Update from SATNAV Africa Joint Programme Office on PNT matters in Africa

62nd Meeting of the Civil GPS Service Interface Committee
September 19-20, 2022

Hyatt Denver at the Colorado Convention Center

By: Alex WANDA & Hebert NGAYA
About the SATNAV Africa Joint programme office

Outcomes of the survey on PNT Infrastructure and Technologies in Africa (an AUC study)

Initiatives towards SBAS implementation on the African Continent
About the SATNAV Africa Joint programme office

**Governance**
- Steering Committee Co-Chairs: AUC, EC
- Main beneficiaries
  - African Union & technical organisations (AFCAC, African Space family)
  - Regional Economic Communities
  - Air Transport users communities (ICAO, CAAs, ANSPs, airports, airlines)
  - Other sectoral organisations (maritime, agriculture, survey & mapping, etc.)
  - Capacity building & innovation frameworks (Training Institutions such as Makerere University)
  - Space Agencies

**Beneficiaries under working arrangements**

**Mission Statement**
To coordinate and support the development of satellite navigation in key sectors in Africa, with aviation as the main driver.

Since 2013, an outcome of Africa-EU cooperation on satellite navigation
About the SATNAV Africa Joint programme office

General Objective
Contribute to the development of satellite navigation in Africa in key sectors, with aviation as the main lever.

Specific Objective
Consolidate the development of SBAS, as well as the adoption and use of GNSS services in Africa.

Business lines

Systems & services
Technical support and capacity building to accelerate the development of regional SBAS modules and the integration of SBAS into continental policies and planning.

Markets & adoption
Support for the adoption and use of GNSS services and the development of associated applications and markets in Africa.
About the SATNAV Africa Joint programme office

**Policy**
- Support to Africa-EU cooperation frameworks on SBAS
- Support to national, regional & international planning mechanism on SBAS
- Advocacy for GNSS SBAS in Africa and global planning mechanisms

**Technical**
- SBAS & GNSS programme management
- Programme and projects concepts (Operation concepts, Site surveys, GNSS monitoring, simulation, etc)
- Standardisation, normalization
- Studies on PNT infrastructure and Technology in Africa

**Institutional**
- Regional SBAS modules concepts
- Concepts on legal and institutional aspects of GNSS in Africa

**Economic**
- Market studies on GNSS in Africa covering all Africa regions
- CBAs, Business cases, impact assessments for all sectors

**Capacity building**
Workshops, training sessions, awareness sessions
Outcomes of the survey on PNT Infrastructure and Technologies in Africa (an AUC study)
Through **Agenda 2063**: The Africa We Want, the African Union has identified space technologies as a critical tool that can boost Africa’s economic growth and development and lead to the rapid transformation of the continent.

To coordinate and manage Africa’s growing space activities at a continental scale, the African Union has passed the 2017 **African Space Agency Act**.

The **African Space Agency (AfSA)** setup to promote and coordinate the implementation of the African space policy and strategy and conduct activities that exploit space technologies and applications.
An Environmental Scan of PNT infrastructure on the Continent

GNSS CORS and Precise Point Position (PPP) Ground Reference Stations

Distribution of GNSS CORS on the African Continent

Precise Point Position (PPP) Ground Reference Stations (Co-shared between Hexagon AB & OmniStar)
An Environmental Scan of PNT infrastructure on the Continent

Navigation Payloads (Supporting PPP/RTK services)

<table>
<thead>
<tr>
<th>Name</th>
<th>Service</th>
<th>Stated performance</th>
<th>Supported Constellations</th>
<th>Method</th>
<th>Owned by</th>
<th>payloads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OmniStar</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VBS</td>
<td></td>
<td>&lt;1m</td>
<td>GPS</td>
<td>DGNSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP</td>
<td></td>
<td>10cm (some parts of Africa not covered)</td>
<td>GPS</td>
<td>LR-RTK</td>
<td>Trimble</td>
<td>IOR (Elev: 19° Az: 39°), ESAT (Elev: 26° Az: 353°)</td>
</tr>
<tr>
<td>XP</td>
<td></td>
<td>15cm</td>
<td>GPS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G2</td>
<td></td>
<td>&lt;10cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Veripos</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td></td>
<td>5cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td>Hexagon AB</td>
</tr>
<tr>
<td>Apex</td>
<td></td>
<td>10-20cm</td>
<td>GPS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apex²</td>
<td></td>
<td>5cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra</td>
<td></td>
<td>15cm</td>
<td>GPS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra²</td>
<td></td>
<td>8cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td>1m</td>
<td>GPS</td>
<td>DGNSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard²</td>
<td></td>
<td>1m</td>
<td>GPS + GLONASS</td>
<td>DGNSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TerraStar</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TerraStar D</td>
<td></td>
<td>10cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TerraStar M</td>
<td></td>
<td>1m</td>
<td>GPS + GLONASS</td>
<td>DGNSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TerraStar C</td>
<td></td>
<td>2-3 cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>StarFix</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP</td>
<td></td>
<td>10cm</td>
<td>GPS</td>
<td>Phase DGNSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G2</td>
<td></td>
<td>10cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G2+</td>
<td></td>
<td>3cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G4</td>
<td></td>
<td>5-10cm</td>
<td>GPS + GLONASS + BDS + Galileo</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td></td>
<td>1.5m</td>
<td>GPS</td>
<td>DGNSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XP2</td>
<td></td>
<td>10cm</td>
<td>GPS + GLONASS</td>
<td>PPP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An Environmental Scan of PNT infrastructure on the Continent

