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The Nigerian Geocentric Datum (NGD2012): Preliminary Results

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Outline

- Introduction
- Implementation of Geocentric Datum for Nigeria
- Coordination of NIGNET to ITRF2008 as a Zero Order Geodetic Network
- Coordination of the Nigerian Primary Geodetic Network (NPGN)
- Data Processing
- Results and Analysis
- Conclusion

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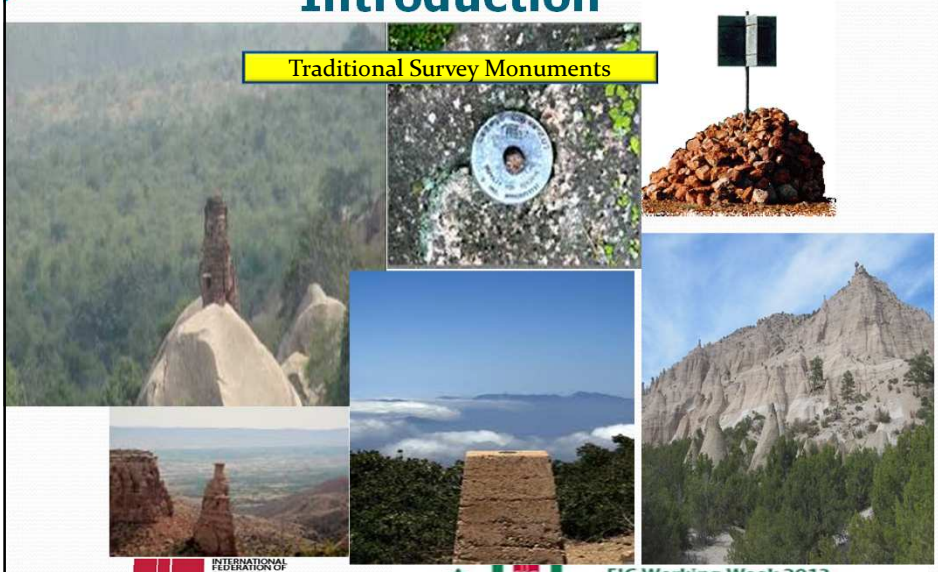
Introduction

Traditional Survey Monuments



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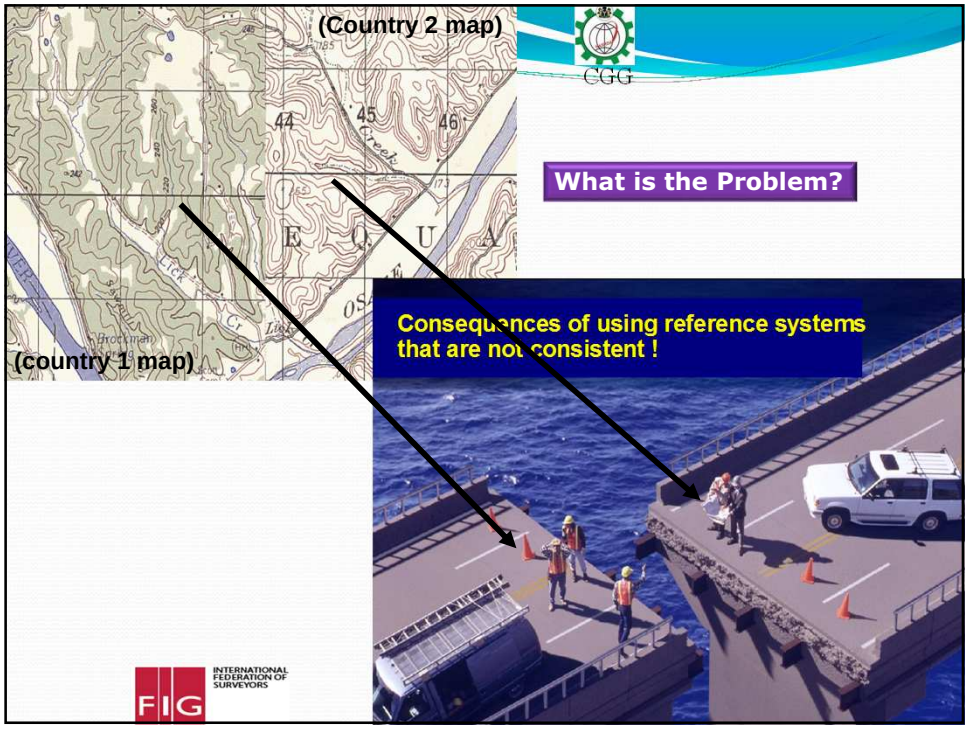
Introduction

