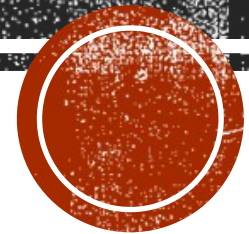


ASSESSMENT OF THE GEODETIC INFRASTRUCTURE IN AFRICA

**PRESENTED BY
GODFREY OGONDA**

**A WORK PACKAGE 2 REPORT
GGOS –AFRICA WORKSHOP**



Work Package 2 Members

Name	Institution	Role on the project
Prof. Paul Baki	TUK	Work Package 2 Lead
Prof. Hussein Farah	TUK	Contributor
Dr. Godfrey Ogonda,	TUK	Contributor
Mr. Isaac Odera	TUK	Contributor
Mr. Ochieng Melli	TUK	Contributor
Dr Alet de Witt	HartRAO/DSI	Contributor
Prof. Roelf Botha	SARAO/TUT	Contributor



INTRODUCTION

- One of the objectives of the project “*Building the Foundation for Geodetic Excellence in Africa*” seeks to lay the groundwork for a comprehensive understanding and enhancement of the geodetic infrastructure in Africa
- This is being achieved through the assessment of the current state of geodetic equipment and computational infrastructure across African nations/Countries
- The assessment of the Geodetic Infrastructure in Africa was accomplished using desktop review, questionnaires and site visits to some select countries



INTRODUCTION

- The assessment of existing geodetic infrastructure and computational resources across African nations was undertaken through:
 - ✓ **Data collection:** Developed and distributed questionnaires to collect data on existing geodetic infrastructure, including GNSS stations, VLBI stations, and data processing centres. Conduct site visits to verify the data and assess the infrastructure's operational status.
 - ✓ **Computational infrastructure assessment:** Evaluated the availability and effectiveness of computational resources, including software tools and data processing capabilities.
 - ✓ **Data analysis:** Analysed the collected data to identify strengths, weaknesses, and opportunities for improvement



SITUATIONAL ANALYSIS

- The application of geodetic data and techniques have diverse applications in the sustainable development of Africa, with impact in the following areas:
- **National Mapping and Surveying:** Providing a foundation for accurate mapping and surveying activities.
- **Resource Management:** exploration and management of natural resources.
- **Infrastructure Development:** road, railways, pipeline, ports etc
- **Geohazards Mitigation:** Monitoring earthquakes, volcanic activity, and other natural hazards.
- **Scientific Research:** Facilitating research in areas like geodynamics, plate tectonics, and climate change.