SBAS Navigation Payloads

**Reception details**

**42°E — NIGCOMSAT 1R**

**L-band Navigation payload L1 beam**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to satellite:</td>
<td>35786.4km</td>
</tr>
<tr>
<td>Location:</td>
<td>0° 42°E</td>
</tr>
<tr>
<td>Elevation angle:</td>
<td>90°</td>
</tr>
<tr>
<td>LNB Tilt (skew):</td>
<td>NaN°</td>
</tr>
<tr>
<td>True azimuth:</td>
<td>NaN°</td>
</tr>
<tr>
<td>Next Sun azimuth match at:</td>
<td>NaN°</td>
</tr>
</tbody>
</table>

**Reception details**

**25°W — ALCOMSAT NAV**

**L-band Navigation beam**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to satellite:</td>
<td>35786.4km</td>
</tr>
<tr>
<td>Location:</td>
<td>0° 25°W</td>
</tr>
<tr>
<td>Elevation angle:</td>
<td>90°</td>
</tr>
<tr>
<td>LNB Tilt (skew):</td>
<td>NaN°</td>
</tr>
<tr>
<td>True azimuth:</td>
<td>270°</td>
</tr>
<tr>
<td>Next Sun azimuth match at:</td>
<td>NaN°</td>
</tr>
</tbody>
</table>

NIGCOMSAT 1R GPS L1 & L5 SBAS Payloads Footprints

ALCOMSAT NAV SBAS Payload Footprints
An Environmental Scan of PNT infrastructure on the Continent

Stand Alone GNSS Reference stations (Monitoring of Tectonic Movements)

<table>
<thead>
<tr>
<th>Initiative</th>
<th>State/region</th>
<th>Number of Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa Array GNSS Network</td>
<td>Pan-African (20 states)</td>
<td>26</td>
</tr>
<tr>
<td>HartRAO’s Space Geodesy Programme</td>
<td>South Africa</td>
<td>9</td>
</tr>
<tr>
<td>Egyptian Permanent GPS Network (EPGN)</td>
<td>Egypt</td>
<td>24</td>
</tr>
<tr>
<td>Virunga Volcanoes Monitoring (KivuGNet)</td>
<td>Central Africa</td>
<td>16</td>
</tr>
<tr>
<td>REGAT (REseau Géodésique de l’Atlas) GPS network</td>
<td>Algeria</td>
<td>56</td>
</tr>
</tbody>
</table>

### Other Networks
- The Horn Africa
  - Ethiopia Tectonics GPS Network
  - Eritrea GPS network
  - Afar GPS Network
- Malawi Rifting GPS Network
An Environmental Scan of PNT infrastructure on the Continent

Stand Alone GNSS Reference stations (IGS Network)

IGS (International GNSS Services) network of reference stations

IGS network on the Continent used by the Scientific community mainly for research
Gaps analysis on PNT (infrastructure & Technology)

Horizontal Accuracy 10 cm and Vertical Accuracy 20 cm up to 1000 km from the reference station (oministar)

GAP in Infrastructure From a Continental Perspective

No. Services available for PPP, RTK & DGNSS
Gaps analysis on PNT (infrastructure & Technology)

Stand Alone GNSS Reference stations (IGS Network)

Ownership of IGS References stations (Inside Africa vs Outside Africa)

Distribution of IGS stations across Regions

<table>
<thead>
<tr>
<th>Constellation</th>
<th>Satellite Ephemerides</th>
<th>Satellite and Station Clocks</th>
<th>SV Range (RINEX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>GLONASS</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>GALILEO</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Beidou</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>IRNSS</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>SBAS</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

No of Stations

- Northern Africa: 1
- Western Africa: 5
- Southern Africa: 19
- Eastern Africa: 13
- Central Africa: 1
Addressing the PNT Technology and Infrastructure Gaps

Proposed approach to addressing deficiencies identified during the study

To Address the Critical GNSS Application Community Needs
- Densification of GNSS CORs networks
- Development of satellite based augmentation systems
- Broadcasting wide area PPP corrections

To Address the Science & Research Community Needs
- Densification of GNSS Reference stations
  - Step ONE: Extension in Existing Networks (E.g. African Array,
  - Step TWO: Development of Regional Data storage and processing facilities
  - Step THREE: Development of New Networks (E.g. Centered Inter African University) Networks
Addressing the PNT Technology and Infrastructure Gaps

