



GEODESY IN NIGERIA: PROGRESS AND DEVELOPMENT

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Introduction

The Nigeria Geodetic Reference System

- ❖ In Nigeria, the regional (local) coordinate system is the Minna Datum based on Clarke 1880 ellipsoid modified. **THE ONE IN USE OFFICIALLY**
- ❖ These datums are defined using two parameters i.e., semi-major axis (a) and flattening (f).

Parameter	Minna Datum (Clarke 1880)
a (semi major axis)	6378249.145 m
b (semi minor axis)	6356514.8696
f (flattening)	1/293.465



The Nigeria Geodetic Reference System

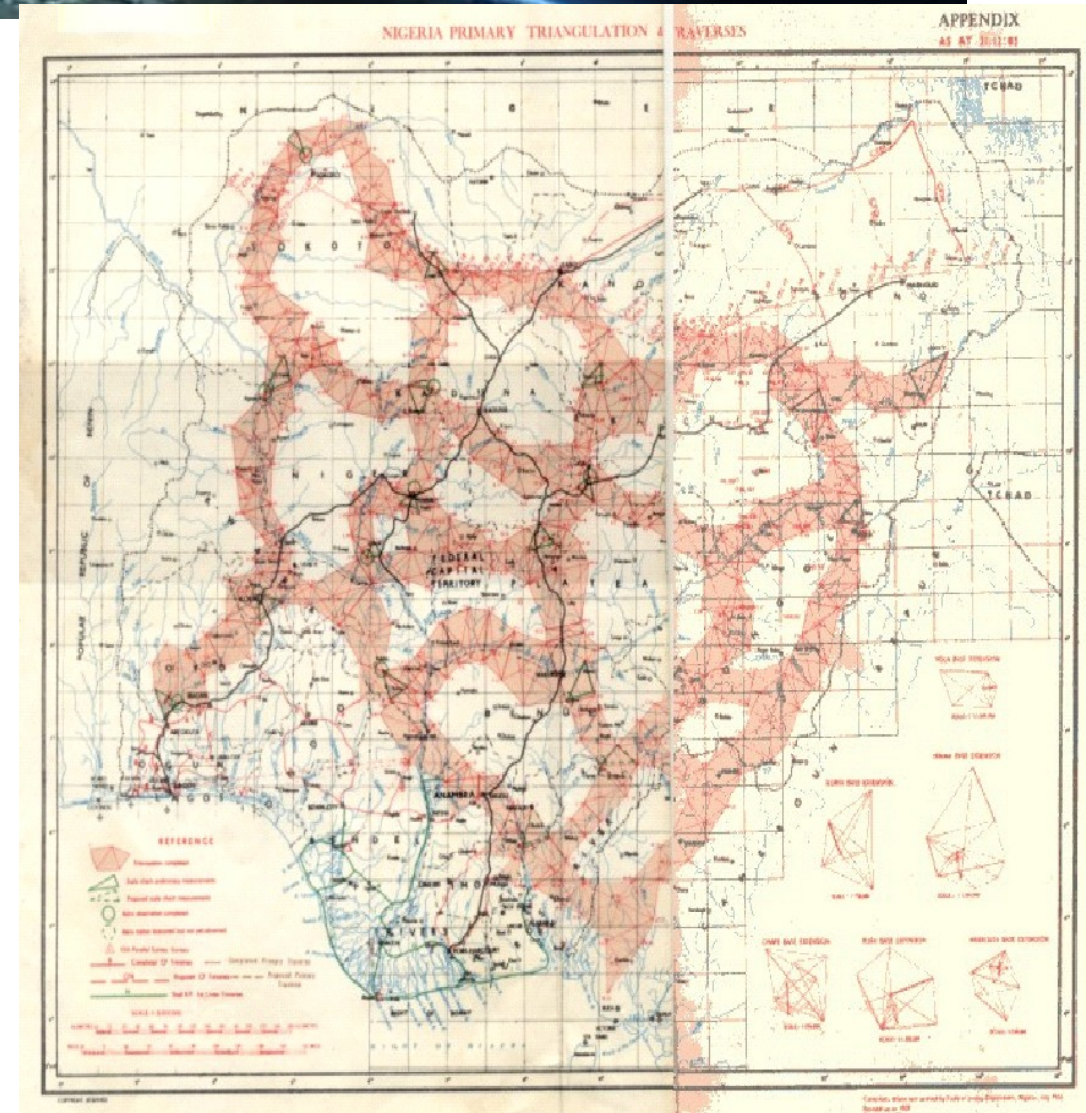
The Minna Datum

The observation of the Nigeria geodetic reference system was carried out between the late **1940's** and **early 1960's** (Arinola, 2006).

The reference ellipsoid is the Clarke 1880 with the **centre and origin not in coincidence with the Earth's centre of mass.**

Rather, **the origin is one of the stations located roughly at the centre of the associated triangulation network** (Onyeka, 2006).

The controls were established using the **traditional survey methods.**





The Nigeria Geodetic Reference System

The Minna Datum

The Minna datum used in the production of the Nigeria primary triangulation network has a **number of inherent deficiencies resulting to serious distortion in the network**. Some of these problems include (Uzodinma, 2005):

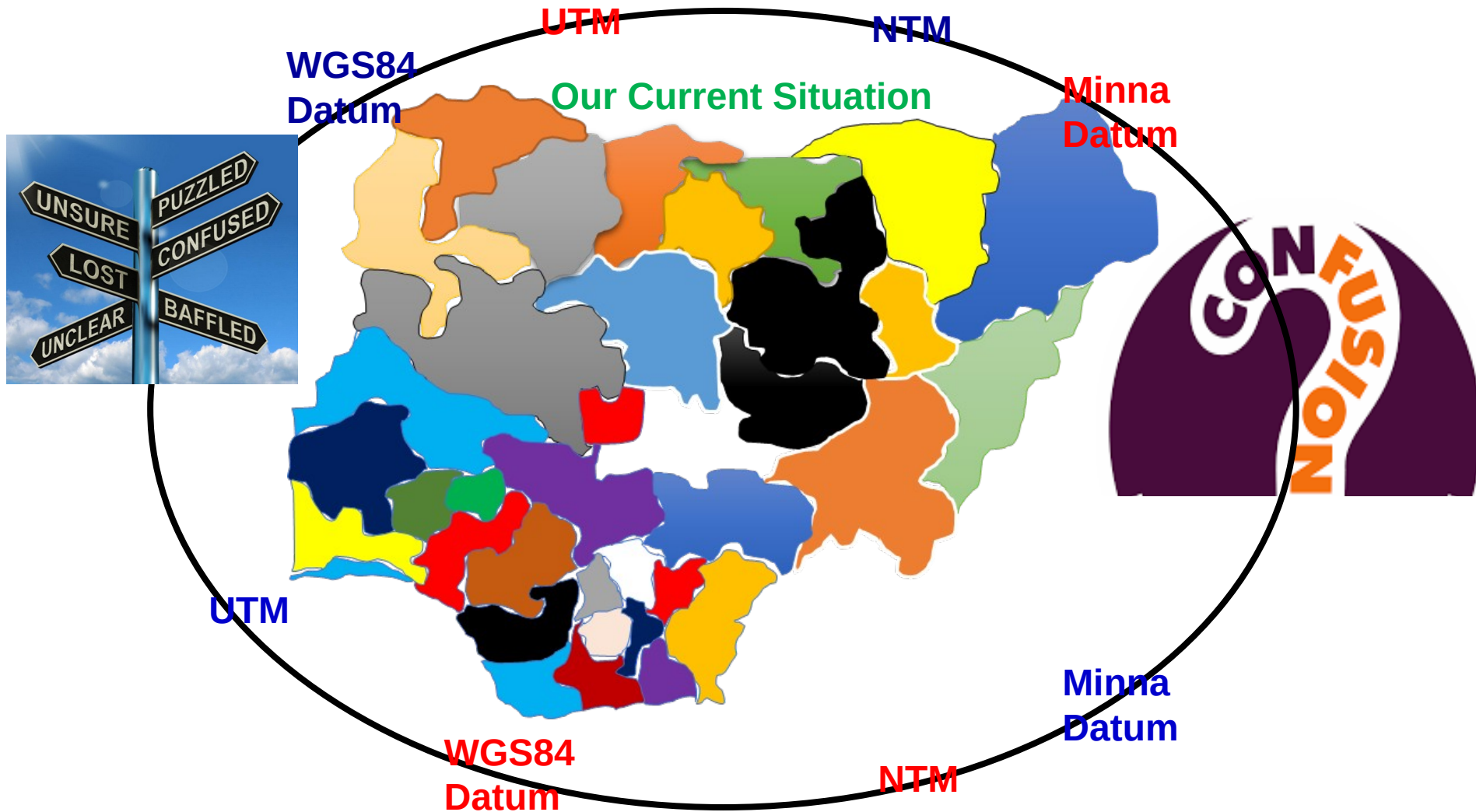
- ❖ in-accuracy of the scale factor by compression of the Clarke 1880 ellipsoid, thereby causing defect in distances measured;
- ❖ the origin of the Nigeria network is poorly defined;
- ❖ there is absence of geoidal height model;
- ❖ difficulties in the determination of the transformation parameters.