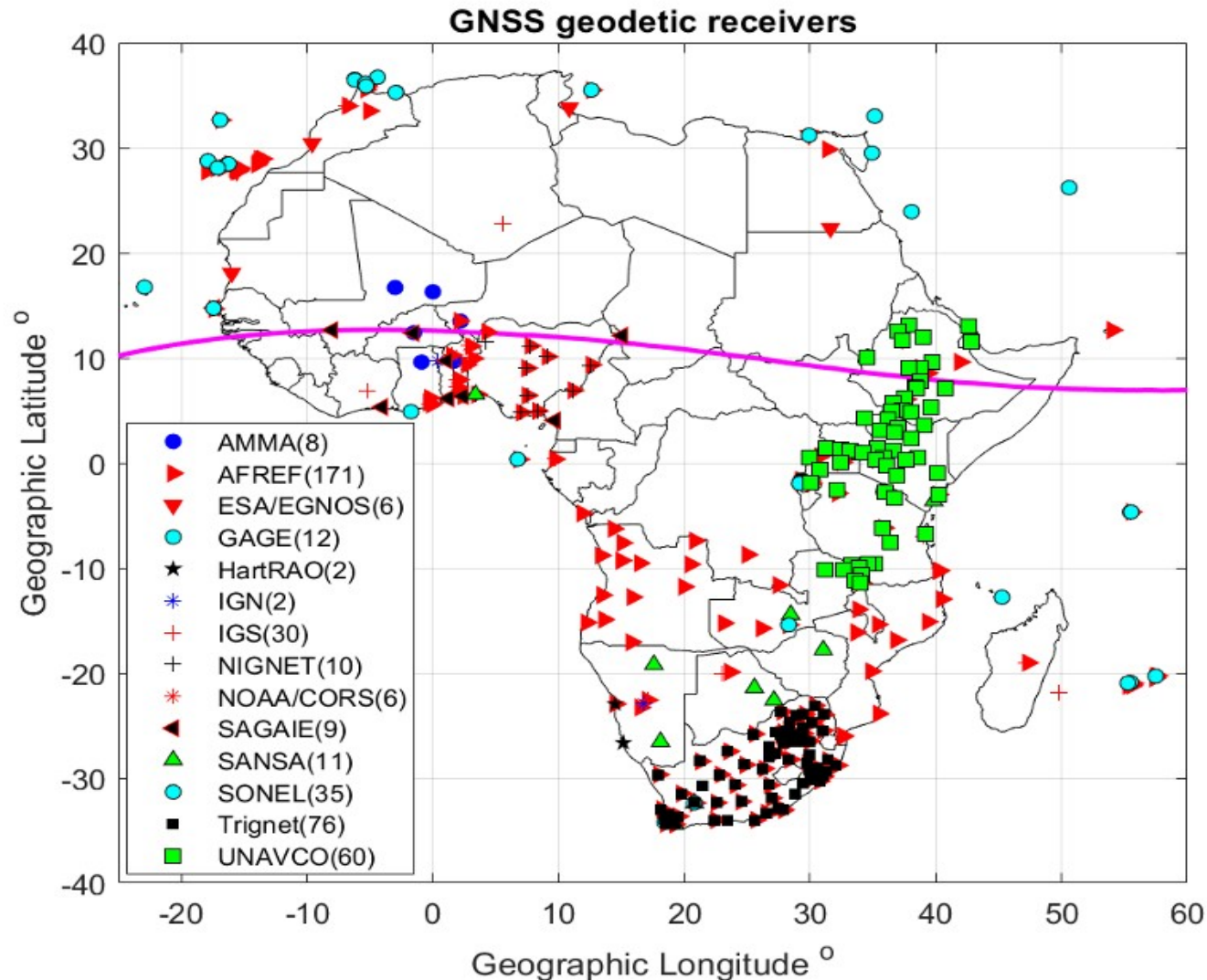


SITUATIONAL ANALYSIS

- All georeferencing requires a uniform coordinate reference frame, yet each of the 54 countries in Africa has its own geodetic reference frame with some countries have more than one reference frame based on different datums.
- Hence, the need for creating a unified geodetic reference frame for Africa was identified as important to Africa's sustainable development. [United Nations Economic and Social Council, *The African Geodetic Reference Frame*, E/ECA/GiSS/17/06, 2017].
- Since then, five major efforts to support the creation of a unified geodetic reference frame for Africa were put in place, starting with the measurement of the 30th Arc of Meridian between 1879 and 1954 and then moving on to the 12th Arc of Parallel between 1967 and 1971 and the African Doppler Survey (ADOS) project between 1982 and 1986 and finally the current AFREF initiative.



SITUATIONAL ANALYSIS



The locations of GNSS geodetic receivers in Africa.

