Journal of Geospatial Surveying (2022) 2:2
DOI: http://doi.org/10.4038/jgs.v2i2.40

ORIGINAL ARTICLE

The Review and Development of the Nigerian Geodetic Control Network

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ARTICLE INFO

Article history:
Received 5 September 2022
Received in revised form 27 September 2022
Accepted 29 September 2022
Available online 12 October 2022

Keywords:
Network
Coordinate and Control

ABSTRACT

The Nigeria Geodetic Networks were established using primarily triangulation, traversing, trilateration, doppler and levelling networks for numerous control requirements in both surveying and national spatial reference networks. These networks have a number of inherent negative failings that affect its reliability of usage. Various investigations have identified many weaknesses in the network, starting with the origin and other subsequent observational and adjustment defects. Thus, the need to obtain accurate and consistent sets of coordinates with the available space technology and equipment to update and strengthen the network has now become necessary. This work reviews the status of the existing Nigeria Geodetic Networks, and possible ways to improve them are highlighted. The work further proposes a strategy to obtain the most accurate and consistent set of coordinates to serve Geodesy and Geodynamics research, spatial referencing and other mapping activities in the country. The proposed programme of action for improving these networks includes: re-observing the existing network, new set of computations and adjustment of the entire network of controls, and the selection of a suitably chosen system to meet the present and future geodetic needs of positioning.

1 Introduction

The geodetic control system is a network of points represented by survey monuments whose coordinates are precisely and accurately determined, depending on the order of the control. The Nigerian coordinate systems are classified into zero, first, second, and third order controls. The zero and first or primary network of controls are reasonably and widely separated, whose coordinates are determined with utmost precision. The secondary or second order is the first breakdown of the first order, and consists of points whose coordinates are determined with accuracy just below the primary ones. Similarly, the third order breaks down the secondary. In short, the networks of established horizontal, vertical and gravity control points were made prior to regional and local surveys. The Nigerian Geodetic controls were established using triangulation, traversing and trilateration, while the vertical controls were established with spirit and trigonometric levelling. Methods adopted in a particular area depend on the terrain and the climatic conditions. The gravity measurements in Nigeria have not been well coordinated. GPS and gravity observations were carried out by various oil prospecting companies in the Niger Delta for their interest, while the Federal Survey Department made the observation for the whole country.

Historically, the Nigerian geodetic network of controls was established in stages, with instruments of varying specifications. The observation of triangulation took several years, using instruments of varying precision and quality. According to Omogui (1973), all survey works completed later than 1930 were not of the qualities and precisions desired, and hence were discarded. Then, Captain J. Calder Wood initiated actions to re-design and re-observe the existing network. Even after that, "there is evidence that the quality of astronomical observations were still low. Neither the instruments available and used nor the observation and reduction methods were such that the results could be accepted as of geodetic standard" (Fajemirokun and Ogwunde, 1978). Apart from the observations, the adjustments were performed in piecemeal. Various investigations revealed many defects in the network right from the origin. Defective origin had affected the whole network. Therefore, there is a need for a project to obtain the most accurate and consistent set of coordinates for the control points with the availability of space technology and equipment to update and strengthen the network.

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2 State of Nigeria Geodetic Network

2.1 The Nigerian Horizontal Controls Network:

The Nigerian horizontal network of controls was computed on the Minna datum. The piecemeal network adjustments of the network have introduced distortions in the network, causing errors of up to ± 50 cm in the relative positions of points separated by hundreds of kilometres. Efforts had been made at various times to make a simultaneous adjustment to the whole network, but there were inconsistencies in the results obtained by different groups. Federal Surveys Department (now office of the surveyor general OSGoF), at various times, strengthened the network through GPS observations. However, it is unclear whether these data have been fully integrated into the national primary triangulation network (Uzodinma, 2005). The Nigerian geodetic control network is adjusted based on Clarke's 1880 referenced ellipsoid with Minna datum as its local origin. The station was named L40 from the serial coordination of the Nigerian geodetic network. The latitude (ϕ) and longitude (λ) of L40 were obtained by projecting the latitude and longitude values of the five points in Minna, Lafia-Beri-Beri, Naraguta, Kano, and Zaria. Likewise, the deviation of the verticals was obtained from the provisional values and not from the actual observation of the station by either of the processes to conform to the Clarke 1880 reference ellipsoid. The generated coordinates of the station are given below as

Latitude, ϕ = 09° 38' 09" N

Longitude, λ = 06° 30' 39" E

Height, H = 279.6 m above the geoid (Awotiwon, 1987).