**Summary of Result:
Inconsistent Datums**





The Nigeria Geodetic Reference System





Modern Geodetic Infrastructure



- ❖ Nigeria has significantly modernized its **space geodetic infrastructure**, transitioning from **traditional passive land networks** to state-of-the-art space-based monitoring platforms
- ❖ This infrastructure is primarily coordinated by **Office of the Surveyor-General of the Federation (OSGoF)**; **the National Space Research and Development Agency (NASRDA)** through its **Centre for Geodesy and Geodynamics (CGG)** in Toro, **Bauchi State**.
- ❖ Institutions and the Private sector





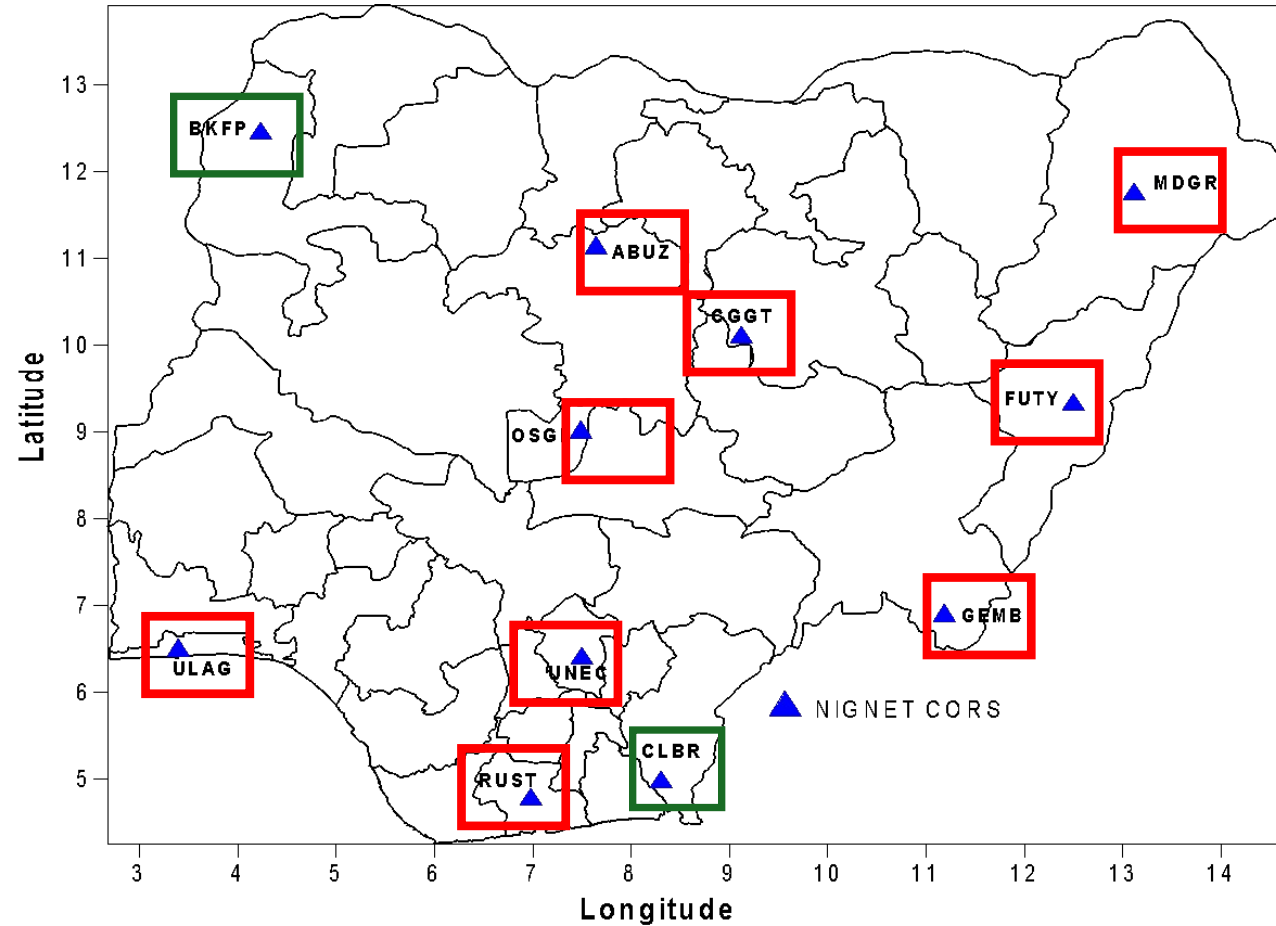
Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



Office of the Surveyor
General of Nigeria (OSGoF)



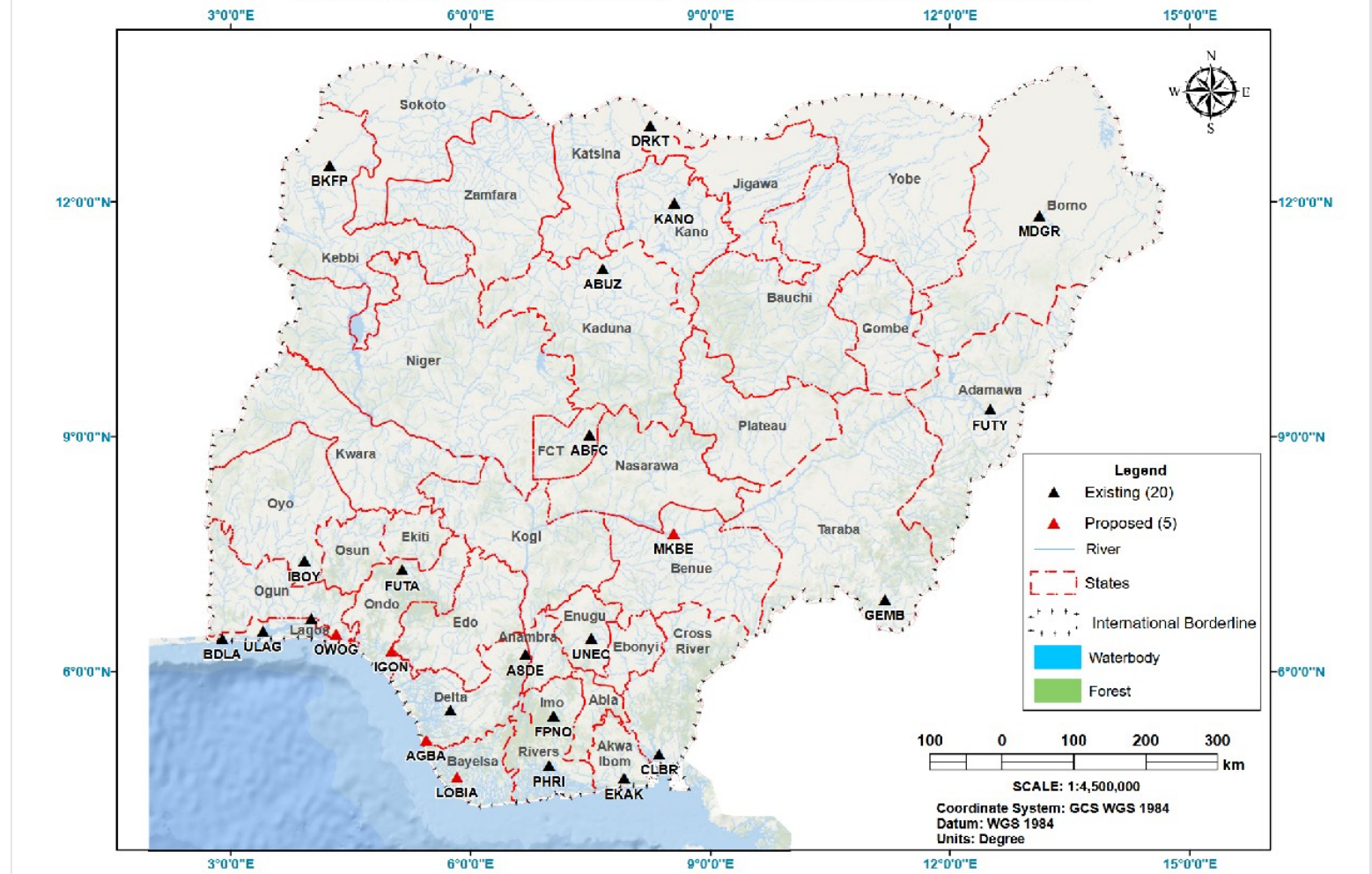
Modern Geodetic Infrastructure: GNSS

CONTINUOUSLY OPERATING REFERENCE STATION



Office of the Surveyor
General of Nigeria (OSGoF)