The pink line is the geomagnetic equator³



FINDINGS

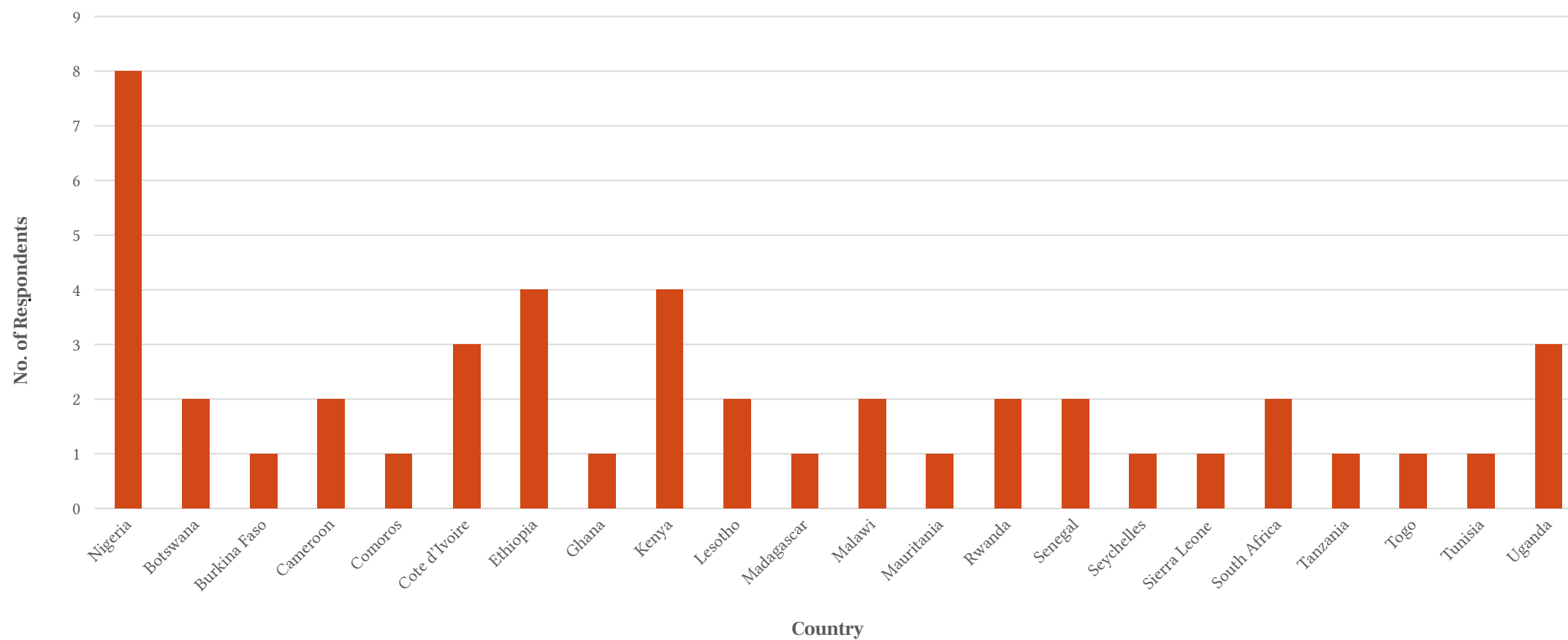
- **Source of Data: Questionnaire and Desk top review**
- The questionnaire was structured according to the following scheme:
 - Section A – Description of respondent's profile.
 - Section B – Information on geodetic infrastructure
 - Section C – Information on the coordinate reference systems
- There was a total of 46 respondents to the questionnaire on geodetic infrastructure from 22 different countries

Respondent Type	Comments	No. of Respondents
Directors of Government Departments	e.g. Deputy Director/ Head of Survey and Hydrographic Services, Head of Government Agencies, Head of Mapping Sections etc.	18
Academic Staff	e.g. Lecturers, Senior Lecturers, Professors, Research Fellows	17
Practitioners	e.g. Registered Surveyors, Licensed Surveyors, Registered Engineers	8
Private Company CEOs	e.g. chief Executive officers of Agencies and Companies	3
		46



FINDINGS

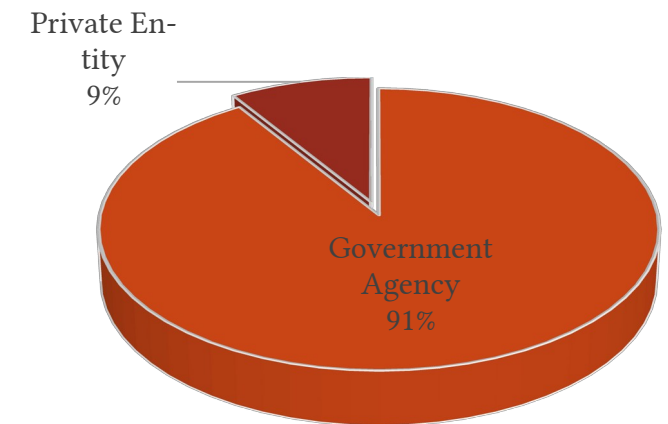
Distribution of the respondents to the geodetic infrastructure assessment



FINDINGS

- **GNSS (Global Navigational Satellite Systems)**
- Two major developments in GNSS that affect their applications:
 - ✓ (1) An increasing trend toward real-time access to high-sample rate data (one hertz and higher); and
 - ✓ (2) New GNSS satellites being developed that add many more satellites and data types to the existing constellations leading to preference on combined GNSS receivers and continuously Operating Reference Stations (CORS).
- The finding indicated that there exist CORS in the 88% of the African Countries while 12% of the respondents indicated that there are no CORS in their respective countries.
- Further, the assessment found out that, out of the existing CORS, 91% are developed, operated and maintained by the respective Governments while only 9% are developed, operated and maintained by private companies/entities.

