CAPACITY BUILDING TOWARDS THE DEVELOPMENT OF GNSS / SBAS IN AFRICA

EU/AFRICA Partnership on Satellite Navigation
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 EGNOS (European Geostationary Navigation Overlay Service) SBAS initiative in Africa, as part of the joint Africa-EU strategic partnership, aims at introducing satellite navigation services based on EGNOS in Africa. The Second Action Plan of the Joint Africa-EU Strategy (JAES) adopted in 2011, following the Tripoli Africa-EU Summit in 2011, included a specific item to expedite cooperation on satellite navigation as the first step towards the provision of SBAS services in Africa. In 2014, Heads of State and Government from Africa and Europe reiterated their commitment to the implementation of SBAS in Africa through the adoption of the JAES Roadmap 2014-2017. The 4th Africa-EU Summit held in Brussels on April 2014 included a commitment to provide sustainable and adequate financial and human resources for the deployment and exploitation of SBAS in Africa.

The introduction of EGNOS SBAS in Africa started with bilateral cooperation programmes between EU and a number of individual African States and regional grouping to support EGNOS initiatives in Africa. It included initiatives in the MEDA\(^1\) region, with ASECNA\(^2\), and also with the Republic of South Africa. For the remaining Sub-Saharan African countries, the EU as a partner of the EU/Africa EGNOS initiated in 2011 a framework programme through Action Plan 2011-2013 “Support to Air transport sector and satellite navigation in Africa”.

The Framework Programme included two projects (SAFIR project and TREGA project) which were specifically created to support the development and introduction of EGNOS SBAS services in Africa. The main outcome of SAFIR is the creation of the EGNOS-Africa Joint Programme Office (JPO) therefore ensuring that EGNOS SBAS is implemented in a coordinated way with a view to achieving a seamless, safe, and efficient provision of EGNOS services all over Africa.

\(^1\) The MEDA programme is the main financial instrument of the Euro-Mediterranean partnership

\(^2\) Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar
2.1 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 geo-stationary satellites in space. GNSS signals are provided by a variety of satellite positioning systems including core constellation systems (e.g. USA’s GPS and Russia’s GLONASS), Satellite based augmentation systems (e.g. Europe’s EGNOS), future Satellite Navigation Systems (e.g. Galileo, BeiDou), ground and aircraft based augmentation systems, as illustrated below.

2.2 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 corrections information via satellites to users of the primary GNSS system services. SBAS complements the primary GNSS system performance to improve accuracy, integrity, continuity and availability making it compliant to the stringent requirements of specialized 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) and BDSBAS (China) are under development and deployment. In addition, there are ongoing initiatives such as SACCSA (South America), Malaysia SBAS, and KSBAS (South Korea). As such, there are ongoing SBAS activities on every continent.

2.3 EGNOS – the European SBAS system

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 available in GPS alone.
### 2.4 EGNOS range of services

There are three EGNOS services that are currently provided in Europe and which it is proposed to introduce across Africa.

- **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 EGNOS Benefits

**IN THE AVIATION SECTOR**

Aviation is the main driver of EGNOS SoL service. EGNOS 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-B\(^3\) will benefit from EGNOS as 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 Navaids, VOR, NDB, ILS Cat I, resulting into cost reduction for ANSPs (air navigation service providers) and airport operators.
- Route optimization, advanced arrival, approach and departure procedures (PBN enabler) resulting in cost saving, fuel savings, CO2 emissions reduction.

In Africa, once the EGNOS system is operational, there will be no need for additional infrastructure to be deployed at the airports. As a result 65% of the aerodromes in Africa that are not equipped with Navaids will benefit from EGNOS SoL service. In addition, about 21% of airports/aerodromes equipped with non-precision Navaids and about 14% equipped with ILS will benefit from EGNOS as a primary navigation aid or as a backup.

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\(^3\)Automatic Dependent Surveillance-Broadcast, a satellite based surveillance technology
IN THE SURVEYING, MAPPING AND GEOGRAPHIC INFORMATION SYSTEM (GIS) SECTORS

EGNOS 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 EGNOS services. Other sectors projected to benefit from an African wide EGNOS service include mapping and GIS sector, and aerial survey.

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

IN THE AGRICULTURE SECTOR

Mechanization can increase capacity to farm land compared to using hand held tools by a factor of up to 50 times, and 10 times in the case of animal drawn ploughs and other tools. In Europe, by precisely locating tractors and other equipment EGNOS has been shown to further enhance efficiency by reducing wastage from the over-application of fertilizers, herbicides and seed wastage during mechanized planting, by as much as 3.55%. EGNOS improves on standalone GNSS by as much as 11 – 15%.