MAP OF OFFICE OF THE SURVEYOR GENERAL OF THE FEDERATION
CONTINUOUSLY OPERATING REFERENCE STATION (CORS) IN NIGERIA





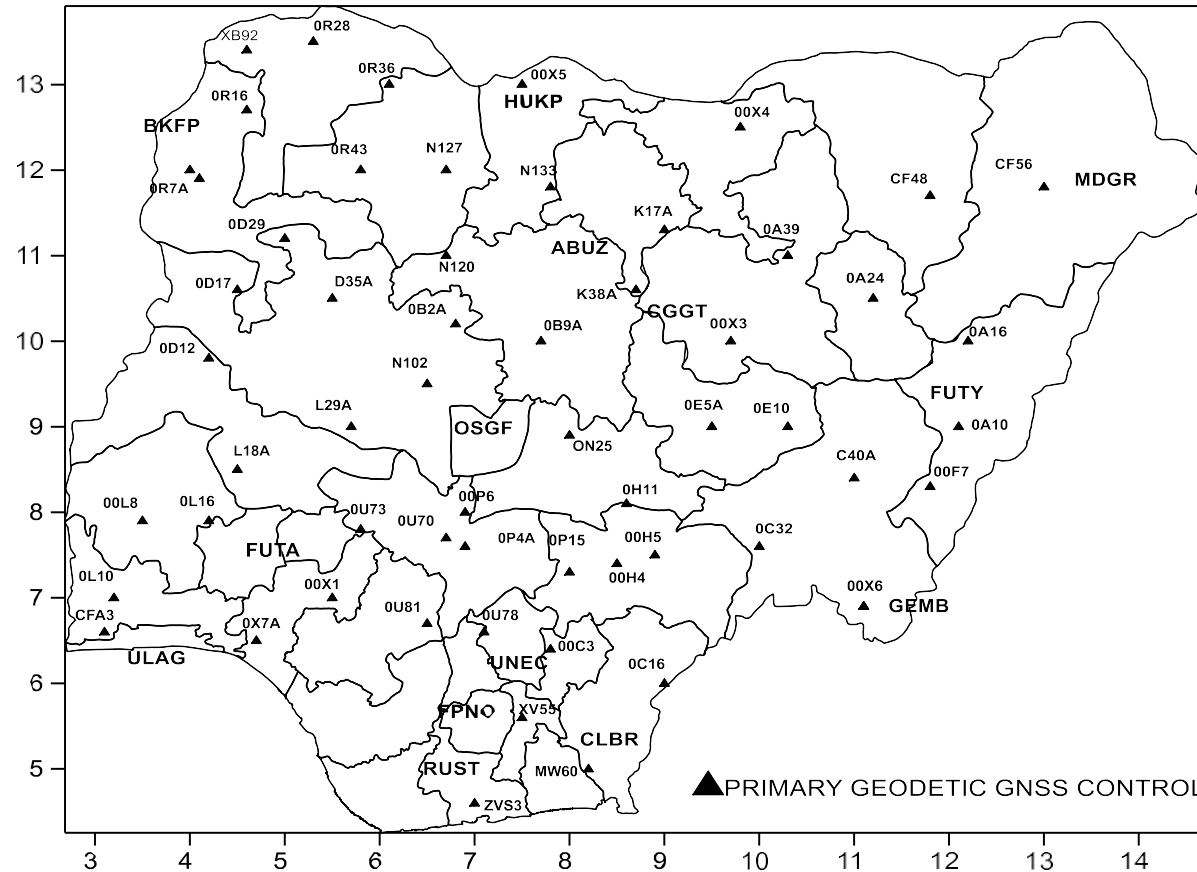
Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



Office of the Surveyor
General of Nigeria (OSGoF)



Passive GNSS Geodetic Controls





Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



Office of the Surveyor
General of Nigeria (OSGoF)



FPNO (Owerri)





Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



National space research and Development Agency (NASRDA)

7 COR Stations





Modern Geodetic Infrastructure: GNSS + Seismometer



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



National Space Research and Development Agency (NASRDA)

GNSS and Seismometer:
An Integrated Geodynamic
Monitoring Stations

7 GNSS Receivers (COR Stations)
13 Seismic Stations





Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



National Space Research and Development Agency (NASRDA)



GNSS CORS Monumentation



Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



National Space Research and
Development Agency
(NASRDA)



GNSS CORS Monumentation



Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



National Space Research and Development Agency (NASRDA)



GNSS CORS Monumentation



Modern Geodetic Infrastructure: GNSS + Seismometer



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



National Space Research and Development Agency (NASRDA)



An integrated Monitoring Stations (GNSS + Seismometer) 7nos



Modern Geodetic Infrastructure: GNSS



GNSS CONTINUOUSLY OPERATING REFERENCE STATION



National Space Research and Development Agency (NASRDA)





Modern Geodetic Infrastructure: GNSS

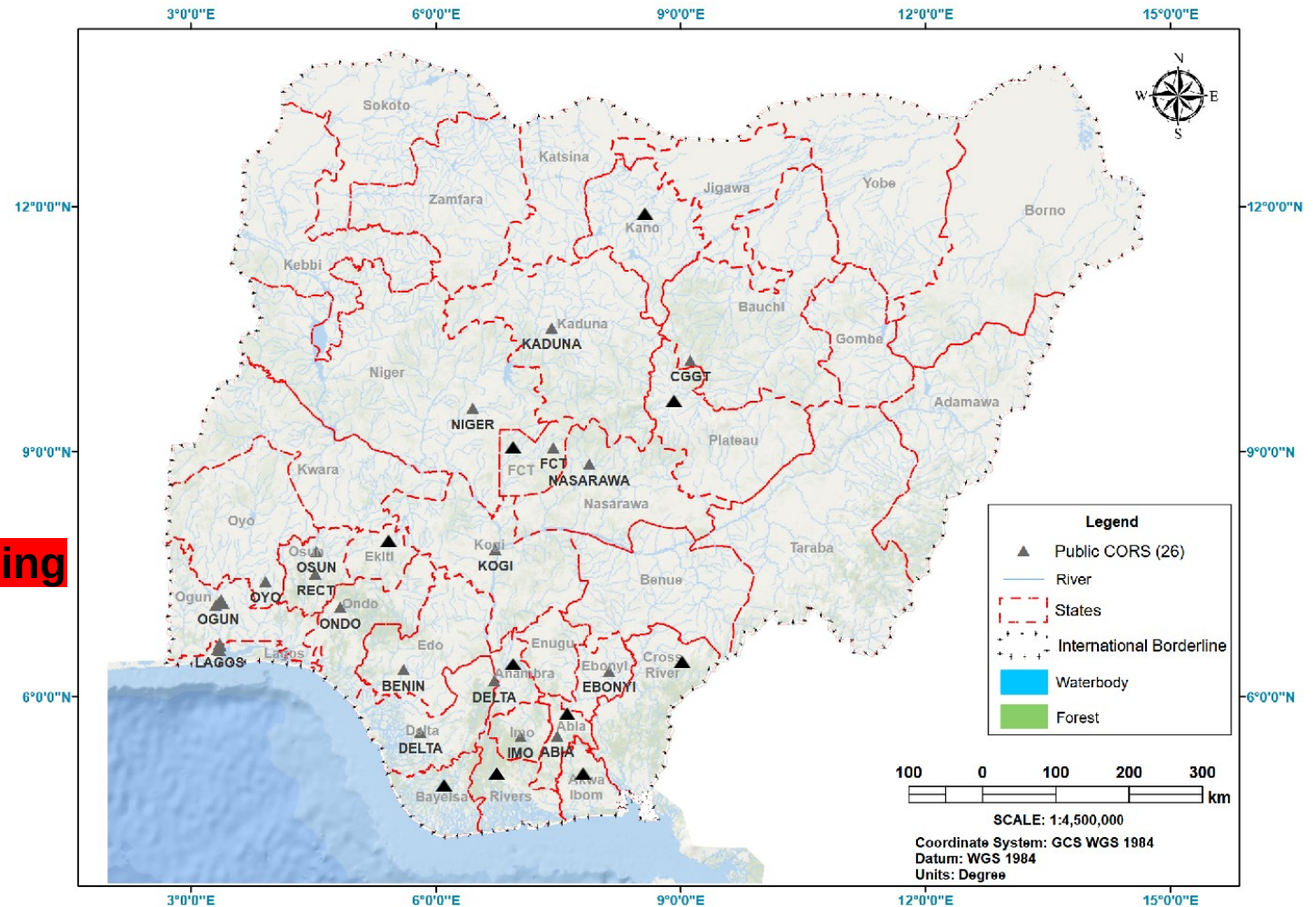


- ✓ State Surveyor General
- ✓ Institution: AGRIGIST
- ✓ Association of Practising Surveyors of Nigeria (APPSN)

