UPDATE ON NIGERIA'S EFFORT WITH PARTNERS FOR A SATELLITE-BASED AUGMENTATION SYSTEM IN AFRICA

BY

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FOR

15 MEETING OF THE INTERNATIONAL COMMITTEE ON GLOBAL NAVIGATION SATELLITE SYSTEMS (ICG)

AT

UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS (UNOOSA), VIENNA

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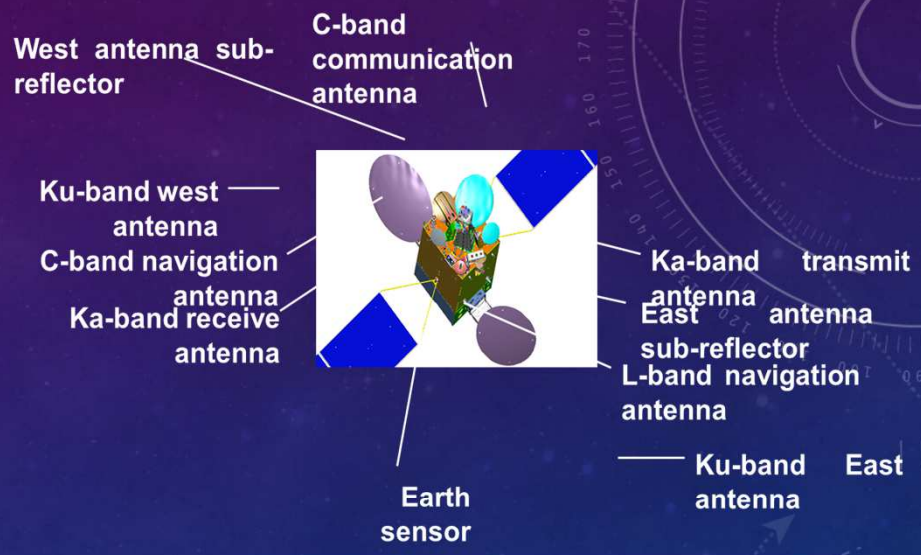
ABSTRACT

The importance and application of global navigation satellite systems (GNSS) has never been greater; there is increasing demand for both commercial and government projects as an emerging technology for adoption; indeed, owning and operating a GNSS facility has become a matter of national esteem especially as it concerns Satellite-based augmentation system (SBAS). SBAS; a less ambitious system than GNSS is a satellite-based system that aids a Global Navigation Satellite System (GNSS) in providing further accuracy, integrity and availability to positioning, navigation, and timing for professional use and application in critical sectors that involves safety of life (SOL) and precise positioning i.e Aviation and Non-Aviation sector which requires verified performance with integrity. The presentation provides insights and progress being made in African continent with SBAS flight demonstrations to sensitize stakeholders towards acceptance and adoption of SBAS technology for its numerous benefits including non-aviation sector with precise point positioning (PPP) to bring centimeter accuracy to African continent.

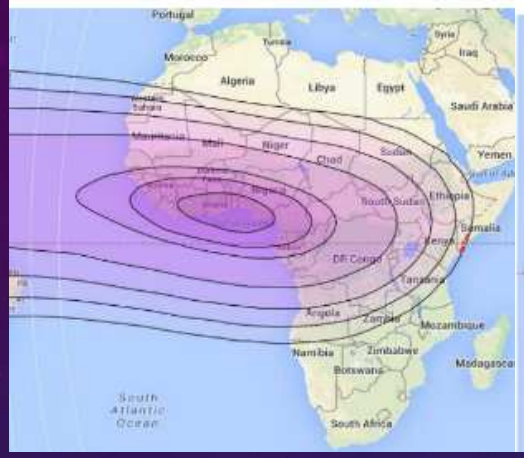
ABOUT NIGCOMSAT-1(R)

- Nigeria's first communication satellite (NIGCOMSAT-1), a quad-band high powered satellite with navigational capability and capacity was launched on 14th May, 2007.
- NIGCOMSAT-1 was Africa's first contribution to the Global Navigation Satellite System as regional Satellite-based Augmentation System (SBAS).
- NIGCOMSAT-1 was however de-orbited on the 10th of November, 2008 due to an irreparable single point of failure on-board the satellite power subsystem.
- The **NIGCOMSAT-1R;** currently in orbit is the insurance replacement for NIGCOMSAT-1 satellite launched on 19th December, 2011.