IN THE MARITIME SECTOR

EGNOS can support the efficiency, safety and optimization of marine transportation when used in combination with other vessel maritime applications. This would help the further reduction of ship navigation casualties, pollution and optimize security. Specifically for the inland waterway where the economic importance far outweighs the need for traditional navigation aids, EGNOS offers a cost effective solution that is easily deployable.

Other areas where EGNOS can be applied include the road sector facilitating road usage control, vehicle e-tolling among others; the rail sector, increasing the situational awareness for trains safety and maintenance crew, as well as in the use of various location based services.
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 an EGNOS-Africa Joint Programme Office (JPO) and the set-up and support for GNSS/EGNOS 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 (V34), governance and liability, safety and certification for the deployment of EGNOS in Africa, and SBAS Services Implementation Roadmap.

The WSs provided a forum for discussions among African Stakeholders about key essential aspects of the GNSS/EGNOS development and also contributed to the initial capacity building in satellite navigation in Africa. They were instrumental in the development of the EGNOS SBAS Services Implementation Roadmap for Africa.

3.2 Roll-Out through a modular approach

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

“The modular approach” is based on deployment of EGNOS 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 EGNOS in Africa under the modular approach as follows:

- **An autonomous scenario** where stakeholders own infrastructures and provide the EGNOS Signal in Space (SiS) and services in their geographical boundaries.

- **An extension scenario** where the Signal-in-Space is provided by an external core EGNOS system, extending its coverage area by added ground infrastructures.

**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 grouping 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 both economic, financial and technical levels) through preliminary studies (impact analysis/Cost Benefit Analysis and technical feasibility) in the modules to facilitate decision making.

**Optimizing 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.

\[ \text{EGNOS second generation based on Dual Frequency Multi Constellation (DFMC)} \]
### Possible EGNOS Modules for Africa

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

- a. Northern Africa module
- b. West and Central Africa module
- c. Eastern Africa module
- d. Southern Africa module

### Mitigation of ionospheric effects on GNSS

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 EGNOS signals is not severely affected by the ionosphere can exploit the current EGNOS technology (single frequency SBAS) (v2 series) to achieve the service performance required by users. Other regions however would have a degraded performance with EGNOS v2. To mitigate this shortfall, a more robust EGNOS technology (EGNOS V3) based on Dual Frequency Multi Constellations (DFMC) is in its final development stage with an operational target date of 2023. Regions already using EGNOS v2 services could then migrate to this new technology. This transition should go hand in hand with required change of users receivers to avoid inconvenience.

### 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>EGNOS v2 L1 services</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Service GPS</td>
<td>2020</td>
</tr>
<tr>
<td>Safety of Life NPA GPS</td>
<td>2021</td>
</tr>
<tr>
<td>Safety of Life NPA+APV1+LPV200(^5) GPS</td>
<td>2023</td>
</tr>
</tbody>
</table>

The indicative timeframes considered are based on the assumptions that Modules start preliminary design studies after the Critical Design Review of EGNOS v3 DFMC programme in Europe, and that the average duration for implementation, qualification, certification and declaration to service is 7 to 10 years depending on the type of service.

### 3.4 Certification of the EGNOS Service Provider

In the aviation sector, the EGNOS SoL will be used as a navigation aid for a specific operational use (LPV procedures) as well as for timing. 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 EGNOS 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. As a result, JPO developed a framework for certification of the EGNOS service provider for consideration by stakeholders. SBAS stakeholders including Space Agencies, CAAs (Civil Aviation Authorities), ANSPs, RSOOs\(^6\), AFCAC\(^7\) and ICAO\(^8\) will play a major role in the certification process of the EGNOS service provider in Africa.

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\(^5\)LPV200 service level with EGNOS V2 L1 is expected in the Northern and Southern African modules

\(^6\)Regional Safety Oversight Organisation

\(^7\)African Civil Aviation Commission

\(^8\)International Civil Aviation Organization
EGNOS implementation in Africa requires efficient coordination within and among countries given the complexity of the Programme. To facilitate the coordination during the implementation of EGNOS in Africa, JPO has developed the Roadmap for the implementation of SBAS services in Africa based on EGNOS for the consideration, approval, and adoption by African States.

4.1 The EGNOS Africa Joint Programme Office (JPO)

The creation of JPO and the African stakeholders’ capacity building programme through working sessions under the EU SAFIR (Satellite navigation services for AFrIcan Region) project can be considered as the starting point of implementation of EGNOS at the continent level in Africa. JPO was created, staffed and operationalized through the SAFIR project and an interim hosting solution is being provided by ASECNA under the SAFIR Delegation as part of its contractual obligations. It commenced operations in December, 2013, in Dakar (Senegal).

JPO Current and future status

JPO was created as the coordinating Structure for EGNOS implementation in Africa. Its main objective is to define the baseline and to oversee the subsequent implementation phase for the specification and procurement of the development and the deployment of GNSS/EGNOS in Africa.