With semi-major axis, a = 6378249.145 m

Flattening, f = 1/293.465

1 m = 3. 28086933 ft

The chain of triangles for the primary triangulation system generally ran from North-South and East-West directions. They were restricted to the highlands and less forested areas of central North-Western and South-Eastern Nigeria. At the same time, traversing was used mainly in the forested areas of the South-West and the low lands of the North-Eastern part of Nigeria (Fajemirokun, 1980). According to Uzodinma (2005), the Nigeria Primary Triangulation network has a fragmentary origin, having been built-up from piecemeal designed local schemes for topographical control and dates from 1930, when Captain J. Calder Wood initiated action to re-design and re-observe the existing network. From careful observation, an average triangular misclosure of 1.0″ was observed over the whole network, with a maximum of 3.67″ along the Minna-Naraguta chain. The average inter-station distance of the network is 24 miles (≅ 40km), the standard error (internal) of azimuth observations of all the Laplace stations gave a mean of +0.59″. Invar tape Bases and Laplace azimuth stations were placed mainly at chain junctions. The entire Geodetic Control consists of about 500 triangulation and 3,000 primary traverse stations, covering an area of about a million square kilometres. Fig. 1 shows the Map of Nigeria with the existing triangulation and traverse stations.

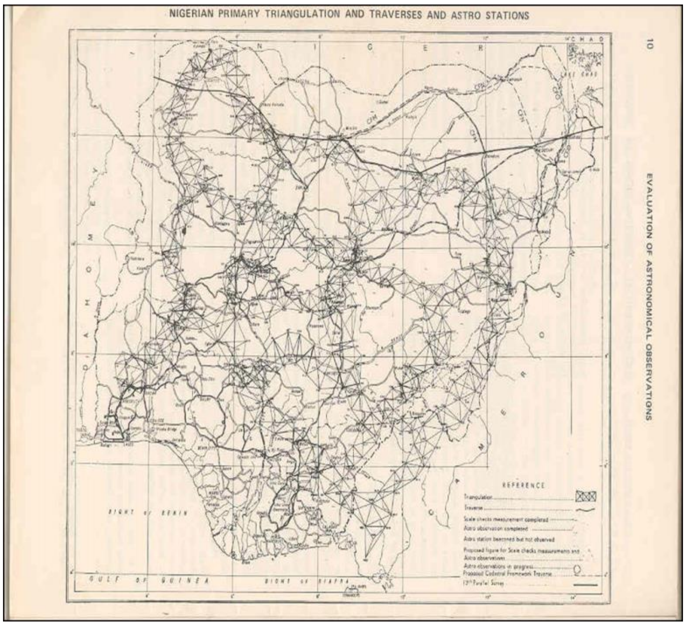

Fig. 1: Map of Nigeria with the existing triangulation and traverse stations.

2.2 The Nigerian Vertical Controls Network

The heights of control points in Nigeria were obtained either through geodetic spirit levelling (for benchmark) or trigonometric heights (for Trigonometric point). The origin was from Lagos's Mean Sea Level (MSL) (known as Lagos datum) height obtained through average tide gauge measurement of at least 19 years of observation at an arbitrary station known as the Lagos survey datum. The average tidal gauge of measurement was used to determine the heights of all control points distributed over the country, including the height of Minna datum (L40). The heights data used are provisional values rather than geodetic heights. The network adjustment was piecemeal rather than network adjustment of geoid heights, so were the deflections of the vertical values, and these have introduced distortions in the network. The heights obtained from geodetic levelling were derived after circuit adjustment of the various levelling loops. The geodetic level nets (Fig. 2) proposed or observed consist of 200 lines to cover the entire country fairly uniformly, except for part of the Taraba State. It comprises of a set controls and each level line starts from a Fundamental Bench Marks (FBM) or Standard Bench Marks (S. B. M.) as the case may be with the Intermediate Bench Marks (I. B. M.). Lower order level nets are tied to them. In addition, extensive levelling was done in the Niger Delta by the oil prospecting companies (Fajemirokun, 1980) to establish control networks for oil prospecting purposes, but are still based on the Minna datum system.