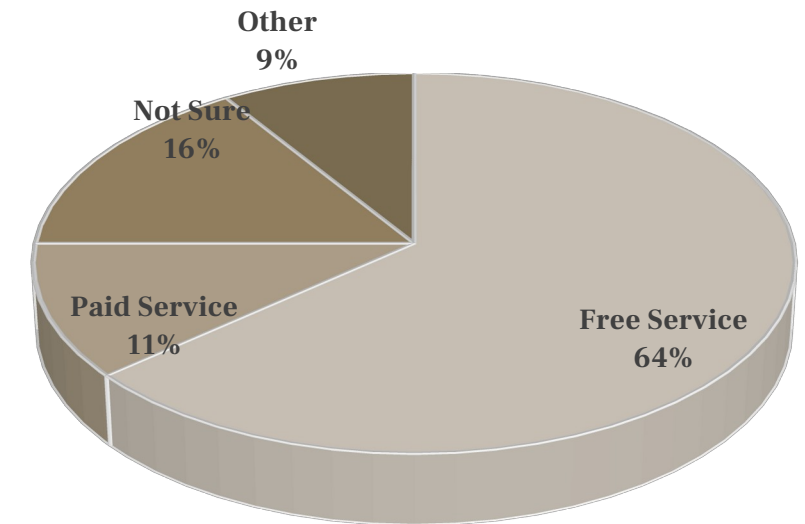
Operation and maintenance of Continuously Operating Reference GNSS Stations (CORS)



FINDINGS

- **GNSS (Global Navigational Satellite Systems)**
- 64% of the GNSS/CORS services are offered by the government for free while 11% of the GNSS/CORS are paid services.
- 16% of the respondents were not sure if the GNSS/CORS services are free or not,
- 9% indicated that the GNSS/CORS services are still under trial or incomplete hence charging for the service is yet to commence.

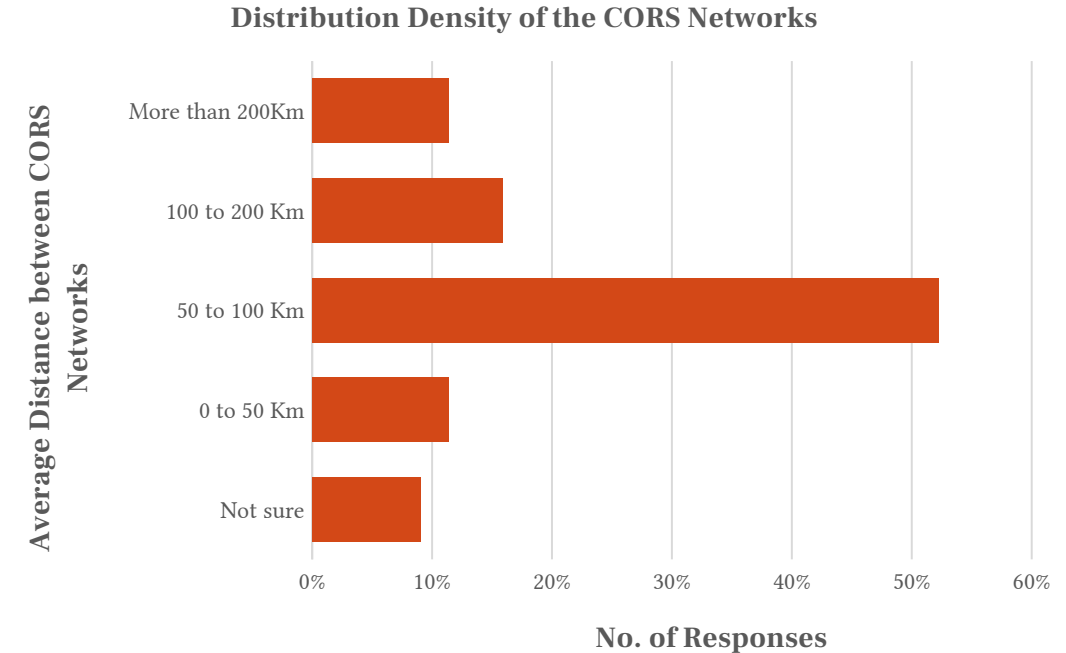
GNSS/CORS Services in the respective Countries