Proposed approach to addressing deficiencies identified during the study

Priority One: Densification of GNSS CORs networks

- **Priority Action 1.1**: Deployment of RTK services in line with African Population density distributions
- **Priority Action 1.2**: Migration from RTK based service to Network RTK (RTK Network densification)
- **Priority Action 1.3**: Regionalization of states’ GNSS CORS networks

Priority Two: Development of satellite based augmentation systems
Addressing the PNT Technology and Infrastructure Gaps
How GNSS is used on the Continent

- Vehicle tracking
- Scientific Research
- Aviation (In support to ABAS + Baro VNAV application)
- Geodesy
- LBS (Location Based Services)
- Core GNSS Constellations
- GNSS Augmentations
- GEO-Informatics (Survey & Mapping)
- Precision Agriculture in Southern Africa
- Coastal Maritime Navigation
On-going SBAS Initiatives, Programmes and feasibility studies on the African Continent
Key Actors in the development of SBAS on the continent

European Commission

PAN African

ASECNA Region

EGNOS V3 (European Neighborhood Policy-South)

Northern Africa

Continental Africa

African Union
ASECNA is leading a comprehensive SBAS programme that foresees operational SBAS services from 2025, with a progressive coverage of the continent, to enhance PBN and ADS-B operations for all phases of flight.
### Activities Undertaken under the programme

- **Phase B Studies** to define the best system architecture to support the delivery of SBAS services:
  - Preparation of the implementation of Phase C and D Stages currently being undertaken
  - Ongoing efforts for the amendment of the ICAO annex 10 to **include ANGA**
  - Securing PRN Codes for ANGA ongoing

<table>
<thead>
<tr>
<th></th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td></td>
<td></td>
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<tr>
<td>Q3</td>
<td></td>
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<td>Q4</td>
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<tr>
<td>Q1</td>
<td></td>
<td></td>
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<tr>
<td>Q2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Phase B1**:
  - Prototype / Test bed
- **Phase B2**:
  - Pre-operational SiS
- **SRR**:
- **PDR**:
- **Demonstrations**
Activities Undertaken under the programme (SBAS Demonstration)

The objective of the demonstration was to foster the adoption of SBAS technology and the following Field Demonstrations were undertaken.

- SBAS flight demonstration carried out at Lome international airport (TOGO) during the 27th January, 2021

- Helicopter demonstration (PinS: point-in-space) flight between Douala and Kirbi in Cameroon on 2nd June 2021

- Demonstration of PPP (precise point positioning) services delivered through SBAS was carried out in Brazzaville (Republic of Congo) during 6th July to 9th July 2021. It involved mapping of the national stadium (stadium Alphonse Massamba-Debat) using a dual-frequency receiver supporting GPS and Galileo)
Under the EGNOS V3 development, EU Agency for the Space Programme (EUSPA) plans on expanding the EGNOS services in European Neighbourhood Policy South countries (ENP-South).

In principle, the ENP-South region covers ten non-EU Mediterranean countries: Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria and Tunisia.

European Satellite Services Provider (ESSP) working on the further expansion of the EGNOS services in ENP-South.
Background to the CBA study

Decision adopted by the AU Member States in 2017 and in line with the APIRG/22 conclusion 22/39, tasked the African Union Commission (AUC) to conduct a continental cost-benefit analysis (CBA) on SBAS introduction in the region, considering existing initiatives.

AFI GNSS Strategy (ICAO APIRG) identifies SBAS as a key enabler of PBN operations.

Assess the SBAS economic attractiveness for the continent, to support the decision-making process by States and Stakeholders on the best implementation options, and enable update of the AFI GNSS strategy accordingly.

Specific focus on the aviation sector, evaluating the operational, safety, environmental, social benefits as well as the costs of SBAS implementation for all aviation stakeholders.
AU Continental CBA study on SBAS implementation

AFCAC (AU’s designated institution responsible for enabling a robust African aviation industry mandated to undertake the study, which was Completed on May 2022

Study Demonstrated high economic attractiveness of SBAS implementation across the whole aviation sector

Airlines: The SBAS business case is highly profitable and attractive, with positive values in all the evaluated financial indicators

Ground-side users (ANSPs, airport operators and SBAS service provider): The business case is profitable as well.

- The socioeconomic impact of SBAS monetised and included in the economic results of the CBA; emphasis on the environmental impact of the SBAS implementation revealed a very positive carbon footprint.
Conclusive Remarks

- SATNAV Africa JPO is grateful with the opportunity provided to take part in the 62nd Meeting of the Civil GPS Service Interface Committee.

- The SATNAV Africa JPO is currently the only continental wide programme concerned with monitoring developments within the satellite navigation domain as such can be a good source of exchanging information on the use of GPS.

- We look forward to having any future cooperation with the Civil GPS Service Interface Committee.