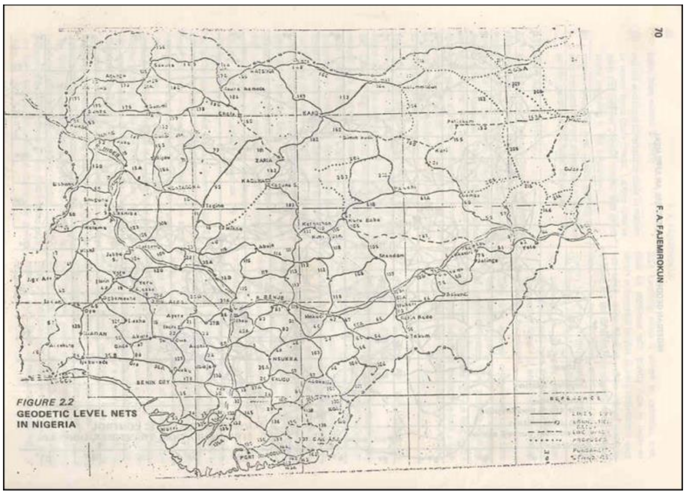

Fig. 2: Map of Nigeria levelling Network (*Source*: Fajemirokun, 1980).

2.3 The African Doppler Survey (ADOS)

Nigeria was one of the sixteen countries which participated in the African Doppler Survey (ADOS) in 1984. The programme established Doppler stations in selected locations across the country. Fig. 3 shows the Map of Nigeria with Doppler Stations along with triangulation and traverse stations.

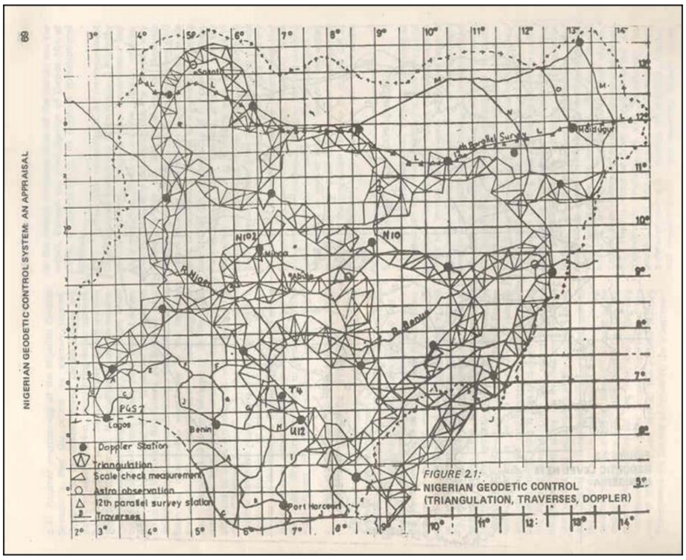

Fig. 3: Map of Nigeria showing Doppler, Triangulation and Traverse Stations (*Source*: Fajemirokun, 1980).

2.4 The Nigerian Gravity Controls Network:

Several gravity measurements were carried out, mostly in oil prospecting sites for exploration activities. These gravity observations are mostly not observed at the national geodetic controls in which such values can be used with the geoidal undulation and deflection of the vertical. These parameters are needed at the observation points to reduce observations to the ellipsoidal surface before geodetic coordinates can be accurately computed. The determination of ellipsoidal parameters: semi-major axes (a), flattening (f), and the origin and the orientation of the network are often referred to as datum determination of reference ellipsoid. This is fundamental to the accurate mapping of any country. In Nigeria, these quantities are not adequately available, and the geoidal and ellipsoidal surfaces are assumed to be the same, a notion often referred to as the "development method". The gravity observations were made for specific purposes, mainly for oil and mineral exploration. The available gravity data were not observed along the level line. Therefore, the completed gravity measurement cannot meet the geodetic needs. Fig. 4 shows the Map of Nigeria with the planned gravity network.