What is the Problem?

- Traditionally each country has its own geodetic reference system resulting in non compatible coordinates systems between countries
- Most of them were confined to small areas of the globe, fit to limited areas to satisfy national mapping requirements.
- Maps in neighbouring countries do not match at the national boundaries

(system1)

(system2)


(Country 2 map)
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What is the Problem?
(country 1 map)
Consequences of using reference systems that are not consistent !
FIG
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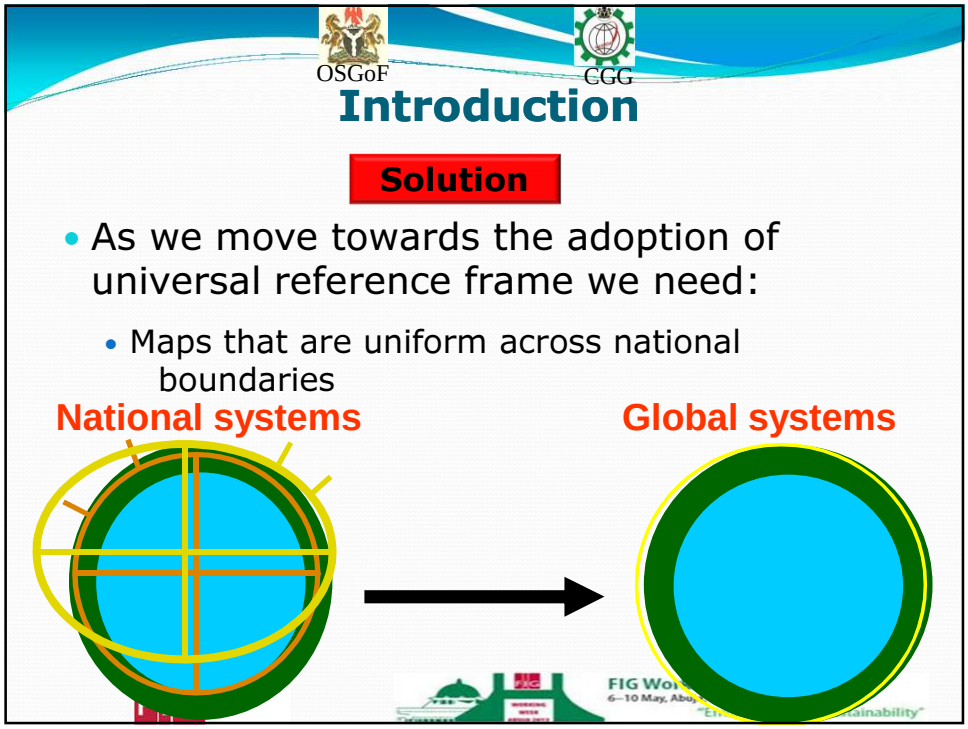
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Introduction
Solution
As we move towards the adoption of universal reference frame we need:
Maps that are uniform across national boundaries
National systems
Global systems