FINDINGS

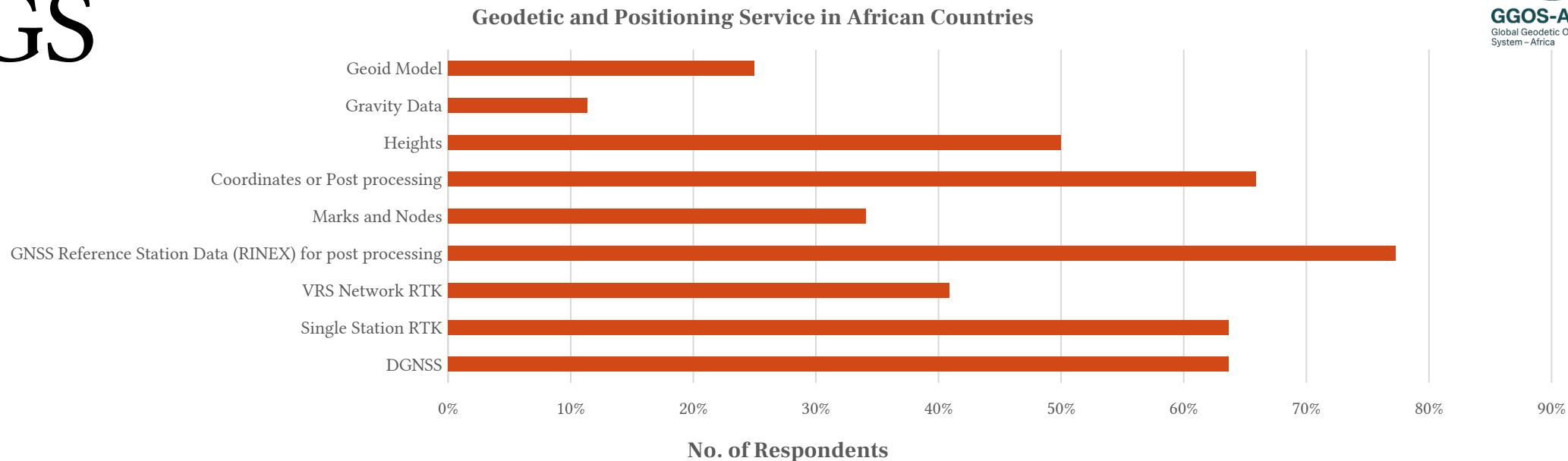
GNSS (Global Navigational Satellite Systems)

- 52% of the existing CORS networks in Africa have an average distribution distance of 50Km to 100 Km,
- About 11% of the CORS networks have a distribution of less than 50Km,
- 62% of the existing CORS networks follow standards, guidelines / best practices,
- 11% of the CORS networks do not follow standards, guidelines / best practices.



FINDI NGS

Geodetic or Positioning Service



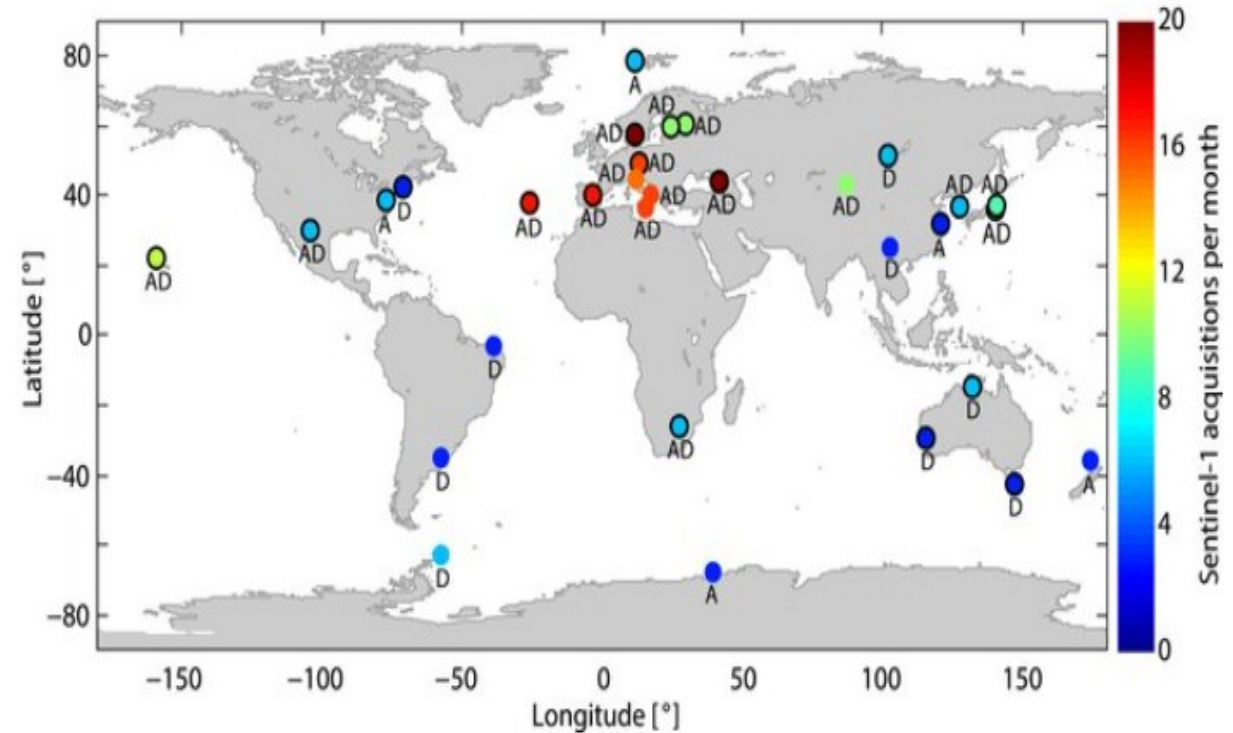
GNSS (Global Navigational Satellite Systems)