Private Companies

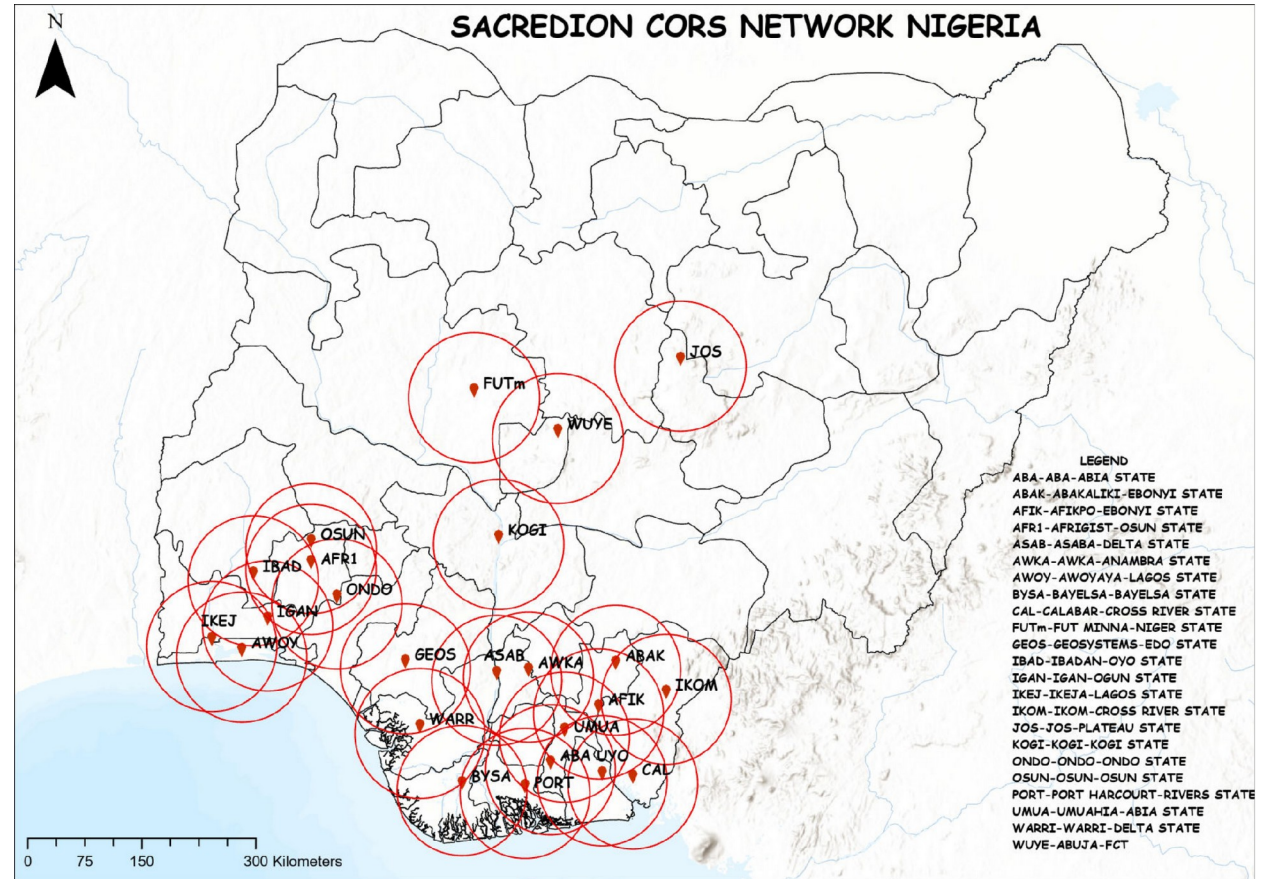
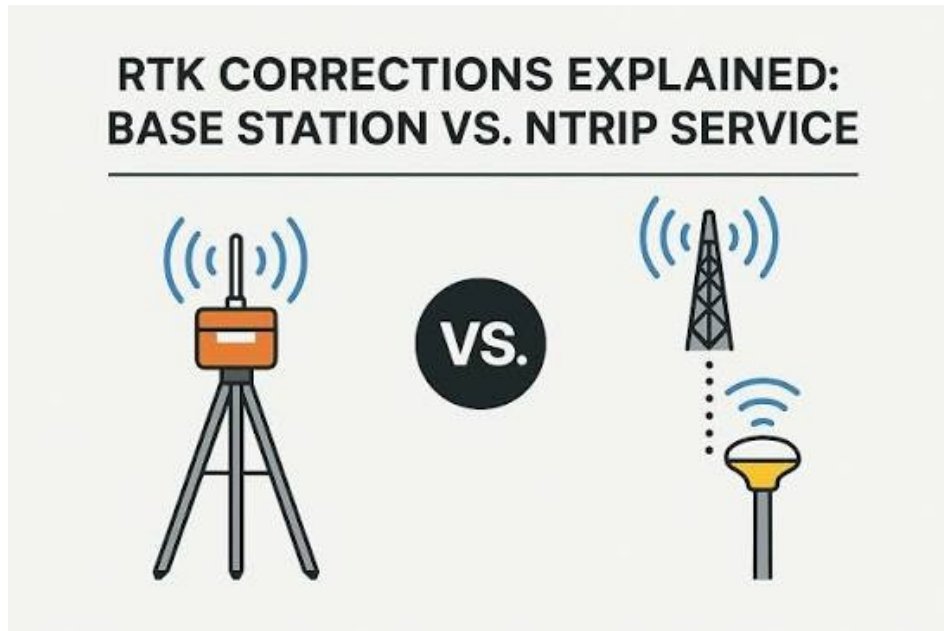
- ❖ Sacredion Online GNSS Positioning Service : 22 CORS
- ❖ OTIC Survey CORS: 25

MAP OF PUBLIC CONTINUOUSLY OPERATING REFERENCE STATION (CORS) IN NIGERIA



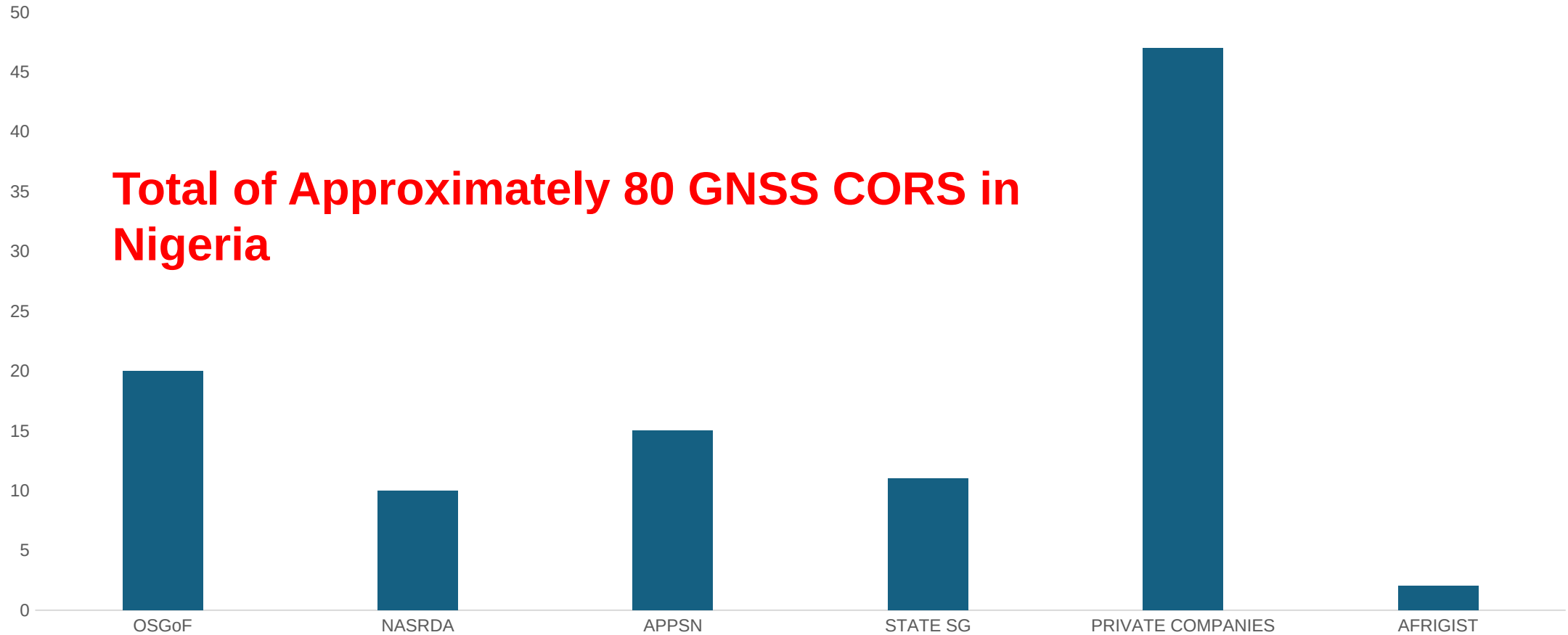
Sacredion Online GNSS Positioning Service : 22 CORS