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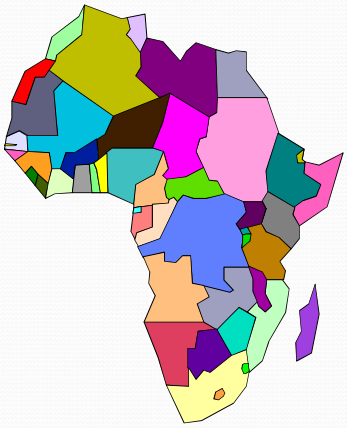
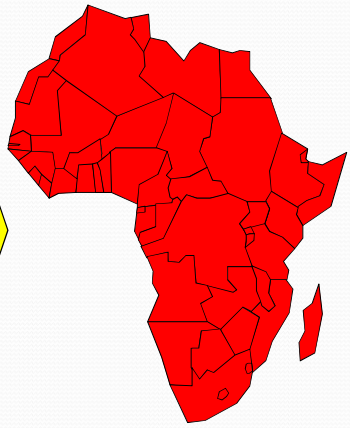
Introduction

Non-uniform systems



GNSS + ITRF

Uniform system



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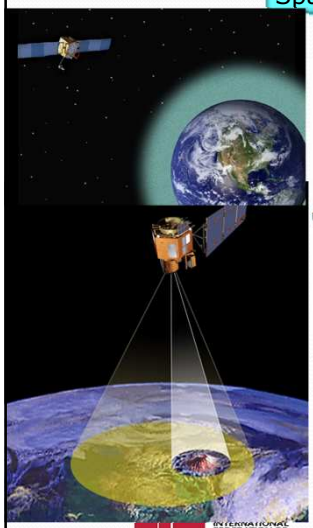
Introduction

Space Science and Technology



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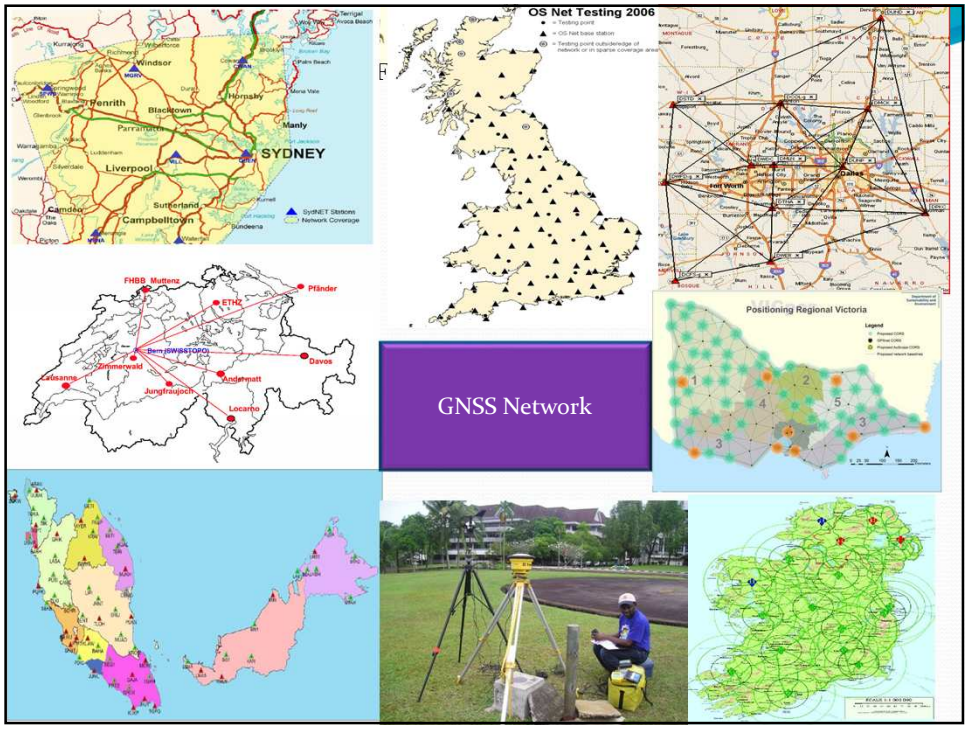
Introduction
GNSS Infrastructure


OS Net Testing 2006
SYDNEY
Windsor
Penrith
Blacktown
Parramatta
Manly
Liverpool
Camden
Sutherland
Campbelltown
FHBB Muttenz
Pfänder
ETHZ
Zimmerwald
Davos
Andermatt
Jungfraujoch
Locarno
Positioning Regional Victoria
GNSS Network

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Introduction

AFREF

- To establish a continental reference system as a basis for national 3-D reference networks.
- To realize a unified vertical datum and to support efforts to establish a precise African geoid.
- To establish continuous, permanent GPS base stations at a spacing such that the users will be within 500km of a base station and that data is freely available to all users.