- 77% of the Countries assessed offer GNSS Reference Station Data for post processing in RINEX format followed closely by Single station RTK at 64% and VRS Network RTK at 41%.
- 20% of the countries have Geoid Models for heighting and 50% provide heighting services.
- Only 6 nations (11%), Uganda, Tanzania, Malawi, Ethiopia, Mozambique and Namibia which have their gravity data going into the EGM2020 model thus providing gravity data for modelling of the Earth.



FINDINGS

- **Very Long Baseline Interferometry (VLBI)**
- African has only one functional VLBI station located in South Africa.
- SARAIO's Hartebeesthoek site in South Africa, hosts 3 geodetic VLBI antennas, a 26-m telescope (both legacy S/X astrometry and geodesy and also K-band geodesy and astrometry), a 15-m telescope (legacy S/X geodesy), and a VGOS antenna (VGOS geodesy and astrometry)
- Another VLBI station installed in Nigeria is expected to start operation in 2026. Nigeria is in the final stages of construction of a VGOS antenna



The global network of the International Very Long Baseline Interferometry Service telescopes



FINDINGS

- **Very Long Baseline Interferometry (VLBI)**
- Future opportunities for geodetic VLBI in Africa
 - ✓ Namibia has the African Millimetre Telescope (AMT) project with commissioning planned for 2028.
 - ✓ Botswana is planning to install a SKA-Mid type telescope in the near future (Germany-SA-Botswana project),
 - ✓ Ghana has a 32-m telescope (converted telecoms dish).
 - ✓ Other countries planning to install a radio telescope are Kenya and Tanzania
 - ✓ Lastly, there are a VGOS telescope on Azores (Santa Maria) and one planned for the Canary Islands. These are both on the African plate and could join an African geodetic VLBI network, even though they are not African owned.



2-metre dish of the Mount Pleasant Radio Observatory's radio telescope



FINDINGS

Satellite and Lunar Laser Ranging (SLR/LLR)

- Satellite and Lunar Laser Ranging (SLR/LLR) in Africa is primarily centered at HartRAO in South Africa, which operates the continent's only active International Laser Ranging Service (ILRS) station, MOBLAS-6.
- A major initiative is underway to develop a combined, high-precision lunar and satellite ranger at HartRAO to improve Southern Hemisphere and Africa in general, which is underrepresented

Doppler Orbit Determination and Radio-positioning Integrated by Satellite (DORIS)

- Key permanent tracking and reference stations in Africa—are in Hartebeesthoek (South Africa), Libreville (Gabon), and Djibouti—These stations contribute continuous tracking data to the International DORIS Service (IDS)