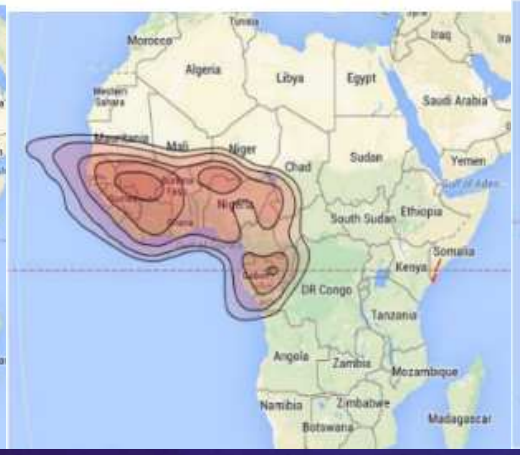


NIGCOMSAT-1R SATELLITE FOOT PRINT

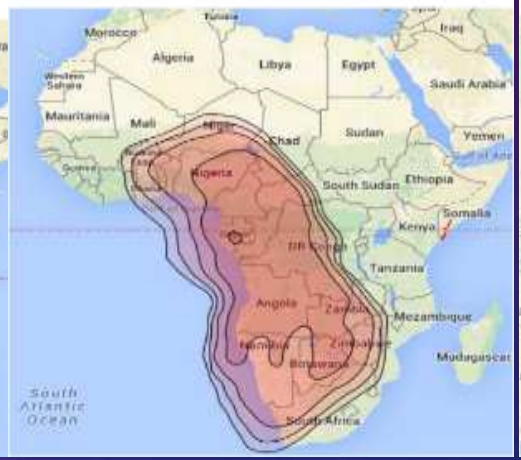
C-Band Ecowas 1 beam



Ku-Band Ecowas 1 beam



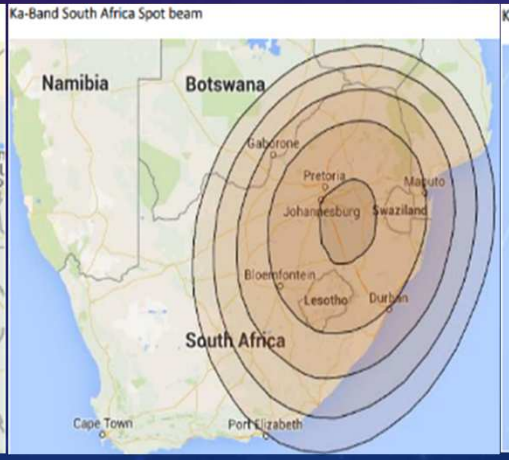
Ku-Band Ecowas 2 beam



Ku-Band Asian (Kashi) beam

Ka-Band Nigeria Spot beam

Ka-Band South Africa Spot beam



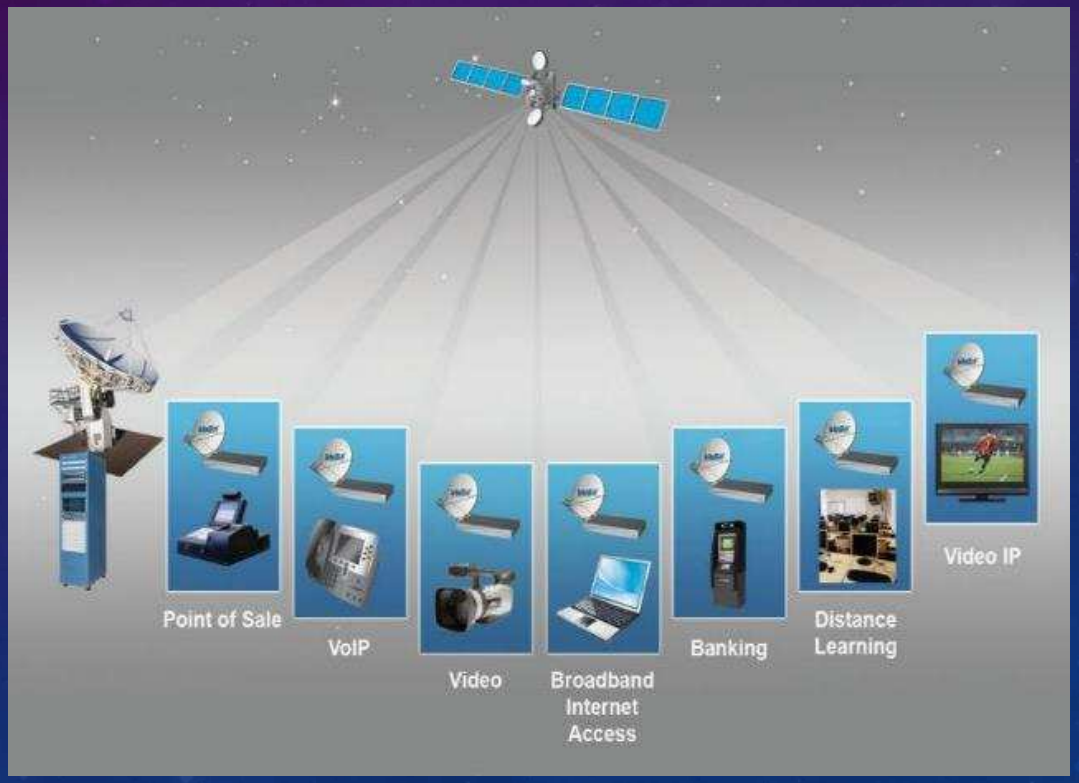
Ka-Band Europe Spot beam

L-Band Navigation Payload L1 beam

BEYOND NIGCOMSAT'S TRADITIONAL RANGE OF SERVICES IS SATELLITE-BASED NAVIGATION CAPABILITY.

NIGCOMSAT

…African Rooted
Globally Positioned



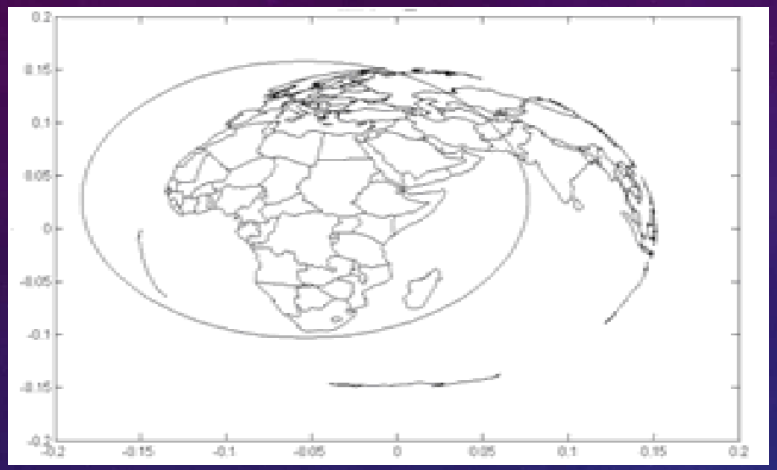
NIGCOMSAT-1R AS A HYBRID SATELLITE

- NIGCOMSAT-1R is a hybrid satellite with a Navigation (L-Band) payload for a Space Based Augmentation System meant to provide a Navigation Overlay Service (NOS) similar to the European Geostationary Navigation Overlay Service (EGNOS).

AFRICA'S SBAS: NIGERIA'S CONTRIBUTION TO SBAS WITH PRN CODE 147.

- Satellite-Based Augmentation System (SBAS) arose from the need to provide Continuity, Availability, Integrity and Accuracy of GNSS signals to eliminate errors and compensate for discrepancies associated with GPS and other navigation systems signals.
- The NIGCOMSAT-1R Navigation (L-Band) payload is a Space-Based Augmentation System meant to provide a Navigation Overlay Service (NOS) similar to the European Geostationary Navigation Overlay Service (EGNOS).
- The SBAS compensates for errors of GNSS in terms of **Integrity and Accuracy and p**rovides **Continuity and Availability.**
- Makes differential corrections and then broadcast the integrity messages as an augmented signal of the original GNSS Signal in Space (SiS) through ***NigComSat-1R*** for a wide coverage.
- **Africa's SBAS in conjunction with ASECNA has Pseudo Random Noise (PRN) code 147.**
- Conforms to **global standard to enhance Interoperability, Compatibility and Zero Interference.**