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Introduction

Office of the Surveyor General of the Federation

- Responsible for the maintenance of the national reference system on which all survey and mapping is based.
- Set up surveying infrastructure throughout the country known as the Nigerian Permanent GNSS Network (NIGNET).
- The NIGNET is a network of GNSS Continuously Operating Reference Stations (CORS) operating 24 hours a day, which provides positional solutions.

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Introduction

Office of the Surveyor General of the Federation

- In view of this OSGoF embarked in the year 2008 on the Global Navigation Satellite Systems (GNSS) technology with the objective of adopting a global unified datum for Nigeria and the transformation of same to the old datum (Minna Datum)
- The Nigerian Geocentric Datum (NGD2012) is to be the new national geodetic datum for Nigeria. It will eventually replace the old Minna Datum of Clarke 1880

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Implementation of Geocentric Datum for Nigeria (NGD2012)

- The development of NGD2012 began:
  - with the establishment of the zero-order network of permanent GPS stations known as the Nigerian Permanent GNSS Network (NIGNET)
  - the establishment of Nigerian Primary Geodetic Network 2011 by strengthening the Nigerian Triangulation Network of 1960s via a GPS campaign at selected stations to form a connection to the NIGNET network.

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Implementation of Geocentric Datum for Nigeria (NGD2012)

- The development of NGD2012
  - √Data processing and adjustment of Zero Order Geodetic Network.
  - √Computation of the new geocentric datum coordinates at a specific epoch.
  - Derivation of transformation parameters.

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Coordination of NIGNET to ITRF2008 as a Zero Order Geodetic Network

- The ITRF2008 has a precision of a few millimetres and forms a robust basis for any regional or national geodetic datum.
- The present estimated accuracy of the coordinates is about 2 to 5mm in position and 1 to 2mm/yr in velocity. The stability of the frame over 10 years is reported to be accurate to better than 0.5 ppb in scale or equivalent to a shift of about 3mm in station height and 4mm in origin (Altamimi, et al, 2007).

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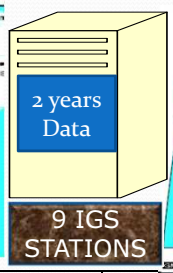
Data Acquisition



Station ID	Station location	Country	Appro. Lat (N)	Apro. Long (N)	Ellipsoidal Height (m)
HARB	Pretoria	Republic of south Africa	-25^0 53' 12.84''	27^0 42' 27.00''	1555.0000
NKLG	Libreville	Gabon	00^0 21' 14. 04''	09^0 40' 16.56''	31.4800
RABT	Rabat	Morocco	33^0 59' 53.16''	353^0 08' 44.52''	90.1000
RBAY	Richards bay	South Africa	-28^0 47' 43.80''	32^0 04' 42.24''	31.7927
SUTH	Sutherland	South Africa	-32^0 22' 48.72''	20^0 48' 37.80''	1799.7659
CAGZ	Capoterra	Italy	39^0 08' 09.24''	08^0 58' 22.08''	238.0000
MAS1	maspalomas	Spain	27^0 45' 49.32''	344^0 22' 0.22''	197.3000
NOT1	Noto	Italy	36^0 52' 33.96''	14^0 59' 23.28''	126.2000
SFER	sanfernando	Spain	36^0 27' 51.48''	353^0 47' 39.84''	85.8000