❖ Broadcasting RTK Corrections





Modern Geodetic Infrastructure: GNSS



Realization of the Nigeria Geocentric Datum (NGD2012)

Commissioned by OSGOF

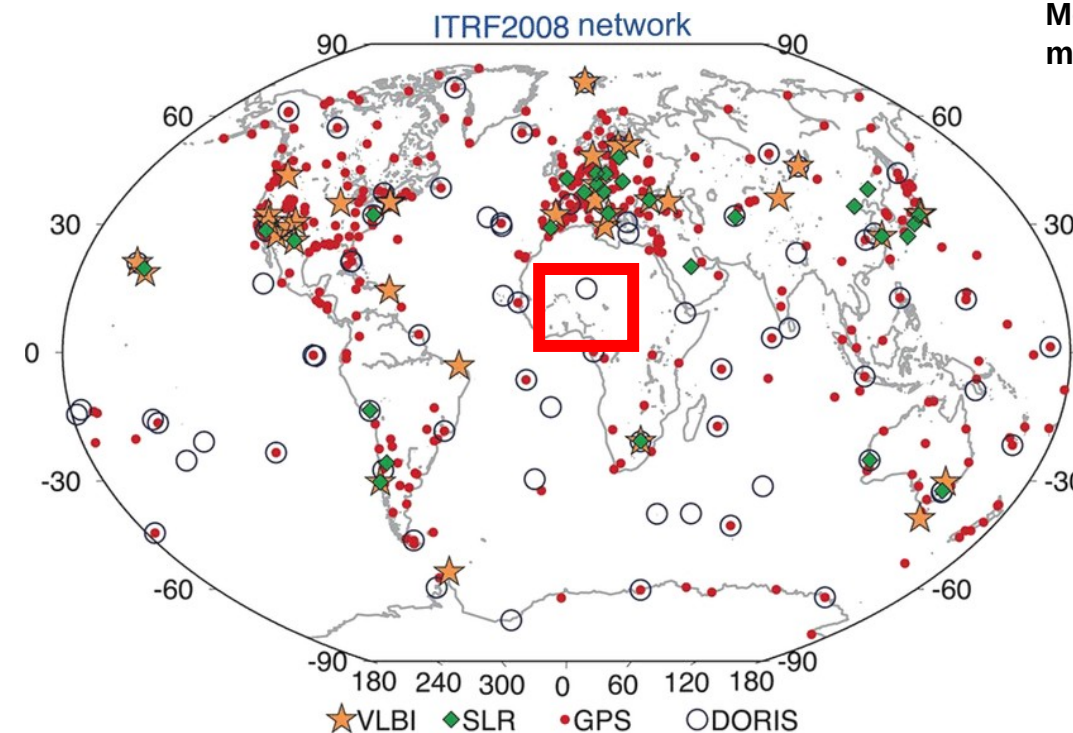
ITRF 2008 Realization of the Nigerian Geocentric Datum (GDN2012):



Station ID	Station location	Country	Approx. Lat (N)	Approx. Long (N)	Ellipsoidal Height (m)
HARB	Pretoria	Republic of south Africa	-25° 53' 12.84"	27° 42' 27.00"	1555.0000
NKLG	Libreville	Gabon	00° 21' 14.04"	09° 40' 16.56"	31.4800
RABT	Rabat	Morocco	33° 59' 53.16"	353° 08' 44.52"	90.1000
RBAY	Richards bay	South Africa	-28° 47' 43.80"	32° 04' 42.24"	31.7927
SUTH	Sutherland	South Africa	-32° 22' 48.72"	20° 48' 37.80"	1799.7659
CAGZ	Capoterra	Italy	39° 08' 09.24"	08° 58' 22.08"	238.0000
MAS1	maspalomas	Spain	27° 45' 49.32"	344° 22' 0.22"	197.3000
NOT1	Noto	Italy	36° 52' 33.96"	14° 59' 23.28"	126.2000
SFER	sanfernando	Spain	36° 27' 51.48"	353° 47' 39.84"	85.8000



NIGNET from ITRF2008 to ITR2020: Justification for a New Realisation (2023)

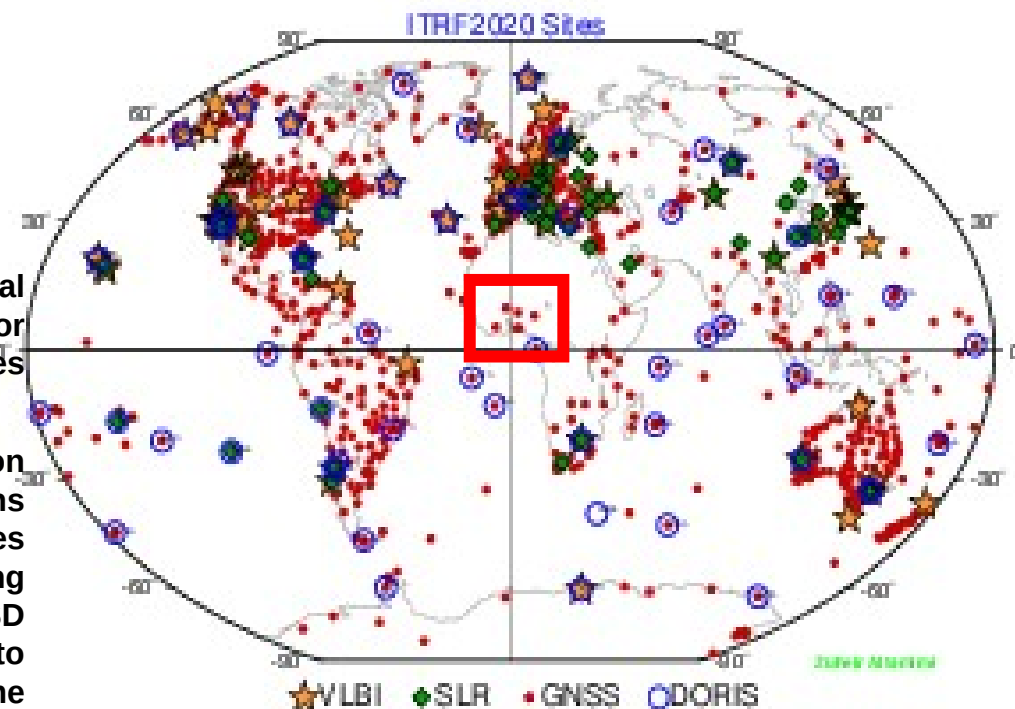


ITRF2008 network comprises 934 stations located at 580 sites (Altamimi, et al 2011).

Modelling of station non-linear motions, namely

The time series of the four techniques were stacked all together, adding local ties and equating station velocities and seasonal signals at colocation sites, Annual and semi-annual terms were estimated for stations of the 4 techniques with sufficient time spans,

Post-Seismic Deformation (PSD) models for stations subject to major earthquakes were determined by fitting GNSS/IGS data. The PSD models were then applied to the 3 other technique time series at earthquake colocation sites



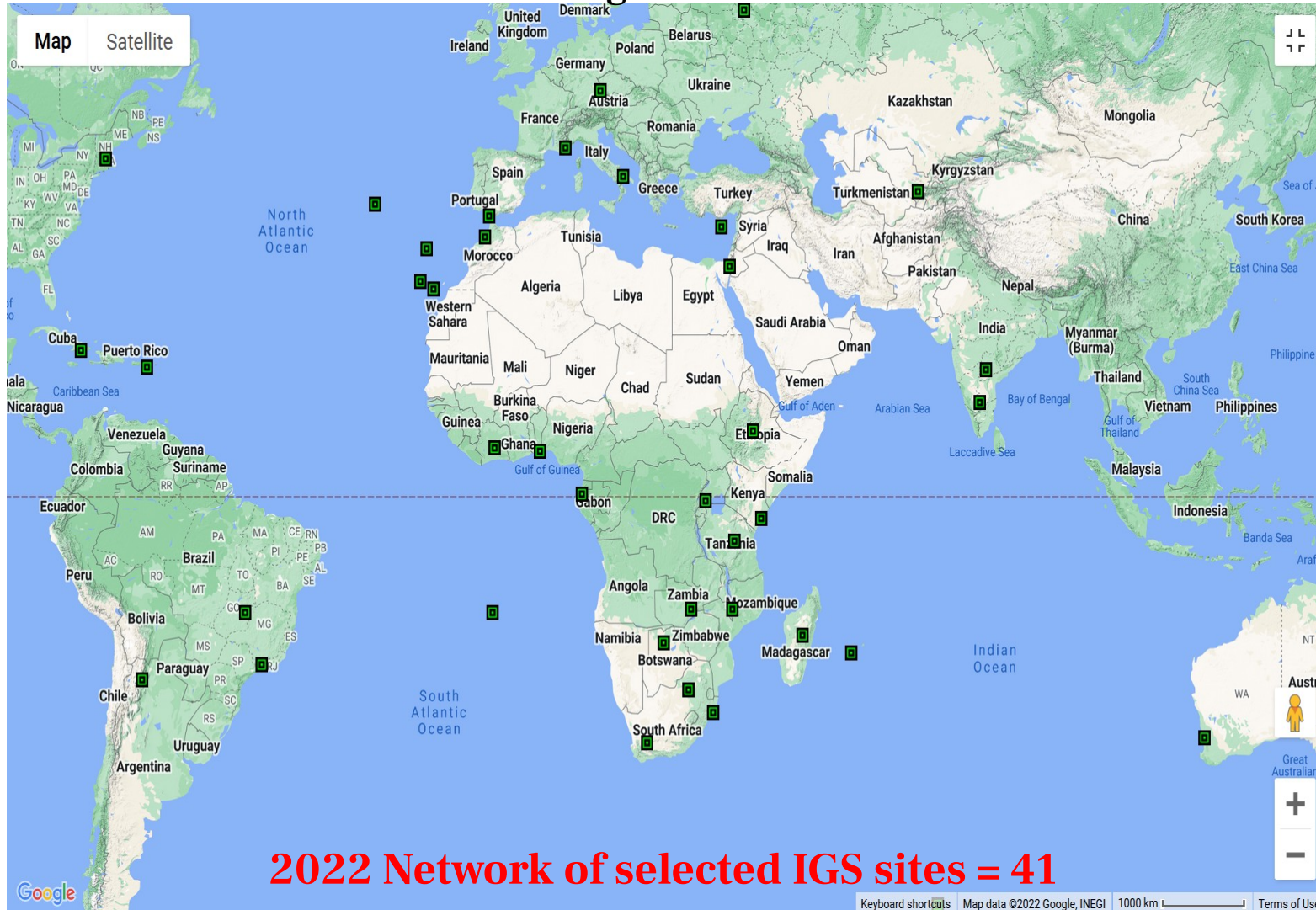
The ITRF2020 includes the positions and velocities of 1344 stations located at 1100 GNSS/IGS sites and 93 co-location sites (Altamimi, et al 2022).