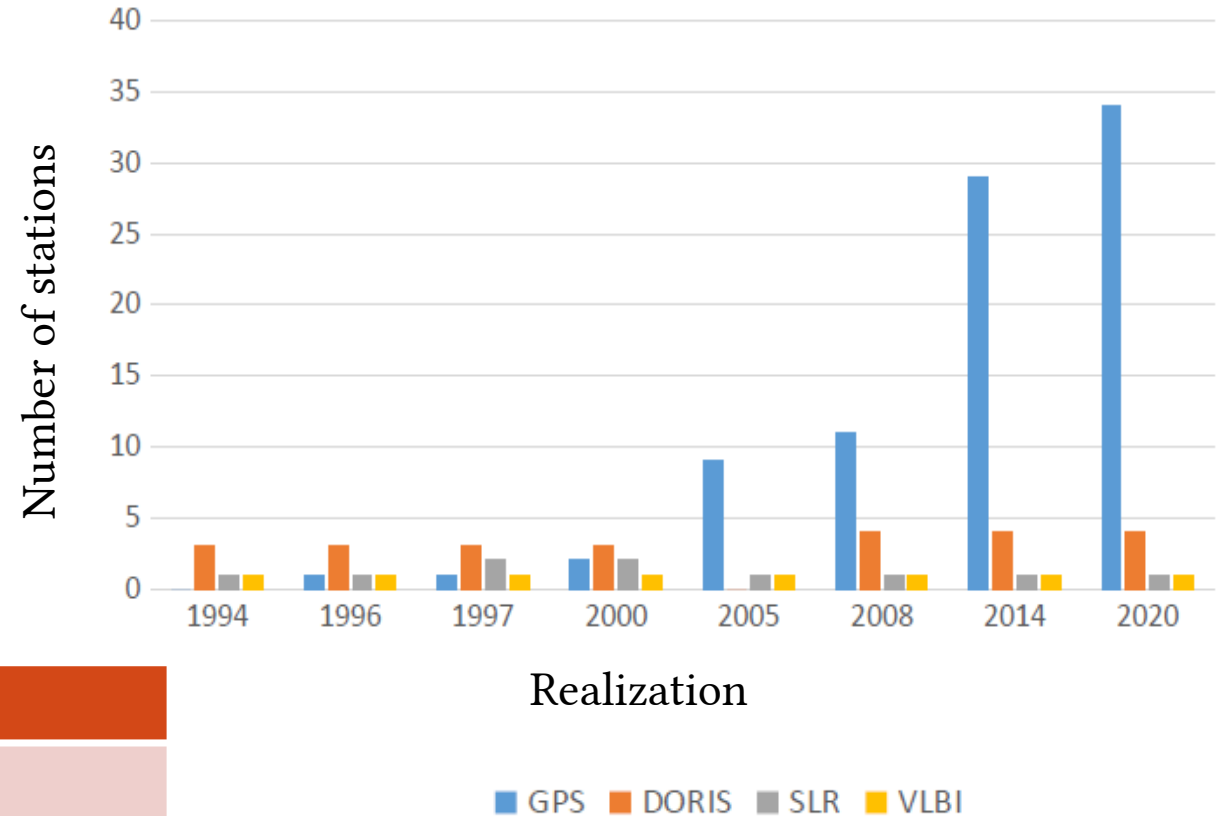


FINDINGS

Geodetic Reference Frames

- The most common Reference Ellipsoids and Geodetic Reference Frames in the various African Countries mainly for CORS include:

REFERENCE ELLIPSOIDS	ITRF
WGS84	ITRF 2000
Clarke 1880	ITRF 2005
Clarke 1880 Modified	ITRF 2008
Hayford 1924	ITRF 2014
	ITRF 2020



CONCLUSIONS

- This assessment specifically highlighted,
 - ✓ the various coordinate reference frame being used by the various African countries
 - ✓ design and operation of GNSS networks including data processing
 - ✓ Geodetic Reference Systems
 - ✓ Distribution of Geoid modelling and Space geodesy techniques (global geodetic observing systems)—such as VLBI, SLR, LLR, and DORIS.



RECOMMENDATIONS

- African countries need to improve the local CORS Real Time National geodetic frameworks including generating RTK and DGNSS solutions for wider applications to support their national development and research
- The African countries should strive to ascertain that the GNSS/CORS networks follow the standard guidelines
- African countries should also work towards designing regional CORS networks to optimize the design of national networks and harmonize the GNSS/CORS datums across the regions
- African countries are encouraged to use and integrate these local CORS to link to the IGS
- CORS coverage in Africa has improved, similar effort should be made on VLBI, DORIS and SLR stations



*Thank
you*