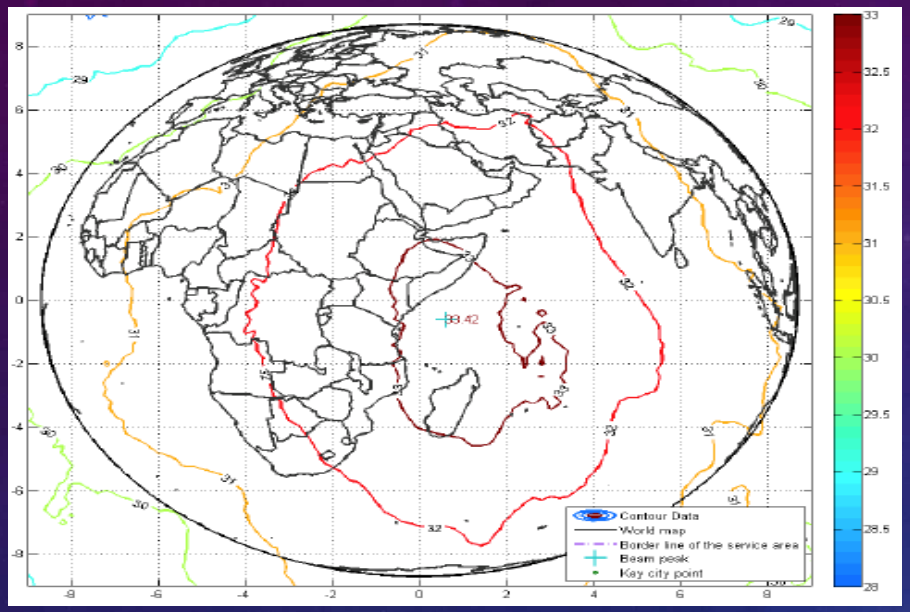
NIGCOMSAT-1R NAVIGATION PAYLOAD: AFRICA'S CONTRIBUTION TO SBAS



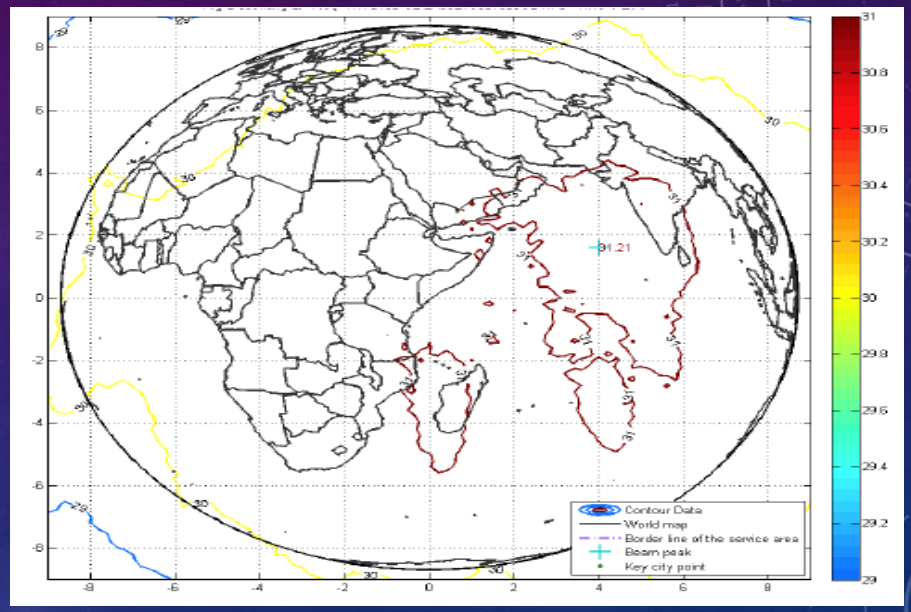
The Uplink coverage beam of NIGCOMSAT-1R
Geo-Navigation Satellite using C –Band Horn Antenna.

NIGCOMSAT Master Control Station with C-L Band Antenna
Systems

NIGCOMSAT-1R NAVIGATION PAYLOAD: AFRICA'S CONTRIBUTION TO SBAS AND GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS).



The downlink coverage beam of NIGCOMSAT-1R Geo-Navigation Satellite on L1 Frequency

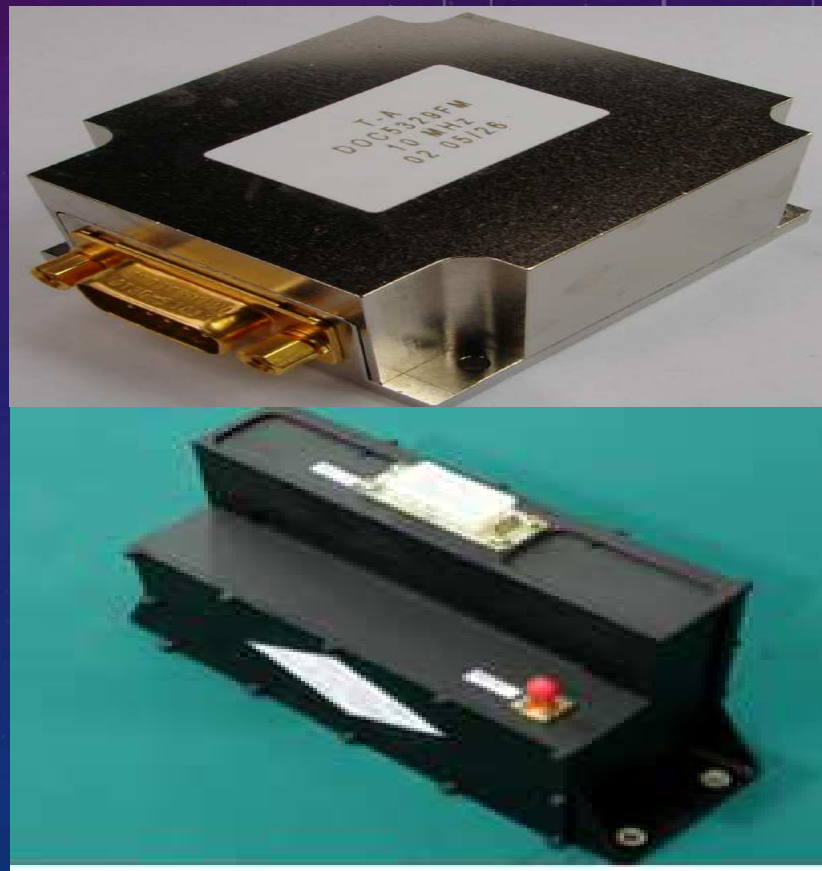


The downlink coverage beam of NIGCOMSAT-1R Geo-Navigation Satellite on L5 Frequency

Channel	Frequency (MHz)	Polarization	Bandwidth (MHz)
L1-Downlink	1575.42	RHCP	4
L5-Downlink	1176.45	RHCP	20

NIGCOMSAT-1R NAVIGATION PAYLOAD: AFRICA'S CONTRIBUTION TO SBAS

- ***10MHz ultra stable crystal oscillator was used for the L-band payload to meet the performance requirements of frequency conversion stability and accuracy.***