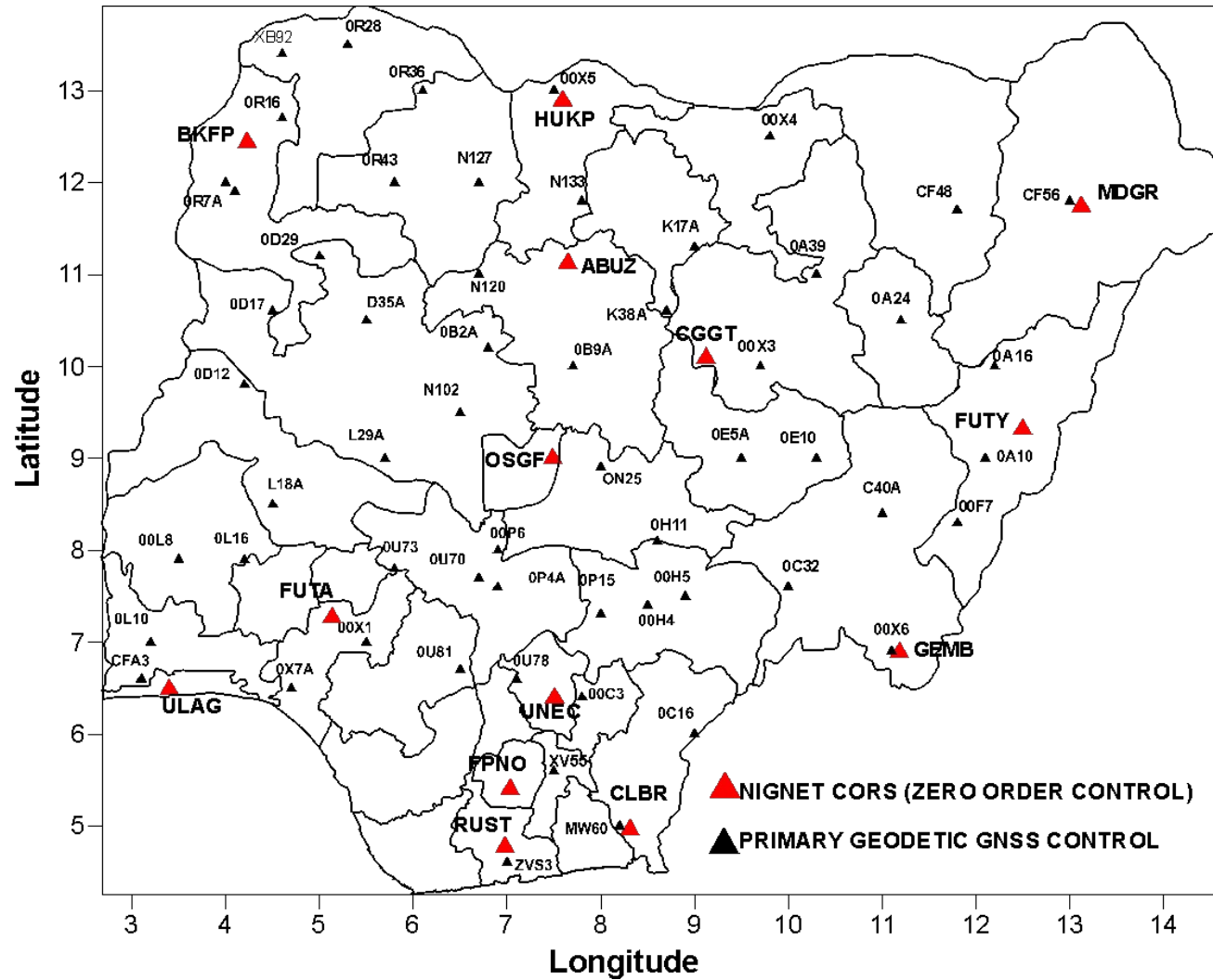
Processing Network

Processing Network- IGS





NIGNET from ITRF2008 to ITR2020: Justification for a New Realisation (2023)





Modern Geodetic Infrastructure: GNSS



GNSS and Seismic Data Computing and Analysis Centre @ CGG Toro



National Space Research and Development Agency (NASRDA)





Modern Geodetic Infrastructure: GNSS



Challenges

- ❖ The new Datum is yet to be adopted
- ❖ State Government COR Station not yet part of the National Geodetic Reference Frame
- ❖ Private COR Station also not yet part of the National Geodetic Reference Frame





Modern Geodetic Infrastructure: VLBI

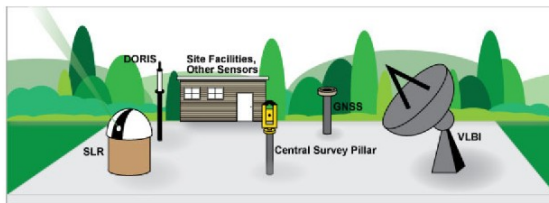


Very Long Baseline Interferometry (VLBI)



GGOS Bureau for Networks and Communications

Bureau Lead: Michael Pearlman



December 3, 2011

GGOS Meetings
San Francisco, CA



GGOS Site Requirements Document

(http://cddis.gsfc.nasa.gov/docs/GGOS_SiteReqDoc.pdf)



December 3, 2011

GGOS Meetings
San Francisco, CA

- Introduction and Justification
 - What is a Fundamental Station?
 - Why do we need the Reference Frame?
 - Why do we need a global network?
 - What is the current situation?
 - What do we need?
- Site Conditions
 - Global consideration for the location
 - Geology
 - Site area
 - Weather and sky conditions
 - Radio frequency and optical Interference
 - Horizon conditions
 - Air traffic and aircraft Protection
 - Communications
 - Land ownership
 - Local ground geodetic networks
 - Site Accessibility
 - Local infrastructure and accommodations
 - Electric power
 - Site security and safety
 - Local commitment





Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry (VLBI)



**GGOS Call for Participation;
The Global Geodetic Core Network:
Foundation for Monitoring the Earth System**

We seek proposals from organizations that would participate in the development, implementation and maintenance of the GGOS Global Geodetic Core Network:

- To implement and operate core space geodesy stations including:
 - existing stations that already have the four techniques implemented and plan for upgrade to the next generation systems;
 - existing stations that have one or more techniques operational, are planning for upgrade to the next generation systems and for the implementation of the remaining techniques;
- To support the network design and planning activity with analysis, simulations, site research (geology, weather, logistics, personnel, etc). To help design and develop the inter-technique vector systems and operational procedures.
- To provide applicable space geodetic instruments for implementation at a GGOS Global Geodetic Core Site in cooperation with a local organization.
- To implement and operate core stations offered by others;
- Call for Participation has been issued through the Services and the IAG.

