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COMPARISON OF THE PROCESSING OF GNSS DATA USING FIXED GROUND STATIONS (TRIANGULATION STATIONS) AND THE NIGNET: A CASE STUDY OF THE SOUTH-SOUTH ZONE OF NIGERIA.

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ABSTRACT

In Nigeria, prior to the introduction of continuously operating reference stations (CORS) most survey were tied to fixed ground stations or triangulation stations in fulfillment of the process of working from whole to part. These stations have coordinates derived on the local datum (Minna). In 2008, OSGOF (Office of the Surveyor General of the Federation), which is the National Mapping Agency of Nigeria, initiated a project to establish NIGNET (NIGerian GNSS Reference NETwork) This network, formed by state-of-the-art CORS (Continuously Operating Reference Stations) GNSS (Global Navigation Satellite Systems) equipment, intends to implement the new fiducial geodetic network of Nigeria. NIGNET will serve many different applications at national and continental levels. In fact, the first motivation to implement NIGNET was to contribute to the AFREF (African Reference Frame) project in line with the recommendation of the United Nation Economic commission of Africa (UNECA) through its Committee on Development, Information Science and Technology (CODIST). At national level, NIGNET will serve primarily as the fiducial network that will define and materialize a new reference frame based on space-geodetic techniques and linked to AFREF.

Abstract Cont.

Currently, NIGNET is formed by fifteen CORS stations covering the entire country. The selection of the locations was carried out considering different theoretical and practical criteria. This paper attempts to use the data obtained from recent GNSS campaign covering the entire South-south zone of Nigeria to do a comparison of processing by the traditional method of controlling survey using fixed ground stations and CORS, which network is referred to as the NIGNET. Of particular note is the fact that with the use of the Trimble Business Centre Software local (Minna) and global (WGS84) values of the points were derived. The coordinates being Geodetic, both the ellipsoidal height (h) and the orthometric heights (H) were displayed. This gave an opportunity to determine the Geoid heights (N) for the stations (N= [H-h]). This paper attempts to do a comparison between the two computations using NIGNET data and Minna (local) data. Hence we shall look at the Global Geodetic values in Latitudes and Longitudes, ellipsoidal heights (h), orthometric heights (H) and the Geoid Heights (N).

Introduction

Basic principles of Surveying.
Working from whole to part, is the one on trial in this study.
It is a fundamental rule to always work from the whole to the part.
This implies a precise control surveying as the first consideration followed by subsidiary detail surveying.
This surveying principle involves laying down an overall system of stations whose positions are fixed to a fairly high degree of accuracy as control, and then the survey of details between the control points may be added on the frame by less elaborate methods. Once the overall size has been determined, the smaller areas can be surveyed in the knowledge that they must (and will if care is taken) put into the confines of the main overall frame.
Errors which may inevitably arise are then contained within the framework of the control points and can be adjusted to it. Thus they have no chance of building up on accumulating throughout the whole survey.

The Nigerian Geodetic Reference System

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

- The reference ellipsoid is the Clarke 1880
- 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.
- The geodetic reference system is based on Minna Datum Which is a local datum with origin of the coordinate adopted.

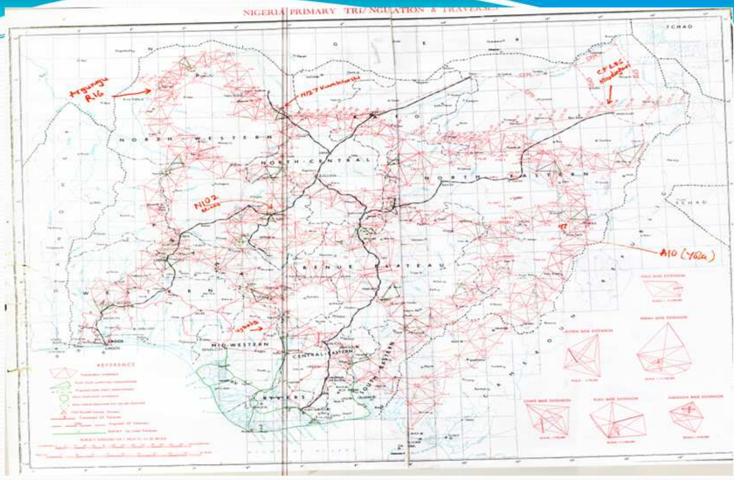

Figure 1: The Nigerian Primary triangulation Network
(Source: OSGOF Archives)

This datum is regional and generally not aligned with global geocentric coordinates frames.
Minna datum used in the production of the Nigerian primary triangulation network has a number of inherent deficiencies resulting to serious distortion in the network.
They include:

i. In-accuracy of the scale factor by compression of the Clarke 1880 ellipsoid, thereby causing defect in distances measured

ii. The origin of the Nigerian network is poorly defined

iii. Absence of geoidal height model.

iv. Difficulties in the determination of the transformation parameters.