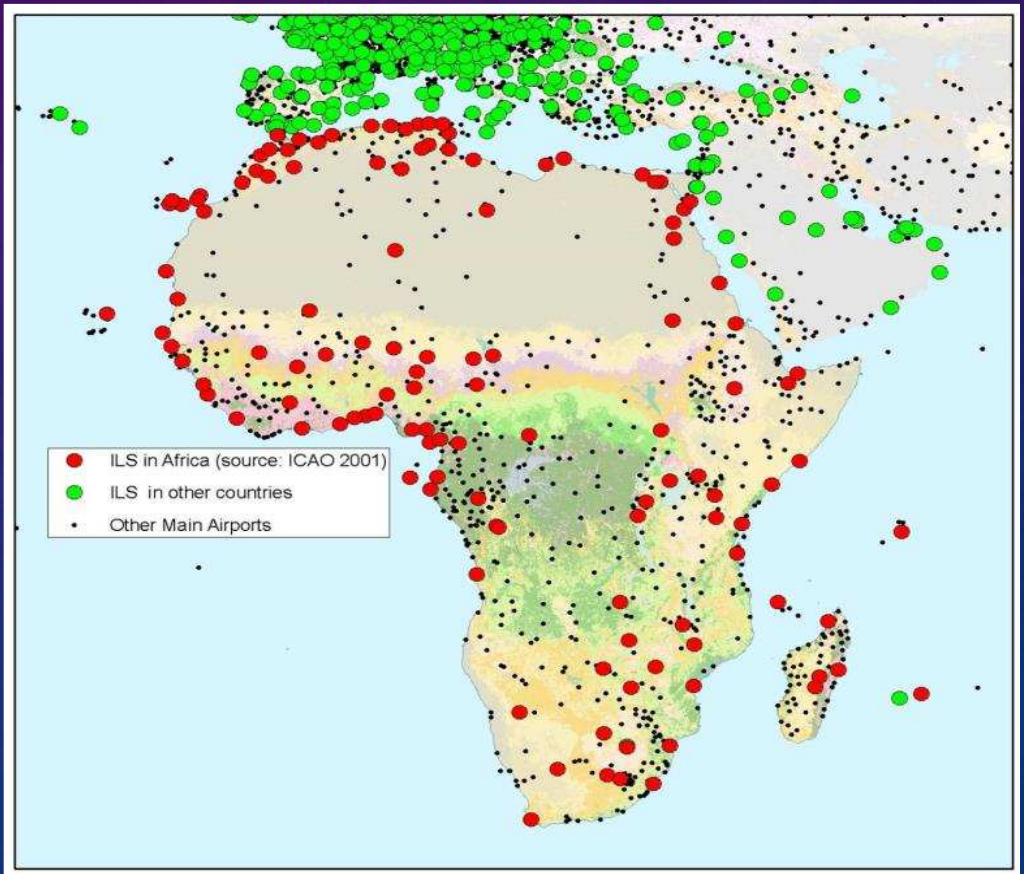
10MHz Master Oscillator

SYNERGY WITH NATIONAL , REGIONAL AND INTERNATIONAL FIRMS AS A MEANS OF OVERCOMING CHALLENGES AND FACILITATING ACCEPTANCE & ADOPTION OF SBAS TECHNOLOGY ESPECIALLY IN THE AVIATION SECTOR.

There is socio-economic and market potential of SBAS in African continent after carrying out needs assessment and gap analysis and validated by stakeholders as it concerns Aviation sector, non-aviation sectors such as maritime, survey, civil engineering, national security challenges, public safety needs etc. However there is a infrastructural gap requiring necessary ground infrastructure to utilize the navigation satellite services and thus need for national and multilateral cooperation with partners to get SBAS system off the ground with sensitization exercise and demonstrations for SBAS technology acceptance and adoption at continental level.

NEEDS AND GAP ASSESSMENT OF SBAS IN AFRICA (AVIATION SECTOR)

In aviation, the instrument landing system (ILS) is a radio navigation system that provides short-range guidance to aircraft to allow them to approach a runway at night or in bad weather safely.



NEEDS AND GAP ASSESSMENT OF SBAS IN AFRICA (AVIATION SECTOR)

- Less than 20% of Runways are equipped with Instrument Landing Systems (ILS) in Africa.

- 2011-2015 [IATA annual review 2016] Controlled Flights into Terrain (CFITs) = 20% of fatalities, most of them occurring in the approach/landing phase and being often associated with imprecise approach.

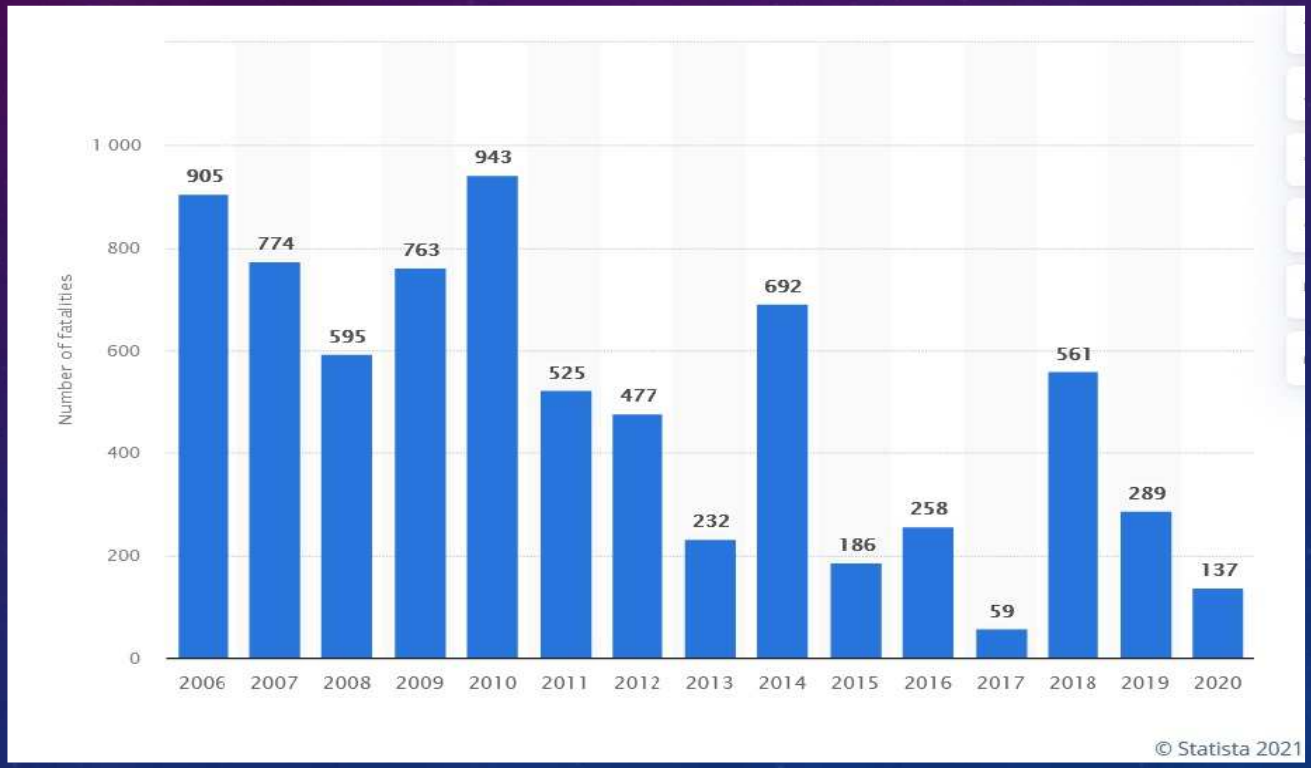
- SBAS helps overcome known safety and operational limitations of the technical constraints of lateral navigation (LNAV) and Vertical Navigation (VNAV) operations.