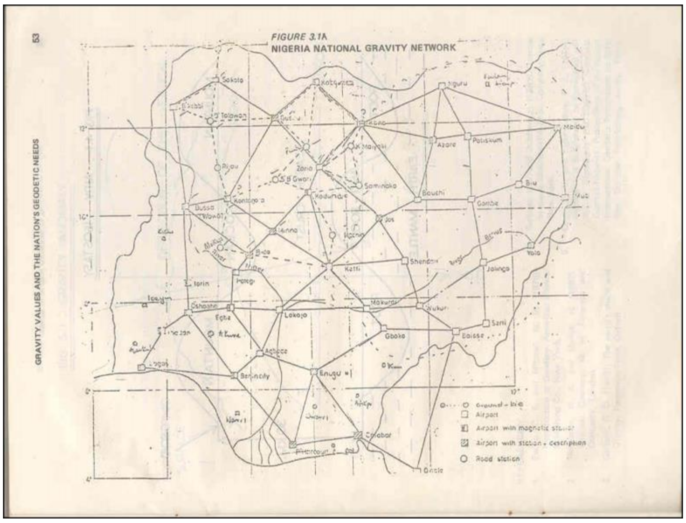

Fig. 4: Map of Nigeria with the planned gravity network.

2.5 Astronomical observations in Nigerian

Astronomical observations are made to determine the position of points and direction (or orientation) of lines on the earth's surface. The distinguishing characteristics of astronomic methods lie in the 'absoluteness' of the coordinates or directions so determined (Fajemirokun and Ogwunde, 1978). Fig. 1 shows the Map of Nigeria with the existing triangulation, traverse stations and astronomical observations. The Nigerian astronomical observations carried out are for:

I. Astronomical observation for property survey or control of lower-order traverses.
II. Astronomical observation for the control of geodetic traverses and triangulation.
III. Astronomical observation for Laplace stations.

2.6 Global Positioning System Observation in Nigeria

Nigerian Geodetic network had made use of the advancement in satellite technology, which has revolutionised the science of surveying and Geoinformatics. The Shell Petroleum Development Company established over 540 GPS stations in 1991. The Federal Survey (Now Office of the Surveyor General of the Federation) had established GPS stations in most parts of the country. In 2006, the "as built survey" of Federal Government properties all over the country was carried out. Contractors were compelled to tie the work to GPS stations. Subsequently, GPS stations were established in all the towns and villages where such Federal Government properties existed. The stations were given coordinates corresponding to the WGS-84 reference ellipsoid. If these stations are collected, and coordinates made available, the applications of GPS technology in surveying will generally improve large-scale industrial mapping, first-order geodetic surveys and height determination for crustal motion surveys (even for the prediction of earthquakes and volcanoes) (Uzodinma and Ezenwere, 1993). The processed observations will provide station positions in Cartesian coordinates (x, y, z), which can be converted to geodetic coordinates (latitude, longitude and height above the reference ellipsoid). It will also provide adequate connections to vertical control network points and determine the geoidal heights (or elevations). However, these stations with GPS-coordinates were mostly available only to the client and the prospecting companies.

2.7 Continuously Operating Reference Station (CORS)

These will serve as a set of control networks established to provide users with active control and real-time control for their survey operation. They will be established to replace the traditional geodetic passive networks for Surveying and Mapping in any country (Dodo et al., 2011). The proposed network will enable continuous GNSS surveying processed at the control centre (OSGoF, Abuja). The final results will be forwarded to the users in the field electronically via the internet (GPRS/GSM). The advantages of Nigerian CORS are as follows:

I. Reduction of investments in the required equipment (by approx. 50%).
II. Reduction in human resources and time (by at least 50%) during the surveying stage.
III. Having an increase in the accuracy, reliability and uniformity in the obtained surveying results (Isioye and Fajemirokun, 2010).