IGS Stations used as fixed station for NIGNET

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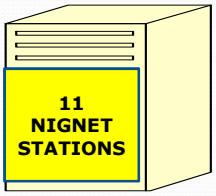
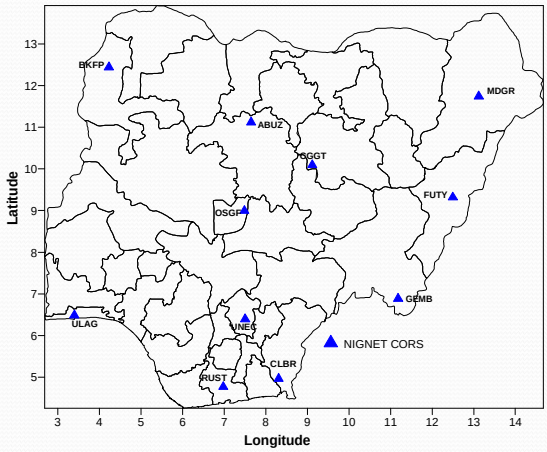
Data Acquisition





The Nigerian Permanent GNSS Reference Network (NIGNET)

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Data Acquisition

GPS Campaigns

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	√	√	√	√	√	√	√	√	√	√	√	√
2011	√	√	√	√	√	√	√	√	√	√	√	√
2010 session	19	28	31	30	31	30	31	31	30	31	30	31
2011 session	31	28	31	30	31	30	31	31	30	31	30	31

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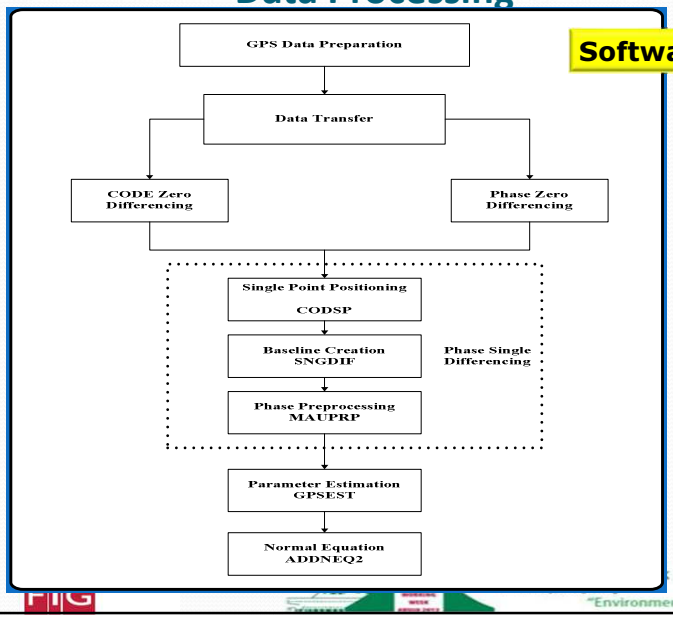
Data Processing



Software used

The Bernese GPS Scientific Software version 5.0

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Data Processing

Processing Parameters

- The GPS data processing is divided into three parts namely
  - Pre-processing
  - Daily Adjustment and
  - Weekly combination.
- Daily pre-processing was preformed to eliminate satellite clock biases, estimate receiver clock correction, and to screen for cycle slips. Quasi Ionosphere Free strategy has been used for the ambiguity fixing with the average resolved ambiguity at around 75%.

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Data Processing

Processing Parameters

RINEX data at 30 second sampling rate
IGS final orbit
24 hours sliding window processing
ITRF 2008 reference frame
Cut-off satellite elevation angle at 10^0
Quasi-Ionosphere free (L_3) ambiguity free
Saastamoinen Troposphere model
IGS fixed stations
Neil Mapping Function
Free network adjustment
Constrain Network adjustment
Ocean Tide Loading for each station [FE2004]

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Results and Analysis

- The daily solutions of independent baselines were computed using carrier phase double difference with Dry Neill Mapping Function for troposphere that was estimated for every two hours.
- Analysis of the weekly solutions were carried out to exclude bad station solutions based on both free and heavily constrained (with respect to the 9 IGS stations) network adjustment.