Nigeria is yet to come out with workable transformation parameters for the whole country, hence the local reference system cannot be precisely transformed to WGS84, given the defects and deficiencies earlier mentioned. It is anticipated that the roll-out of Continuously Operating Reference Station (CORS) network in Nigeria will result in very significant improvements in the Positional Uncertainty (PU) attainable by surveyors using Global Navigation Satellite Systems (GNSS) positioning technology. Improvements will be noticeable in remote and under-developed areas, particularly with regard to cadastral (e.g. customary land) and resource sector surveys. The basis for any regional CORS network is usually the latest realization of the International Terrestrial Reference Frame (ITRF

Country	Datum	Realization	Reference Epoch
Australia	GDA94	ITRF92	1994.0
China	CTRF2000	ITRF97	2000.0
Indonesia	DGN1995	ITRF2005	1995.0
Japan	JDG2000	ITRF2000	2000.0
Malaysia	GDM2000	ITRF2000	2000.0
New Zealand	NZGD2000	ITRF96	2000.0
Papau New Guinea	PNG94	ITRF92	1994.0
South Korea	KGD2002	ITRF2000	2002.0

Table 1: ITRF aligned datum of some selected countries

Global Navigation Satellite Systems (GNSS) offer autonomous geo-location.
There are six known GNSS constellations namely:
NAVSTAR (GPS) (operational systems) (owned by America) Fully Operational
GLONASS, (operational systems)
Galileo,
Compass,
QZSS, and
IRNSS.
Galileo and COMPASS are expected to be operational in the near future

Some of the augmentations systems currently existing are WAAS (USA), EGNOS (Europe), MSAS (Japan), LAAS (USA) and most recently the NIGNET (Nigeria).
The implementation of the network of Continuous Operating Reference Stations (CORS) which makes up the NIGNET began in 2009. Today, the NIGNET CORS network currently consists of 15 fully operational locations.
The NIGNET network GNSS Nigeria initiative.
Geared towards 'creating awareness and improving geo-location' within Nigeria.

VISUAL EARTH ⟶ GNSS Nigeria ⟶ OSGOF/SEGAL

The Nigerian Permanent GNSS Reference Network (NIGNET)

- Established by the Office of the Surveyor General of the Federation (OSGOF).
- To implement new reference frame for Nigeria as recommended by United Nation Economic Commission of Africa (UNECA) through Committee on Development, Information Science and Technology (CODIST)
- NIGNET is formed by network of Global Navigation Satellite System, Continuous Operating Reference Stations (CORS)
- It is expected that, NIGNET will directly contribute to the Africa Reference Frame (AFREF). Presently, there are fifteen (15) NIGNET CORS stations

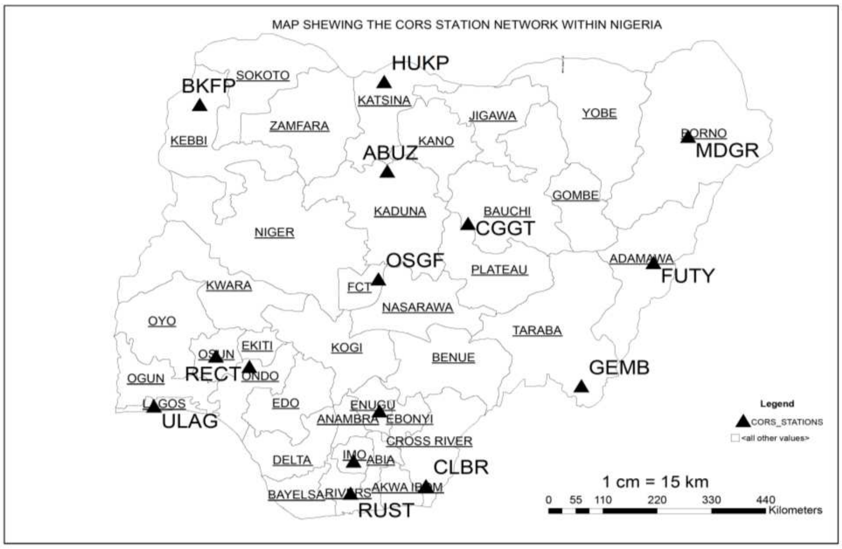

Figure 2: The Nigerian Permanent GNSS Reference Network (NIGNET)

GNSS has emerged to become a vital component in high precision positioning suitable for survey and mapping.

GNSS and unified GIS applications over large areas has caused the existing Minna datum to become obsolete with regional datum and generally not aligned with global geocentric coordinates frames.

Many countries have implemented and adopted a geocentric coordinate frame for their geodetic datum. World Geodetic System of 1984 or WGS84 is one such global geodetic datum maintained by the US Department of Defence.