- Reduced maintenance Costs of Legacy Systems and calibration requirements
- SBAS is a Cost-effective solution in complement to ILS.

COST BENEFIT ANALYSIS OF SBAS TECHNOLOGY IN AFRICA

Main benefits in Aviation is CFIT reduction and Supporting Automatic Dependent Surveillance Broadcast (ADS-B) implementation. Support ground infrastructure represents the highest investment required in Africa and thus the cost benefit analyses (CBA) for an Inter-regional SBAS takes a more pragmatic approach with considered benefits that can be measured in financial terms accruing to the civil aviation sector. Cumulated benefits of SBAS for aviation in the AFI region over a 30-year period will amount to €1,650 millions compared to expected investments of about €360 millions. Discounted net benefits amount to €210 millions, which makes a hugely positive case for SBAS implementation in Africa. We are in conjunction with Agency for Aerial Navigation Safety in Africa and Madagascar (ASECNA) working on SBAS initiative and program to help define the way SBAS system, a Performance–based Navigation(PBN) should be deployed at best for the needs of the continent.

NUMBER OF WORLDWIDE AIR TRAFFIC FATALITIES FROM 2006 TO 2020*



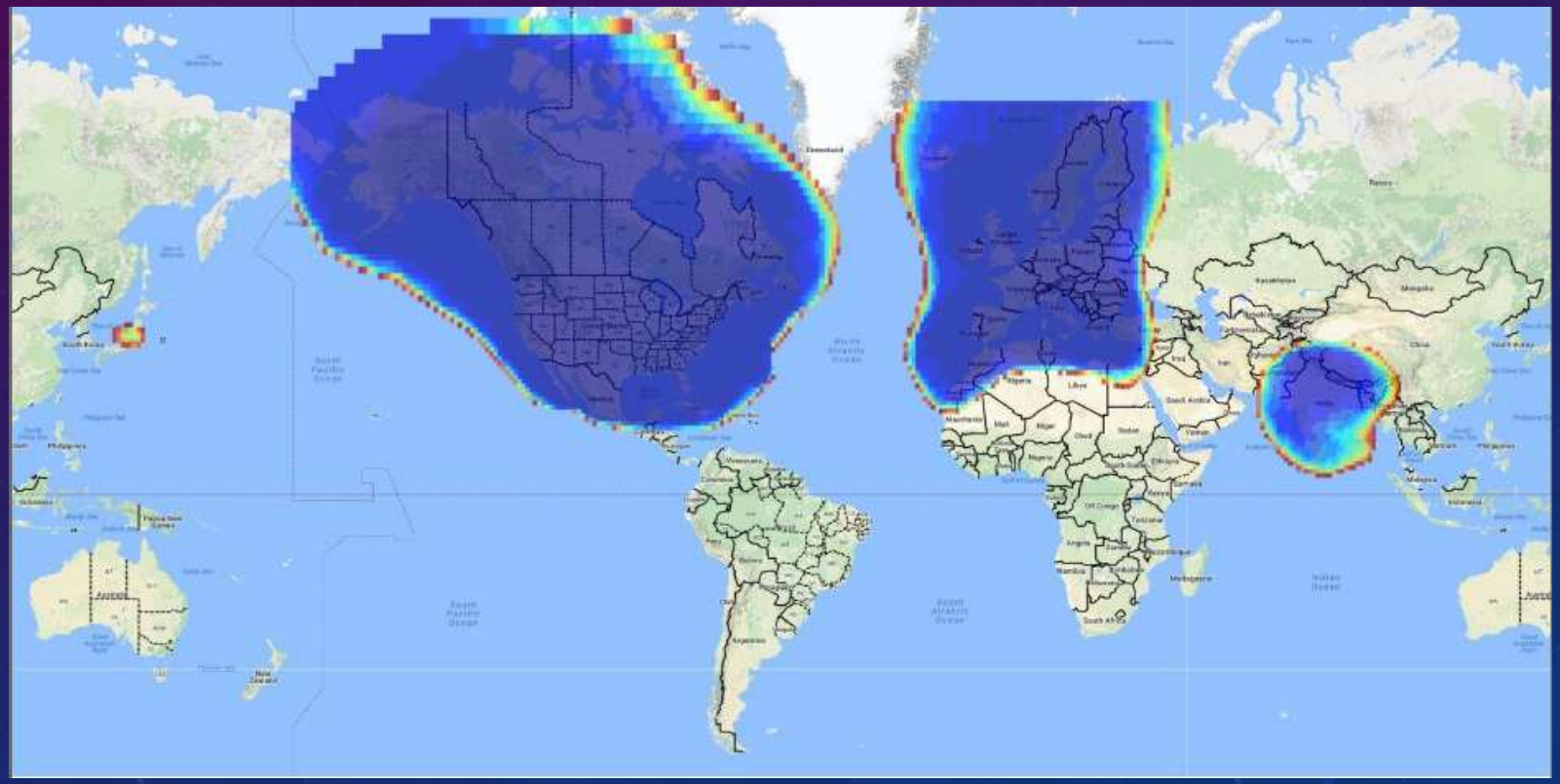
https://www.statista.com/statistics/263443/worldwide-air-traffic-fatalities/

AIRPLANE CRASH/FATALITIES BY PHASE OF FLIGHT STATISTICS

- Odds of being killed on a single airline flight 1 in 29.4 million
- Number of fatalities per million flight hours 12.25
- Survival rate of passengers on a fatal crash 24 %
- Fatalities by Phase of Flight
  - 0% during Taxi, load/unload, parked, tow
  - 16 % during Take-offs
  - 14% during Climb (flaps up)
  - 13% during Initial Climb
  - 16% during Cruise
  - 4% during Descent
  - 37 % during Initial Approach (12%), Final Approach (13%), & Landing (12%)