December 3, 2011

GGOS Meetings
San Francisco, CA



RESPONSE TO CALL FOR PARTICIPATION IN THE GLOBAL GEODETIC CORE NETWORK

Submitted by

**NATIONAL SPACE RESEARCH AND DEVELOPMENT AGENCY (NASRDA)
CENTRE FOR GEODESY AND GEODYNAMICS (CGG)
P.M.B 11 TORO, BAUCHI STATE, NIGERIA**

**Designated Head of Unit: Mr. T. A. Yakubu
Participants: Prof. D. M. J. Fubara
Dr. J. D. Dodo**

THE CAPABILITY OF TORO OBSERVATORY FOR GLOBAL GEODETIC OBSERVING SYSTEM (GGOS)

Abstract

The Centre for Geodesy and Geodynamics (CGG), Toro, Nigeria was established by the Federal Government of Nigeria in 2002, following the approval of the National Space Policy Program. The Centre is charged with the primary responsibility of carrying out scientific research and monitoring activities in crustal and coastal deformation and subsidence that could lead to earthquake/tremors and/or be precursor to volcanic





Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry

(VLBI)



Global Geodetic Observing System of the International Association of Geodesy

February 28, 2012

Dr. Seidu O. Mohammed
Mr. T. A. Yakubu
National Space Research and Development Agency (NASRDA)
Centre for Geodesy and Geodynamics
P.M.B. 11 Toro, Bauchi State
NIGERIA

Dear Dr. Seidu O. Mohammed:

Thank you for the NASRDA response to the GGOS Call for Participation: The Global Geodetic Core Network: Foundation for Monitoring the Earth System. Our criteria for site designation are attached.

A site in Toro, Bauchi State, Nigeria would certainly fill a large geographic gap in the international space geodesy network. It would also be the only multi-technique site in northern Africa. The geological stability of the site and the clear weather make the site very appealing and the historical data from the GPS receivers is important to evaluating the site. The current GNSS operation at the site provides an important geodetic time history and demonstration of local expertise. We also note the infrastructure and staff already in place, and the apparent availability of space. We have designated the Toro as a Candidate, Offered Site that could house a core site if the systems and associated support could be found.

Legacy Core Sites will play a very important role in the network for many years to come, but the implementation of newer technologies will be essential as GGOS strives toward mm site performance. As the performance of space geodesy techniques improve, expand geographically and are closely coupled with other ground based measurement, data products and the value of

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E-mail: bianco@asi.it

properly related to the mm level to support the evolution of the Terrestrial Reference Frame requirements of GGOS. An established ground survey capability and environmental monitoring is important to providing a sound understanding of local and regional dynamics.

The goals set by GGOS are challenging and very exciting, and they will address major societal issues. Ground networks built and operated through international cooperation will be an essential part of the GGOS measurement complex. The participation of the NASRDA team in partnership with others would make a valuable contribution to international programs. We will make your proposal known to NASA and the GGOS community and urge them to consider options for a partnership on the site.

We look forward to your participation on our road to meeting the GGOS challenges.

Sincerely,

Dr. Michael Pearlman
Director
GGOS Bureau for Networks and Communication

Enclosure



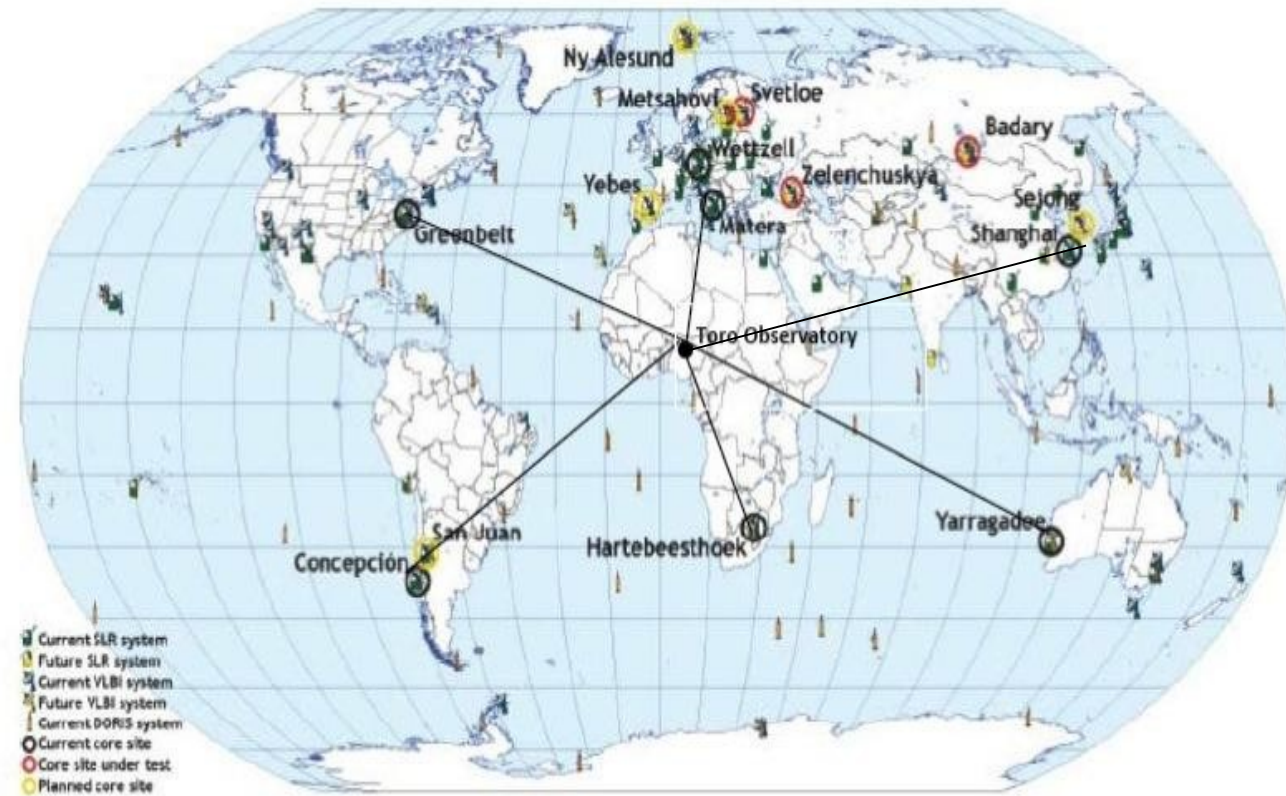


Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry (VLBI)

Agency (Country)	Sites
BKG/FESG (Germany)	Wettzell
NERC (UK)	Herstmonceux
IRA (Italy)	Medicina, Noto, Sardinia
OSO (Sweden)	Onsala
FGI (Finland)	Metsahovi
IGN Spain)	Yebes
SPC (Poland)	Borowiec
SHAO (China)	Shanghai, Beijing, Changchun, Wuhan, Kunming, Urumuqi, Sanyo, (San Juan)
GA (Australia)	Yarragadee, Mt. Stromlo, Katherine, Hobart
NASRDA (Nigeria)	Toro
NASA (US)	GSFC, Westford, Kokee Park, Monument Peak, Fortaleza, McDonald, Mt. Haleakala, Hartebeesthoek, Papeete, Arequipa
RIG (Czech Republic)	Pecny
NRF (South Africa)	Hartebeesthoek,
ASI (Italy)	Matera
KACST (Saudi Arabia)	Riyadh (SALRO)



GGOS Call in 2011





Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry (VLBI)

CGG Toro as GGOS “Candidate Site”

- “A site in Toro, Bauchi State, Nigeria would certainly fill a large geographic gap in the international space geodesy network. It would also be the only multi-technique site in northern Africa. The geological stability of the site and the clear weather make the site very appealing and the historical data from the GPS receivers is important to evaluating the site. The current GNSS operation at the site provides an important geodetic time history and demonstration of local expertise. We also note the infrastructure and staff already in place, and the apparent availability of space. We have designated the Toro as a Candidate, Offered Site that could house a core site if the systems and associated support could be found”.