Another realization of the global geodetic datum is the International Terrestrial Reference Frame (ITRF) and is compatible with WGS84 at the centimeter level. The most rigorous way for geodesists to achieve centimeter level accuracy is to perform GPS measurements relative to ITRF control stations since DoD stations are not available to civilians.

All modern GNSS use geodetic reference systems closely aligned with ITRF (e.g. the US GPS system's WGS84), with few millimeters and forms a robust basis for any regional or national geodetic datum.

As the ITRF continues to stabilize, it is anticipated that differences between future realizations of ITRF will differ from one another by less than a few millimeters at a common epoch.

The ITRF 2008

(ITRS) is a world spatial reference system co-rotating with the Earth in its diurnal motion in space.

Realizations of the ITRS are produced by the IERS ITRS Product Centre (ITRS-PC) under the name International Terrestrial Reference Frames (ITRF). ITRF coordinates are obtained by combination of individual TRF solutions computed by IERS analysis centres using the observations of Space Geodesy techniques

The Benefits of a Geodetic Datum based on ITRF

An ITRF based geocentric datum or CORS network will among others;

- Provide direct compatibility with GNSS measurements and mapping or geographical information system (GIS) which are also normally based on an ITRF based geodetic datum.
- Allow more efficient use of an organization spatial data resource by reducing need for duplication and unnecessary translation.
- Help promote wider use of spatial data through one user friendly data environment.
- Reduce the risk of confusion as GNSS, GIS and navigation systems become more widely used and integrated into business and recreational activities

Focus of this Paper

In view of the aforementioned challenges relating to Nigeria local Datum on which the National Triangulation Network was based and considering the benefits of a Geodetic datum based on ITRF, the OSGOF deemed it imperative to carryout GNSS observation and compare the processing results of using triangulation stations and the NIGNET.

Case Study

South – South zone of Nigeria

Scope of Work

- Construction of 95 No. 40cm x 40cm x 40cm surface dimension pillars within South-South zone as follows: Akwa Ibom – 4 No, Bayelsa – 9 No, Cross River – 22 No, Delta – 21 No, Edo – 18 No and Rivers – 21 No.
- Using 2 No. triangulation stations as controls for base receivers
- Using NIGNET (COR) Stations as controls/base stations
- Pillar observation using the static relative GNSS positioning method
- Baselines processing using triangulation stations as control stations
- Baselines processing using NIGNET (COR) Stations as control stations
- Network adjustment using precise (final orbit) ephemeris
- Data analysis and presentations.

Equipment Used

4 units of Trimble R8 dual frequency GNSS receivers with complete accessories were used for the project.

Year of Observation: 2012

Methodology

There are several methods of positioning using GNSS receivers.
Static method of observation using four (4) units of Trimble R8 GNSS receivers was adopted. It is the ideal method for long baselines of which an accuracy of 5mm+1ppm rms can be attained. Hence, this is often recommended for very high accuracy surveys such as control and geodetic surveys.

The base receivers were set on reference/base stations and tracks satellites continuously. Roving receivers moved from one unknown station to the other. A minimum of 4 satellites is required for a fix with Geometric/Position Dilution of Precision (GDOP/PDOP) of <6.

When NIGNET (COR) Station was used as reference/base station, all the receivers were used as rovers. Minimum duration of observation was 2hours throughout the project.

Comparison between Processed GNSS Data Using Triangulation Stations and the NIGNET Stations

- Summary of Result

After data processing and adjustment using triangulation stations and the NIGNET stations, the adjusted coordinates in Minna datum were compared. The differences in latitude, longitude and height were in the average of -**0".07292**, **0".0303** and **-1.7314m** respectively, except in the case of Akwa Ibom and Cross River States where the differences in latitude, longitude and height were relatively large in the average of **3".0822**, **0".6318** and **-0.1075m** respectively.

Data Analysis

The difference in adjusted coordinates (latitude, longitude and Height) as obtained show that Nigeria triangulation network is not so far from the ITRF however, this analysis is not conclusive due to time constraint. It is most likely that the cumulative error from the ground stations might have affected the processing results in Akwa Ibom and Cross River States thereby resulting to the large difference obtained.

Conclusion

Although the Nigeria triangulation network has inherent errors it is still relevant to local survey within the Country. Numerous Surveys at both National and State levels had been carried out using the network. However, considering the benefits of ITRF upon which the NIGNET is based, it is pertinent to say that the use of NIGNET for survey projects henceforth should be encouraged.

Recommendations

•Further research on the comparison between Processed GNSS data Using triangulation stations and the NIGNET stations should be conducted.
•The transformation parameters between the local and the Global coordinates are essential in the adoption of NIGNET for survey projects.
•The use of NIGNET for survey projects henceforth should be encouraged.