To upgrade the Nigerian geodetic networks, the universal or global reference ellipsoid of WGS84 was adopted in the established network of CORS stations in Nigeria that gave birth to the Nigerian GNSS Reference Network (NIGNET) as established by the Office of the Surveyor General of the Federation (OSGoF). The primary mission behind NIGNET is to implement a new reference system for Nigeria in line with current recommendation of the United Nations Economic Commission of Africa (UNECA) through the Committee on Development Information Science and Technology (CODIST) (Jatau et al., 2010). The core of NIGNET is formed by a network of Global Navigation Satellite Systems CORS. It is expected that NIGNET will directly contribute to strengthening the Africa Reference Frame (AFREF) (Dodo et al., 2011). According to Ayodele et al. (2019), NIGNET is fit for the purpose in defining of the Nigerian Geodetic Reference Frame. Despite the excellence in design and data quality observed, the network is not adequately designed in terms of infrastructural capacity for continuity in data transmission over the network. The Federal Government would require establishing over 200 CORS to complement the existing ones in order to tackle the dearth of geospatial data in the country. As of 2021, only 24 are on the ground (Taiwo, 2021). Some of these CORS are currently not working or having some other issues posing major challenges to users.

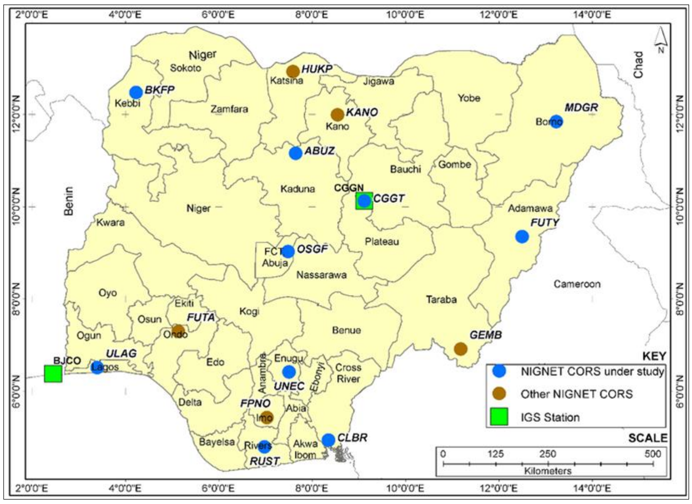

Fig. 5: Map of Nigeria showing the CORS and NIGNET (*Source*: NIGNET website, 2022).

2.8 The Defects in the Nigerian Geodetic Network

The Nigerian Primary Geodetic Network contains some severe distortions. These distortions are traceable to four sources.

I. Scale defects arising from using wrong conversion factors in computing lengths: A false computation of Invar Base compression of the Clarke 1880 ellipsoid by 1/138,000 occurred in the distance measurements. This defect occurred because the measured distances were given in the “Clarke” foot while the computations were done using tables prepared with the “British” foot (Oyeneye, 1985).
II. Orientation problems arising from:
    a. Insufficient constraints.
    b. The failure to apply necessary correction or incorrect reduction procedure. For instance, corrections for deflection of vertical and polar motion were not applied to the observed astronomic coordinates.
    c. The failure to determine the orientation parameters of the geodetic coordinates axes. According to Ezeigbo and Edoga (1980), this problem manifests when we want to relate the geodetic coordinates of a station derived using modern techniques (say Doppler satellite) to the classical geodetic coordinates of the station.
    d. Absence or inadequate distribution of Laplace stations: Only nine out of the 19 Laplace stations positions were observed at the junctions of the triangulation chains. To make matters worse, half

of the geodetic network observed stations are located on the western part. According to Ezeigbo and Edoga (1980), 'the network of controls, in which one section of it is strongly oriented at the reference system to the detriment of the rest is prone to distortions. This omission denied adequate azimuth checks, thus introducing distortions in the network. One of such distortions is the considerable variations of up to 25″ in the deviation of the vertical in different parts of the network in comparatively short distances of 60 km, even in relatively flat topography (Adaminda and Field, 1985) and (Uzodinma, 2005).

e. Defects Arising from poor definition of the Network Origin: There are assumption on Clarke 1880 that the ellipsoidal geoid being coincidental and parallel at the origin of the network (L40). This implies assigning zero values at the origin of the geoid height (N_o) and deviation of the vertical (ξ_o, η_o).