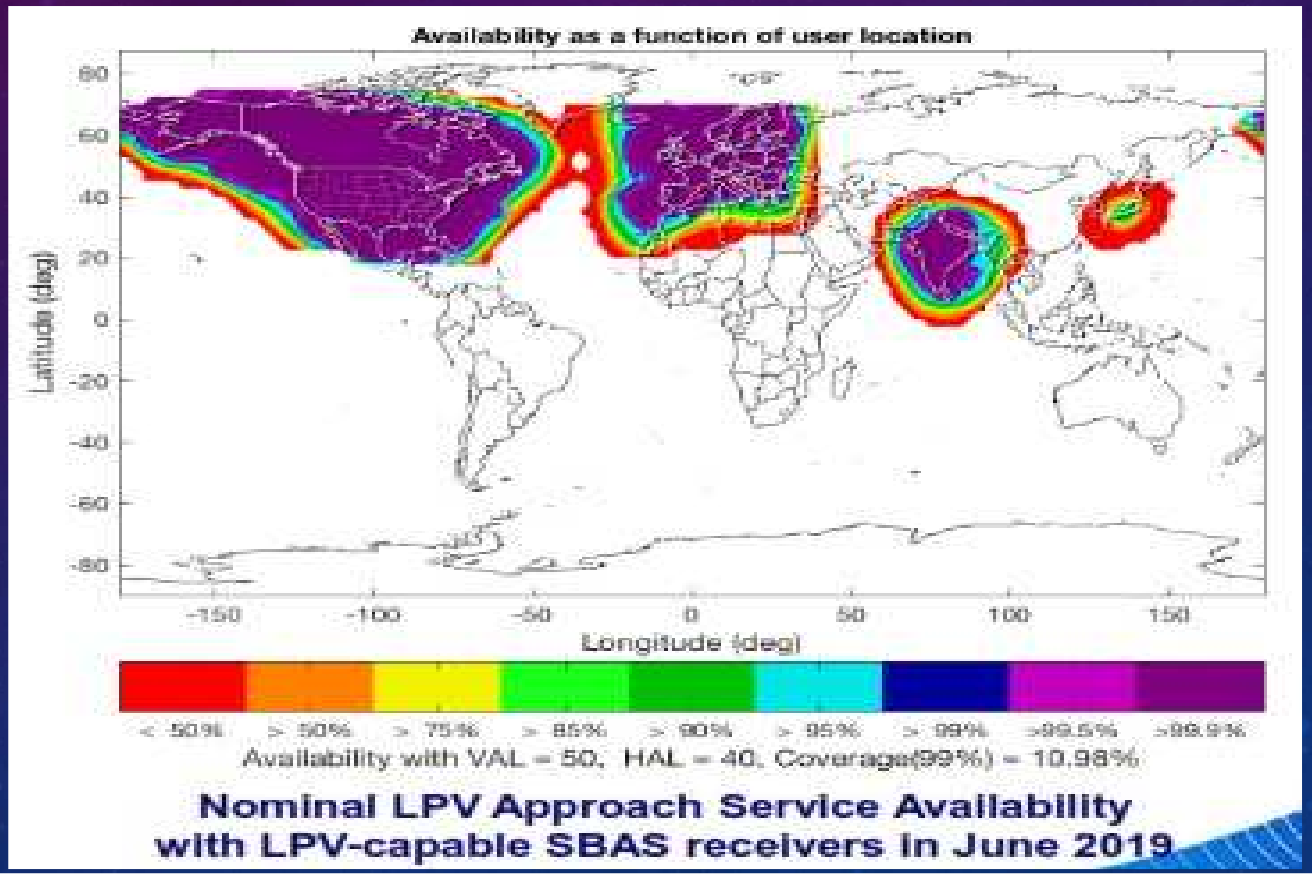
https://www.statisticbrain.com/airplane-crash-statistics/

SBAS DEVELOPMENT: APPROACH COVERAGE MAY 1, 2016

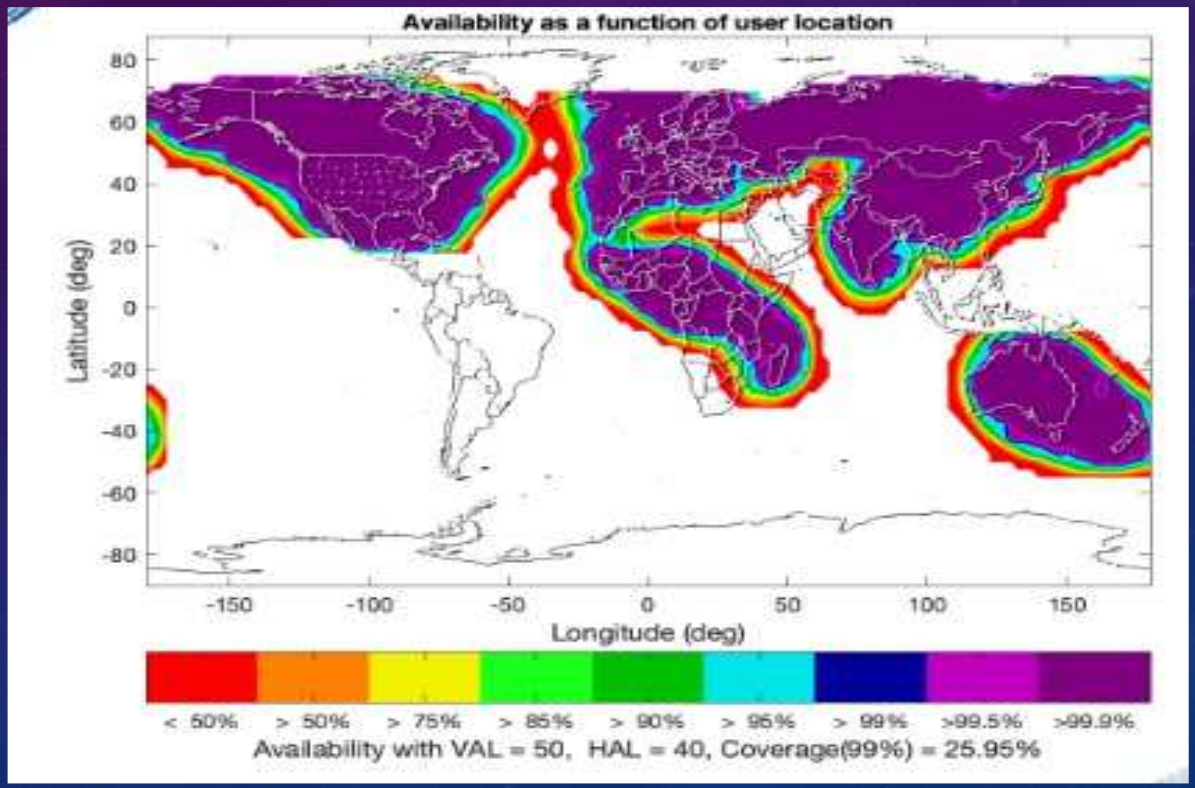


COURTESY OF FAA TECH CENTER

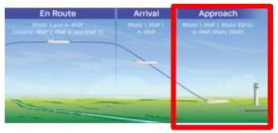
SBAS DEVELOPMENT: APPROACH/LANDING SERVICES AS AT JUNE, 2019.