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Results and Analysis

Final Combined Solution

- Two strategies were employed to obtain optimal results and to check for outliers in the final adjustment. The two strategies are as follow:
  - **Free Network Adjustment with introduction of Helmert Transformation**
  - **Heavily Constrained Adjustment**

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Results and Analysis

Free Network Adjustment

- The objective of the free network adjustment with the introduction of Helmert transformation was to adjust the weekly normal equation freely and transform them using the nine (9) IGS station for determining the NIGNET station coordinate; while the Eleven (11) NIGNET Stations were subsequently used to determine the sixty (60) GPS monument station coordinates.
- This process allowed for the internal reliability investigation and to detect outliers. With the introduction of reference velocity for the fixed stations, the final coordinates for all stations were transformed to the middle of the observation epoch.

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Results and Analysis

Free Network Adjustment

```
Program : HELMR1                                  Bernese GPS Software Version 5.0
Purpose : Helmert Transformation
Campaign: C:\HELMERT                              Default session: 2280 year 2012
Date    : 21-Aug-2012 16:54                       User name      : DODO2
================================================================================

JUN2010 CAMPAIGN:SESSION 7
--------------------------------------------------------------------------------

FILE 1: FEBRUARY 2010 CAMPAIGN: SESSION 6
FILE 2: ITRF2008 FOR GPS

TRANSFORMATION IN EQUATORIAL SYSTEM (X, Y, Z):
RESIDUALS IN LOCAL SYSTEM (NORTH, EAST, UP)

------------------------------------------------------------------------------
| NUM |      NAME      | FLG |        RESIDUALS IN METERS        |     |
|-----|----------------|-----|-----------------------------------|-----|
|   1 | CAGZ           | W I |   -0.0160     0.0379     0.0178 | *   |
|   2 | HARB           | W I |    0.0003     0.0004     0.0004 |     |
|   3 | MAS1           | W I |   -0.0001    -0.0004     0.0013 |     |
|   4 | NKLG           | W I |    0.0000    -0.0008    -0.0008 |     |
|   5 | NOT1           | W I |    0.0013     0.0393     0.0272 | *   |
|   6 | RABT           | W I |    0.0000     0.0009    -0.0009 |     |
|-----|----------------|-----|-----------------------------------|-----|
|     | RMS / COMPONENT |    |    0.0002     0.0008     0.0011 |     |
------------------------------------------------------------------------------

NUMBER OF PARAMETERS  :      7
NUMBER OF COORDINATES :     12
RMS OF TRANSFORMATION :      0.0010 M

PARAMETERS:

TRANSLATION IN  X     :          0.0405 +- 0.0013 M
TRANSLATION IN  Y     :         -0.0755 +- 0.0041 M
TRANSLATION IN  Z     :         -0.0529 +- 0.0027 M
ROTATION AROUND X-AXIS:  -  0  0  0.00097 +-  0.00004 "
ROTATION AROUND Y-AXIS:     0  0  0.00216 +-  0.00010 "
ROTATION AROUND Z-AXIS:  -  0  0  0.00288 +-  0.00015 "
SCALE FACTOR          :         -0.0034  +-  0.0002 MM/KM

NUMBER OF ITERATIONS  :      3
```

IGS Stations

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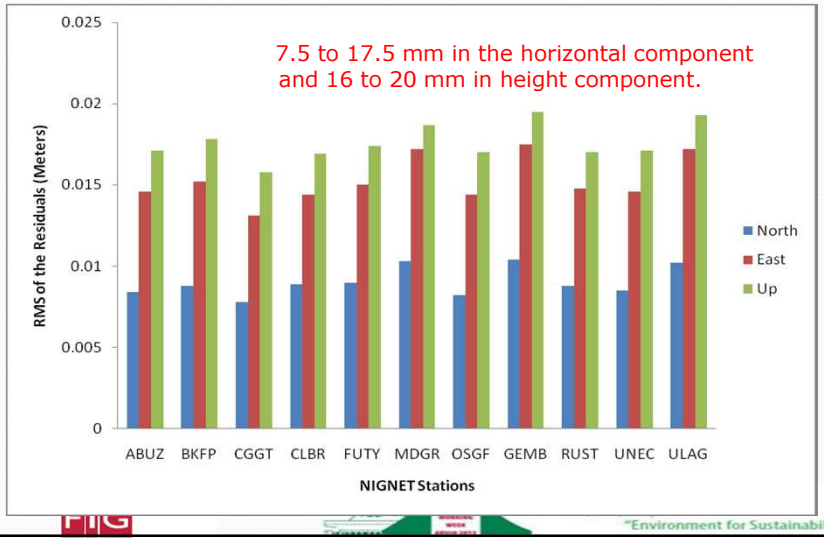
Results and Analysis