An Excerpt from GGOS approval (Pearlman, 2012)





Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry (VLBI)





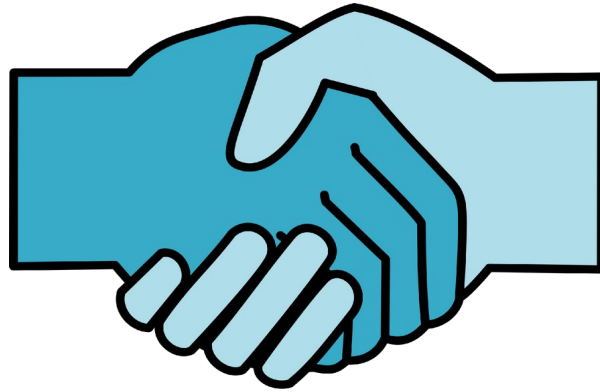
Modern Geodetic Infrastructure: VLBI

Very Long Baseline Interferometry (VLBI) @ CGG Toro-Nigeria

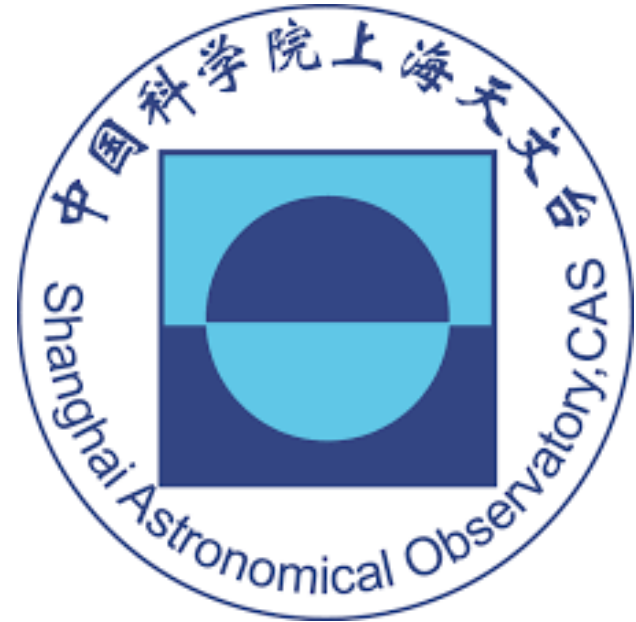
VGOS



NIGERIA
CHINA



2022



Modern Geodetic Infrastructure: VLBI

Very Long Baseline Interferometry (VLBI) @ CGG Toro-Nigeria



VLBI Site Preparation Began in 2023

1. Rock Test and Analysis
2. Rock Blasting
3. Site Setting out





Modern Geodetic Infrastructure: VLBI

Very Long Baseline Interferometry (VLBI) @ CGG Toro-Nigeria



Project Flag-off



14th Nov. 2024

Modern Geodetic Infrastructure: VLBI

Very Long Baseline Interferometry (VLBI) @ CGG Toro-





Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry (VLBI) @ CGG Toro-Nigeria





Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry (VLBI) @ CGG Toro-Nigeria





Modern Geodetic Infrastructure: VLBI

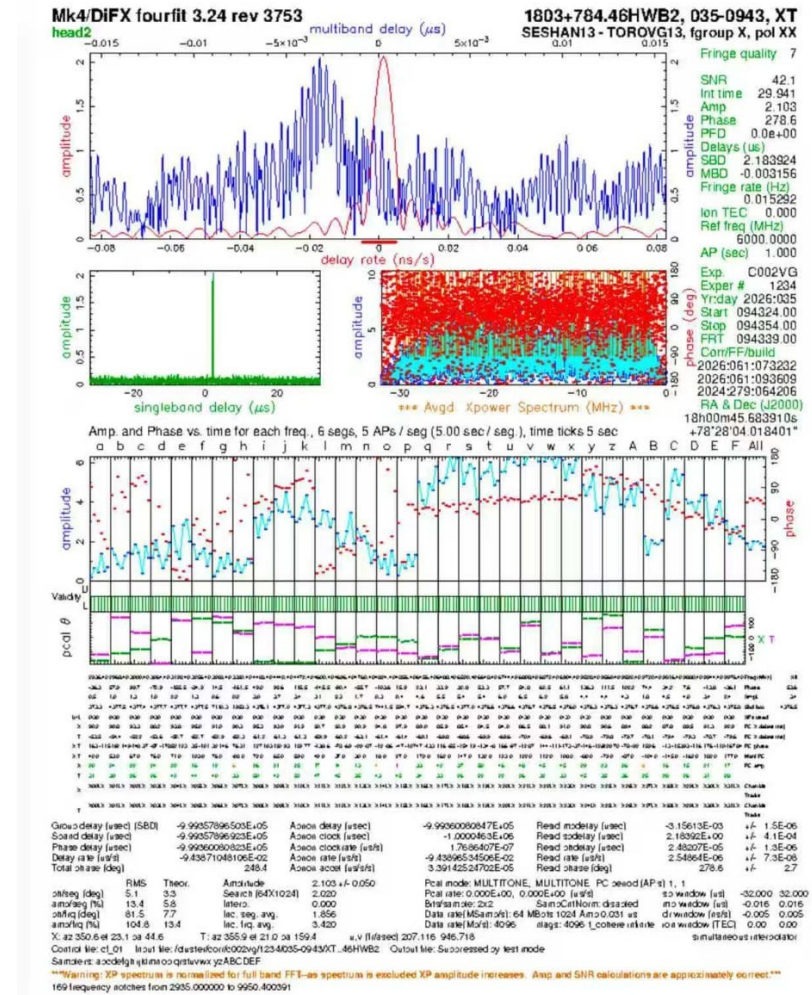


Very Long Baseline Interferometry (VLBI) @ CGG Toro-





GOS-Africa
Global Geodetic Observing



Press a key: 'h'=hardcopy, 's'=save, 'q'=quit, other=continue



Modern Geodetic Infrastructure: VLBI



Very Long Baseline Interferometry (VLBI) @ CGG Toro-Nigeria



The Backend Servers





Modern Geodetic Infrastructure: VLBI



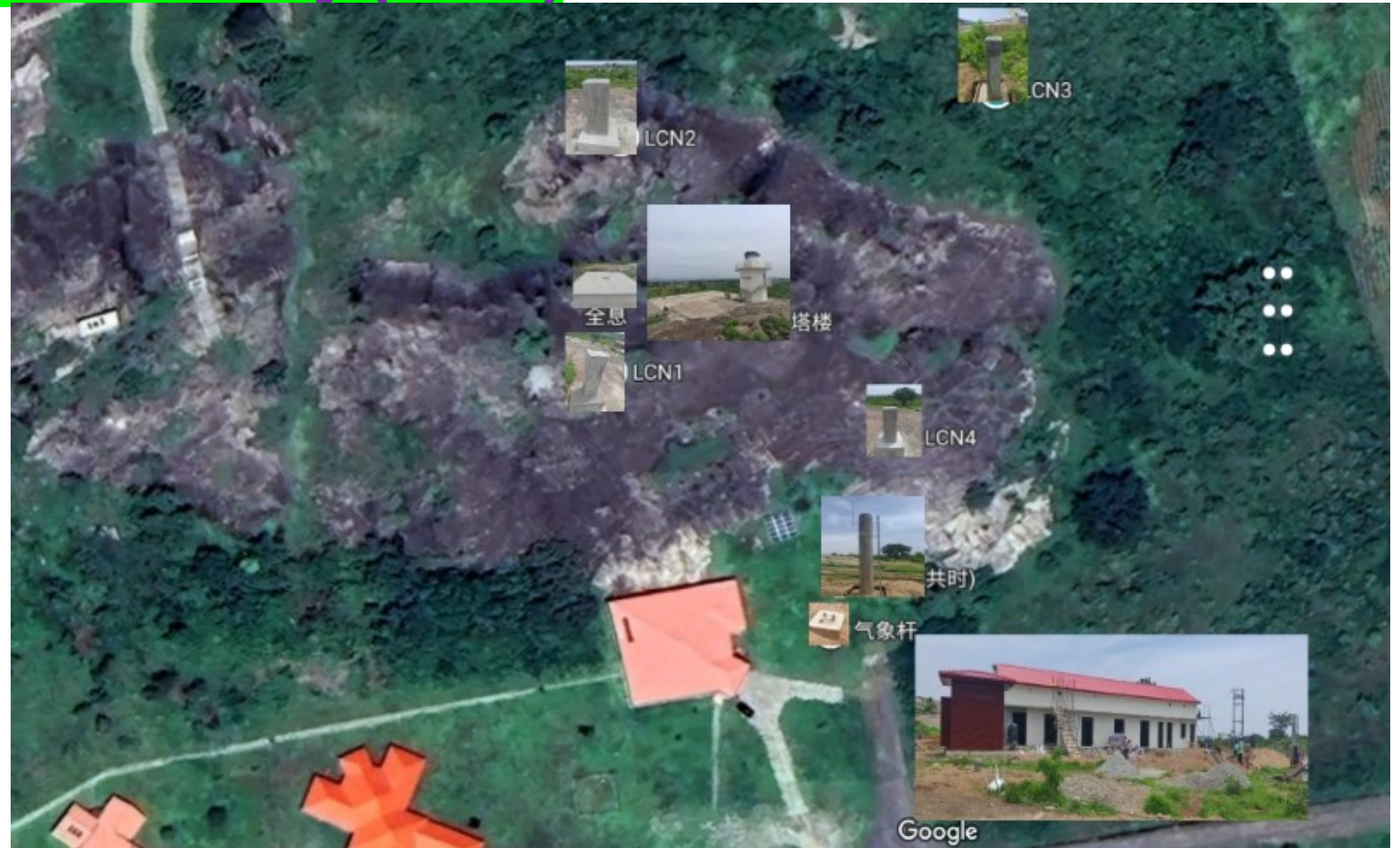
Very Long Baseline Interferometry (VLBI)



Modern Geodetic Infrastructure: VLBI

Very Long Baseline Interferometry (VLBI)

The VLBI Observatory layout





Modern Geodetic Infrastructure: SLR



Satellite Laser Ranging (SLR)





Thank you