SBAS DEVELOPMENT: PLANNED SBAS SERVICES WITHIN THE NEXT 4 YEARS



SBAS Services



CWAAS	2007
LPV	538

EGNOS	2011
Cat-I	261
LPV	694*

SDCM	

MSAS	2007
NPA only	
LPV	2023

KASS	2022

BDSBAS	2022

WAAS	2003
Cat-I	1049
LPV*	4084
LP	725

A-SBAS	2024

GAGAN	2013
LPV	65 Pending publication

SouthPAN	2023

Operational	Planned year

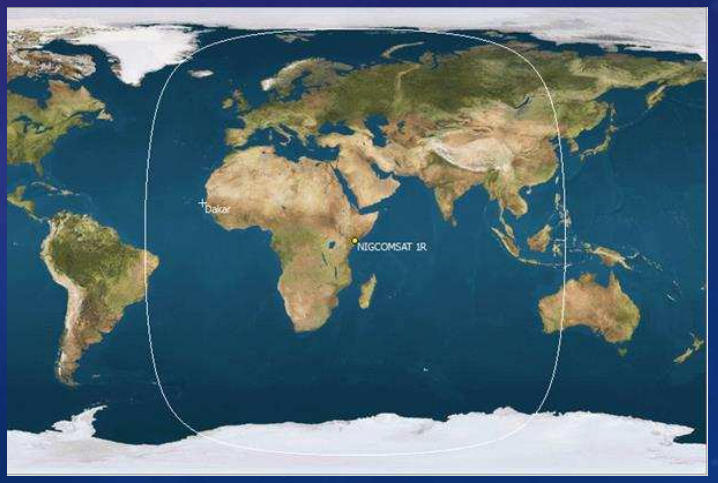
SBAS SIGNAL BROADCAST AND DEMONSTRATION EFFORTS IN AFRICA

- SBAS (Satellite-Based Augmentation System) signal broadcast over Africa & Indian Ocean (AFI) region began since September 2020, providing the first SBAS open service in this part of the world via NIGCOMSAT-1R Satellite.
- **On the 27th of January 2021, a series of 5 flight demos at Lomé International Airport was conducted. The goal of the trial was to show in real configuration the efficiency of SBAS technology which pursues autonomous provision of SBAS service over the continent to augment the performances of satellite navigation constellations of GPS and Galileo.**
- The tests were carried out utilizing ASECNA's calibrated aircraft; ATR42-300, which was equipped by Pildo Labs with specific sensors and embarked on 5 rotations over Lome airport. The demonstration showed ability of the system to allow landings on the two ends of the runway without deployment of local ground infrastructure and with a performance level close to the use of Instrument Landing Systems (ILS). It demonstrates the benefits of safety-of-life of SBAS services in terms of flight safety, efficiency and environmental protection.
- The outcomes of demonstrations and sensitization exercise, is a crucial step forward in the adoption, provision and use of satellite navigation services in the African region and surrounding waters.

FIELD DEMONSTRATION TO DRIVE ACCEPTANCE AND ADOPTION OF SBAS TECHNOLOGY IN AFRICA.

INFRASTRUCTURE DEPLOYED FOR THE DEMO

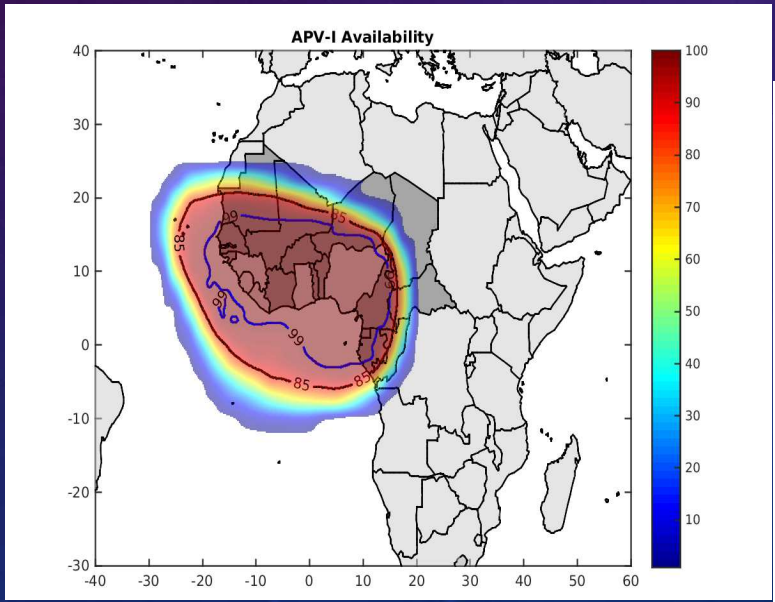
- ✓ Extended SAGAIE GNSS stations.
- ✓ Representative system prototype deployed in Dakar.
- ✓ Uplink station in Abuja and NigComSat-1R Navigation Payload



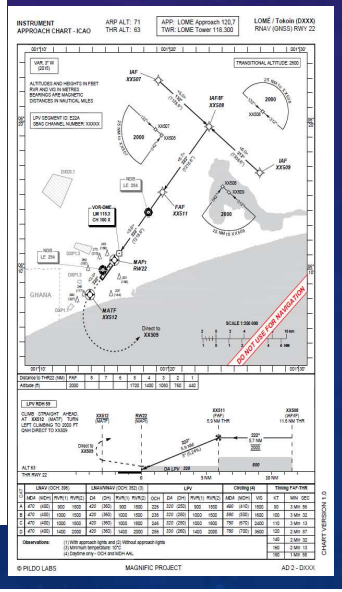
FIELD DEMONSTRATION TO DRIVE ACCEPTANCE AND ADOPTION OF SBAS TECHNOLOGY IN AFRICA.

We began broadcast of a SBAS (Satellite-Based Augmentation System) signal over Africa & Indian Ocean (AFI) region since September 2020, providing the first SBAS open service in this part of the world via NIGCOMSAT-1R Satellite

RWY 22 at Lome International Airport, TOGO



APV-1 availability (05/10/2020)



OPERATIONAL BENEFITS OF SBAS

- Approach with vertical geometric guidance on non-instrumented runways
- Lower minima compared to Non-Precision Approach (NPA)
- Better stability than Instrument Landing System (ILS)
- SBAS performance is not sensitive to temperature fluctuations and has no barometric or temperature limitations.
- Performance not impacted by barometric pressure, temperature fluctuations or barometric mis-setting.
- SBAS provides benefits beyond aviation to all modes of transportation. i.e maritime, railroads, inland waterways etc.
- SBAS provides not just approach capability but en-route capability.
- SBAS does not require the installation or maintenance of ground-based navigation aids or landing systems.

OTHER BENEFITS OF SBAS AS IT CONCERNS IMPROVEMENT OF SAFETY AND REDUCTION IN OPERATIONAL COSTS AND ENVIRONMENT.