Free Network Adjustment



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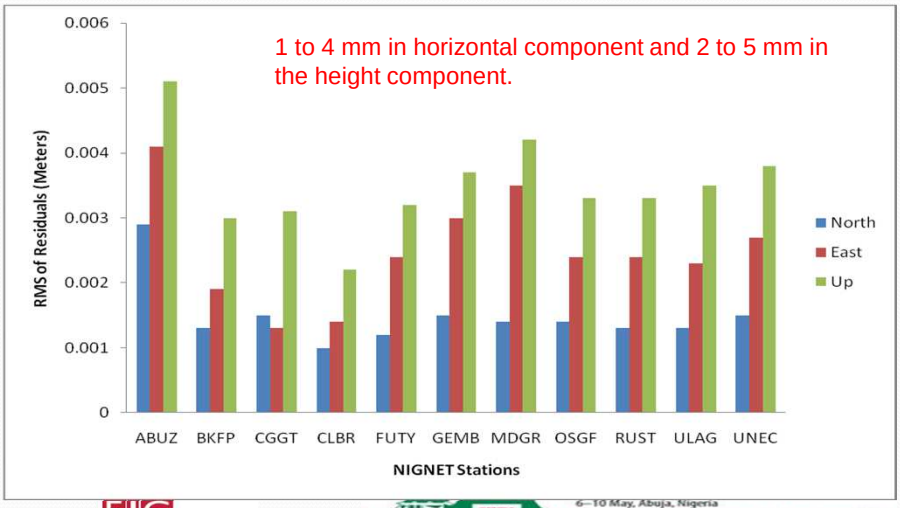
Results and Analysis

Heavily Constrained Adjustment



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Results and Analysis

Free Network Adjustment versus Heavily Constrained Adjustment

NUM	NAME	FLG	RESIDUALS IN METERS		
1	ABUZ	I I	0.0003	0.0000	0.0000
2	BKFP	I I	0.0003	0.0000	0.0002
3	CGGT	I I	-0.0002	-0.0001	0.0003
4	CLBR	I I	0.0000	0.0000	0.0004
5	FUTY	I I	-0.0003	-0.0003	0.0002
6	GEMB	I I	-0.0001	0.0005	0.0002
7	MDGR	I I	0.0001	-0.0003	-0.0005
8	OSGF	I I	-0.0001	0.0000	-0.0002
9	RUST	I I	0.0000	0.0001	-0.0003
10	ULAG	I I	0.0000	0.0001	-0.0002
11	UNEC	I I	0.0000	0.0000	-0.0001
	RMS / COMPONENT		0.0002	0.0002	0.0003

NUMBER OF PARAMETERS : 7
NUMBER OF COORDINATES : 33
RMS OF TRANSFORMATION : 0.0002 M

The two coordinates set fits nicely

PARAMETERS:

TRANSLATION IN X : -0.0007 +- 0.0011 M
TRANSLATION IN Y : -0.0018 +- 0.0015 M
TRANSLATION IN Z : 0.0016 +- 0.0017 M
ROTATION AROUND X-AXIS: 0 0 0.00001 +- 0.00004 "
ROTATION AROUND Y-AXIS: - 0 0 0.00005 +- 0.00005 "
ROTATION AROUND Z-AXIS: - 0 0 0.00005 +- 0.00005 "
SCALE FACTOR : 0.0001 +- 0.0002 MM/KM

NUMBER OF ITERATIONS : 2

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Coordination of the Nigerian Primary Geodetic Network (NPGN)

- GPS observations were carried out on some existing Nigerian Primary Triangulation stations, while some stations were re-established.
- A GPS campaign was carried out from October 2010 to April 2011. A total of 60 stations were observed for a period of 48 hours to form the strengthening network.
- These stations were connected to the Zero Order Geodetic Network (NIGNET) and thus defining a new Nigerian Primary Geodetic Network (NPGN) based on NGD2012 reference frame.

