: Nequick Iono VTEc Map generated at 13h UT for a day (Courtesy of https://gssc.esa.int/)

One of the drivers for adopting this regional approach is also the varying ionospheric effects on GNSS signals exhibited mainly in low latitude areas of Africa where ionospheric effect is one of the most prominent threats to GNSS and the region around the magnetic equator.

The improvement in algorithm development and knowledge of the ionosphere characterisation has enabled the development of solutions that immensely reduce the impact of ionosphere in low latitude areas and the advent of Dual Frequency Multi Constellation (DFMC) SBAS will allow for the elimination of the effect of the ionosphere on GNSS signals.

Targeted SBAS services for Africa

In Africa, the SBAS services targeted at this stage are driven by aviation, a sector in which only 20% of African airports are equipped with ILS and where operational and safety limitations of LNAV and Baro-VNAV operations are noted. Hence the need for RNP APCH APV with geometric guidance (up to LPV) operations.

SBAS provides effective solutions for CAT-I equivalent operations on the very large number of instrument runway ends not served by ILS as well as a service continuity during maintenance and ILS renewal periods.

As for geometric guidance, it overcomes the known limits of safety and operation of the technical constraints of LNAV / VNAV operations.

The following levels of service are expected to emerge in Africa by 2030:

A-SBAS Mono Frequency Mono Constellation (GPS)	Date
L1, L5 Pre-operational/Open Service	2020
Safety of Life L1 services for en-route/NPA, APV-1	2024

Dual Frequency A-SBAS - Multi-Constellation GPS+GALILEO	Date
Open Service GPS, GPS+GALILEO	2025
Safety of Life NPA GPS, GPS+GALILEO	By 2028 +
Cat I auto land	By 2030 +
Safety of Life Maritime	N/A
EDAS services	N/A

Certification of the SBAS Service Provider

The primary goal of the certification of the SBAS service provider is to demonstrate system compliance and deliver the service to the airspace users. Given the regional nature exhibited by SBAS, the regulatory framework will be regional within a regional governance system. Typical governance framework will have to include safety supervision/oversight organs (RSOO in the case of Aviation) and authority in charge of regulations.



Looking ahead to a nearer future of SBAS in Africa



The Africa-EU strategic partnership on satellite navigation adopted by Heads of State and Governments of Africa and Europe is an opportunity for Africa to benefit from satellite technology, as other regions of the world, and to develop and streamline its competences in GNSS and SBAS technology. Indeed, the cooperation Programme on Satellite Navigation addresses the true priorities in the Continent among which Safety-Security; Economic resilience; Digitalisation; Climate change while keeping in mind the credo of all-inclusive Programme' No country left behind'.

While there is increased interest in SBAS and new impetus since the AU Specialized Technical Committee (STC) Ministerial Meeting of Lomé on 13-17 March, 2017 which recommended the Cost Benefit Analysis study and strategy, JPO will ensure the communication outreach of GNSS/

SBAS services goes beyond Aviation towards non-Aviation user Communities throughout the Continent to foster the economic and social development anticipated through use of Satellite Navigation Systems and applications.

Furthermore, at the eve of the Space Economy era, JPO is set to support Africa to get its stake as a global player in PNT. As a Pan-African instrument in charge of Satellite Navigation and services coordination and support, JPO is looking forward to states' further commitment and full support in finalizing its operationalization considering its thorough transformation of its mandate with expansion of its activities on all GNSS services and applications

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