The governance of the JPO is assured by a Steering Committee, made up by the ACP Secretariat, representatives of EC, AUC, AFCAC, RECs, and as observer members of the SAFIR project team one ASECNA representative.

JPO consists of ten experts, coming from different African countries and regions, competitively recruited. The recruitment process which included two tailored training sessions under the TREGA (Training EGNOS GNSS in Africa) project at the UNESCO-International Centre for Theoretical Physics (ICTP) in Italy, ensured that the final recruits have the best potential to undertake JPO future mission. The establishment of the coordination entity (JPO) will be a major stepping stone of Africa in the operationalisation of Africa/EU partnership as its finalization will ensure harmonized, safe and cost effective introduction of SBAS EGNOS in Africa.

JPO has therefore undertaken internal studies on its institutionalization and made recommendations for consideration by AUC and EC. The recommendations consist of the short term (2017) and long term (2020+) JPO legal and institutional structures based on the existing framework of the AU.

JPO current activities

To undertake its mission, JPO developed a Work Programme whose main outcomes are the GNSS/EGNOS services implementation roadmap and the subsequently JPO action plan. The two main deliverables have been achieved as a result of JPO undertaken activities which included:

TECHNICAL RELATED ACTIVITIES:

• the needs assessment of aviation and non-aviation applications; determination of opportunities that can support extension of EGNOS to Africa;
• assessment of ILS equipage in Africa;
• GEO Satellite payloads survey;
• the identification and consolidation of a framework for the certification of EGNOS/SBAS service provision in Africa;
• studies on the legal and institutional issues related to EGNOS implementation in Africa; and
• development of the JPO institutionalization process.

RAISING AWARENESS AND BUILDING CONFIDENCE IN EGNOS

JPO has been very active in participating in:

• international forums on GNSS/SBAS;
• specialised aviation and stakeholders’ conferences, meetings, and workshops; SAFIR working sessions; and
• dissemination of information through the project website (www.aviation-africa.eu/SAFIR) with a view of increased awareness of GNSS EGNOS as well as JPO recognition as a key actor on SBAS initiative in Africa today.
JPO future activities

The future activities of the JPO will be guided by the JPO Action Plan (2016-2017 and then 2018-2020) with the focus on: (i) supporting the process of establishing modules and ongoing EGNOS initiatives in Africa, (ii) institutionalization of JPO, and (iii) development of a coordination framework for EGNOS 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, awareness campaigns.

4.2 The GNSS/EGNOS Services Implementation Roadmap

The Roadmap has been developed to support African States in the introduction of harmonised, safe and cost effective EGNOS SBAS services. It proposes a strategy for EGNOS implementation in Africa and includes the main milestones necessary to support the process of decision making and subsequent implementation.

Figure 3 JPO Roadmap – High Level Objectives

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

Establish EGNOS SBAS modules in Africa

Implement and exploit the EGNOS system in the modules

User adoption

Roadmap High Level Objectives
4.3 Stakeholders role in the implementation of EGNOS 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 EGNOS in Africa.

**AUC/AFCAC ROLES**

AUC (African Union Commission) through AU is a co-signatory of the Africa-EU strategic Partnership, hence has the ultimate ownership of the programme for the EGNOS 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. Aviation is the main driver of EGNOS SoL service.

**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 EGNOS implementation. The following RECs^9^ are considered as key policy actors in the creation of the modules in Africa: UMA and 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, CAAs, USER COMMUNITIES**

Considering that ICAO PBN drives GNSS/EGNOS uptake, ICAO guidance and its involvement during the consideration of technical matters is crucial. For ANSPs (air navigation service providers), Aerodromes operators, and Aviation Training Organisations (ATOs), they have crucial inputs on the exploitation of EGNOS 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 partner in the decision making and implementation processes.

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^9^UMA (Union Maghreb Arabe); ACAC (Arab Civil Aviation Commission); ECOWAS (Economic Community of West African States); ECCAS (Economic Community of Central African States); EAC (East African Community); IGAD (Intergovernmental Authority on Development); COMESA (Common Market for Eastern and Southern Africa); CEN-SAD (Community of Sahel-Saharan States); SADC (Southern African Development Community)
The high-level political commitment to the introduction of EGNOS based satellite navigation services in Africa, the fact that approximately 90% of the African States are already participating in ongoing EGNOS initiatives in Africa (MEDA region, ASECNA, and the Republic of South Africa), the establishment of JPO as an African GNSS programme management entity and acquired GNSS competences and skills by African stakeholders, and the availability of EGNOS implementation roadmap serve as a significant baseline that Africa shall exploit to ensure harmonized, safe and cost effective introduction of EGNOS based satellite navigation services.

To ensure progress in implementation of EGNOS based satellite navigation services in Africa, full commitment from the African decision makers and stakeholders is needed.