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Coordination of the Nigerian Primary Geodetic Network (NPGN)

- The observed data from the sixty (60) GPS monuments were processed using the same NIGNET stations processing procedure.
- The strengthening of the network involved two stages
  - The Free network and
  - the heavily constrain network adjustment. In the constrained adjustment,
- NIGNET stations held fixed to adjust the observed baseline vectors to obtain the link station's coordinates to conform to NGD2012.

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Coordination of the Nigerian Primary Geodetic Network (NPGN)

- The new NPGN has been successfully established with connection to the Zero Order Geodetic Network and its coordinates referred to the ITRF2008 Epoch 00.0 with an accuracy of 1 to 10mm.
- Quality assessment for network shows that differences less than 10 mm is achieved. Only one station in NPGN could not be processed due to poor data quality.

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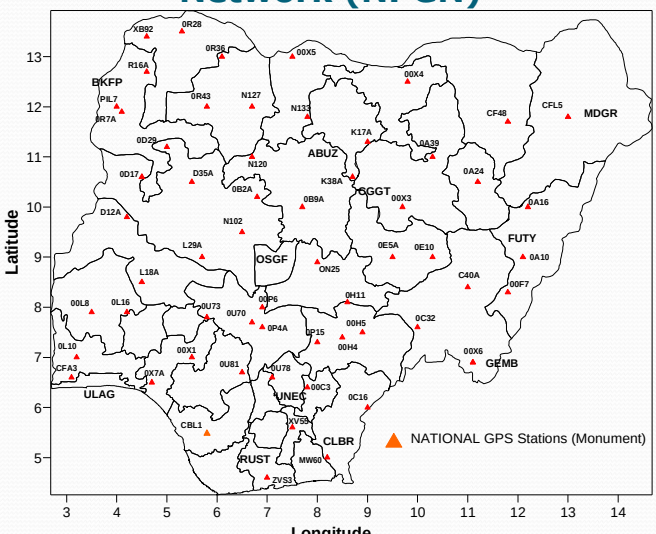
Coordination of the Nigerian Primary Geodetic Network (NPGN)



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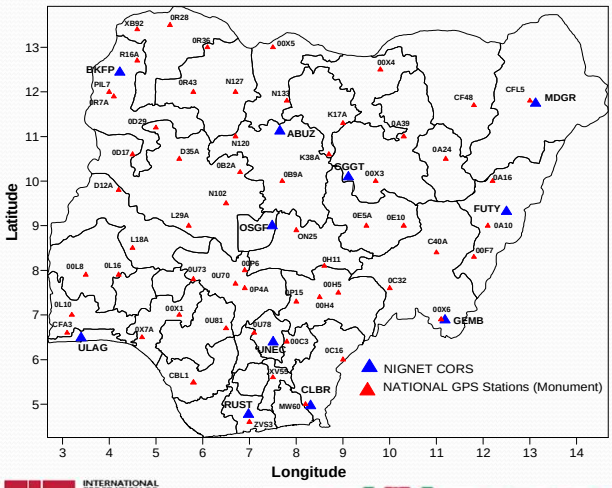
The Geocentric Datum Map of Nigeria



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Conclusion

- The Nigerian Geocentric Datum NGD2012 is a fulfilment of the African Reference Frame (AFREF) vision. With an accuracy of 10 mm defined in ITRF2008, it will form the backbone for all surveying and mapping activities.
- High Quality Coordinates of NIGNET Stations obtained
- The Zero Order Geodetic Network is to be finally defined on ITRF2008 reference frame.

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Conclusion

- A new geodetic datum known as **Nigerian Geocentric Datum (NGD2012) is underway !!!!!!!!!!**

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Thank you

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