- Reduced Controlled Flight into Terrain (CFIT) risk/accident
- Reduced delays, diversions and cancellations due to weather conditions
- Reduced flight times
- Reduced fuel consumption
- Reduced CO2 and Noise emissions
- Reduced Flight crew workload by eliminating RAIM prediction requirements. RAIM=Receiver Autonomous Integrity Monitoring.
- Increases Airspace capacity.

FEEDBACK FROM PILOTS ON SBAS FLIGHT DEMONSTRATION CARRIED OUT ON 27TH JANUARY, 2021 AT LOME INTERNATIONAL AIRPORT.

Air Côte d'Ivoire

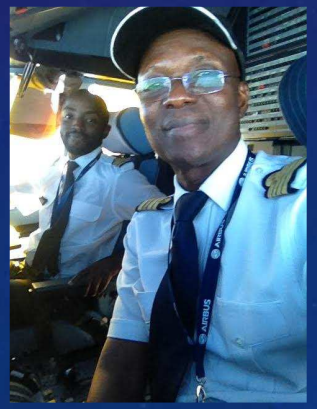
'SBAS means flight safety through approaches with minima equivalent to ILS CAT-1 everywhere at all times'

Capt. Zouel Bayli

ASKY
The Pan African Airline

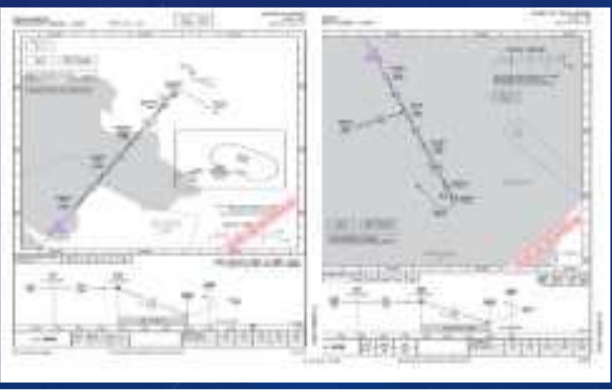
'SBAS can revolutionise navigation for the approach phase'

Capt. Patrice Moevi



HELICOPTER DEMONSTRATION FLIGHT BETWEEN DOUALA AND KRIBI IN CAMEROON ON 2ND JUNE, 2021

The helicopter demonstration flight was conducted along a low-level, two-way route linking two Point in Space (PinS) approaches to the Douala airport and a point near the oil platforms located on the Kribi coast, both in Cameroon. The flight was performed using a helicopter provided by Heli Union and an SBAS validation receiver from Pildo Labs. The aim of the experiment was to demonstrate the ability of the SBAS system to improve the safety of satellite navigation for helicopters through increased GNSS performance as regards flight safety, efficiency & environmental protection for enroute navigation as well as landing/approach phase.



AVIATION

- Exponential development of SBAS services in the world and widely acknowledged by airspace users.
- Most aircrafts expected to be SBAS capable from 2030. However, retrofit solutions are currently available at lower cost.
- Reduced and simplified equipment on board aircraft: SBAS airborne equipment acquisition, integration and installation costs is very minimal.
- Flight crew training costs (≈ 0).
- SBAS services expected from 2024 based on ASECNA strategy (Francophone countries in Africa).
- This is a potential for progressive coverage of the continent

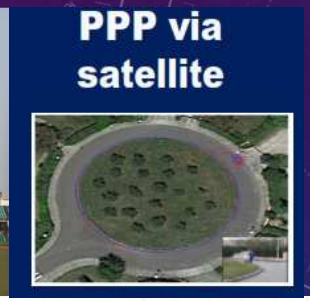
APPLICATIONS AND SOLUTIONS IN NON-AVIATION SECTOR

SBAS/GNSS APPLICATIONS

OTHER GNSS/SBAS APPLICATIONS

The SBAS demonstration at Brazzaville, Republic of Congo between July 6 to 9, 2021 was in Non-Aviation sector delivering precise point positioning (PPP) to centimeter level.

The national stadium Alphonse Massamba-Debat employing a dual-frequency GNSS chipset receiving GPS and Galileo signals. The SBAS demo corrections improved positioning from 3-10metres to centimetric level: 5 cm (East), 6.1 cm (North) and 14.4 cm (Up) with 68% confidence level. To show the improved accuracy, the demonstration device followed the marking of the football stadium as below: Football Stadium Video Link.



OTHER GNSS/SBAS APPLICATIONS

The demonstration with our partners showed system's ability to achieve positioning accuracy to within centimeters across the entire African continent. A world first, this satellite service paves the way for applications in a broad range of sectors, including precision agriculture, land and maritime transport, rail safety, drone navigation, mapping and surveying, mass-market applications etc.

We also demonstrate special urgent warning alert service via satellite showing system's ability to broadcast a warning message via SBAS signal to mobile phones, without requiring a terrestrial network. This service sends a message to the populations concerned, providing information on the type of danger and instructions to be followed. A typical example is warning alert for forest fires, landslide, terror raids etc.

OTHER GNSS/SBAS APPLICATIONS

- Security of National Infrastructure: Pipelines, Power Lines, Gas Reservoirs, Strategic national Infrastructure.
- Improved Agricultural Practice with high yield.
- Improved Emergency Services, Recovery Services, Search & Rescue: NEMA, Fire Fighters, FRSC etc
- Utility Management: Energy and Communications Company for timing & synchronization.
- Geographic Information System Companies
- Tourism
- Telematic Services i.e Insurance Companies
- Environmental Protection, Characterization and Demography
- Paramilitary Organizations, Security Agencies etc
- Scientific Research

CONCLUSION ON SBAS TECHNOLOGY IN AFRICA

- SBAS services expected from 2024 in Western/Central Africa and IO
- The Potential for progressive coverage of the continent is huge
- Support en-route down to CAT-I (DH/200 ft) operations
- Enhancement of PBN and ADS-B operations
- Significant improvement in operational safety, efficiency (operational costs reduction) and environmental protection benefits.
- Feasibility and benefits of SBAS demonstrated on the field at LFW
- No specific cost/recovery mechanism or increase of air navigation charges for the use of SBAS services.
- No penalization for airlines not yet interested

CONCLUSION

- SBAS adoption in Aviation sector in Africa aligns with the Single African Air Transport Market (SAATM) agenda of African Union (AU); a flagship project of the AU agenda 2063 to advance the liberalization of civil aviation in Africa through a unified sky and acting as an impetus to the continent's economic integration agenda.
- Exponential development of SBAS services is ongoing worldwide and Africa as a continent should not be left out.
- 'Commercial Aircraft are 5 times more likely to have an accident flying a non-precision approach than flying a precision approach' Flight Safety Foundation; March, 1996.

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International Committee on Global Navigation Satellite Systems