   $N_o = \xi_o = \eta_o = 0$

   Where: $N_o = h_o - H_o$ (h_o= geodetic height of L40)

   Ezeigbo and Edoga (1980) observed that the systematic error of 0.9″ exists in all geodetic azimuths computed at the origin. This systematic error must be corrected for any meaningful application of the Laplace condition at any station away from the origin.

f. Poor definition of the Network Origin has affected the height system: Uzodinma (2005) submitted that the height of L40 above the Mean Sea Level (H_o) is 279.6 m. The accuracy of this height value is in question because it is based on the inaccurate Lagos Vertical Datum (Field, 1978) in Uzodinma (2005). Also, the coplanarity of the ellipsoid with the geoid at the origin is in doubt due the fact that on different occasions, the two surfaces have been determined to be inclined at either the angle of 6.35″ (1928) or 1.6″ (1968) (Field, 1978) in Uzodinma (2005). The problem has resulted from the failure to reduce the astronomical observations to the agreed Conventional International Origin, C. I. O. Hence, the result was a geoid tilted from the north-western side to the northeast as reported in Ezeigbo (1991).

III. Scale and orientation defects arising from the poor definition of the network origin: The problems arising from scale are due to the following:

   a. Arbitrary choice of reference ellipsoid: the choice of parameter semi-major axis and flattening (a and f) of reference ellipsoid with its location relative to the geoid surface over the country will influence the scale error in the geodetic positioning. In Nigeria, where the geoidal map is not available for reduction purposes, fitting the ellipsoid to the geoid will determine the amount of scale error we may contend with (Ezeigbo and Edoga, 1980).

   b. The reduction procedures applied to the observations: Ezeigbo and Edoga (1980) observed that the correction applied as a result of the two conversion factors does not affect the actual reduction of the horizontal distance to the mean sea level. Also, the scale checks programme reported by Omoigui (1973) was aimed at removing the distortion through re-measuring the Base line nets and re-adjusting the whole network of chains on an electronic computer. Oyeneye (1985) reported that the programme could not be utilised because available observations were not evenly spread over the country.

   c. The routine for deriving the geodetic coordinates of the origin of the network: the geodetic coordinates of the origin of the network were obtained by adopting the mean value of the projected astronomic coordinates from four stations. This procedure speaks of geodetic coordinates on the same Clarke 1880 ellipsoid differently located and oriented. Therefore, they cannot be homogeneous sets of coordinates.

IV. Scale defects arising from the wrong reduction of observed data to the ellipsoid due to the absence of the geoid height model. The observations of gravity in Nigeria have never been coordinated. The available gravity data were collected to satisfy other desires other than the geodetic research. This had made geoid determination to be defective in this country. The lack of a Geoid height model had forced the adjustment of the network to be made via the development method rather than the correct projection method. This makes the observations to be reduced to the geoid rather than to the ellipsoid.

V. Consequently, introducing geodetic reduction distortions in to the network. As a result, a geoidal profile along the 12th parallel Traverse (CFL series) indicates geoidal height discrepancies of up to 12 m (Adaminda and Field, 1985). Also, investigations by Ezeigbo (1991) and Agajelu (1990) identified scale distortions between 1-3 ppm in the network due to the absence of a geoid height model in the North-Eastern part. Apart from that, the so-called development method adopted for the computation has cast a great deal of doubt on the credibility of our geodetic data, particularly now that the result from measurement obtained using precise modern instruments reveals a lot of biases on such data.

2.9 Other defects are:

I. The Lagos Survey datum, where all benchmarks in the country heights are referred to, has not coincided with the Mean Sea Level. There were attempts to analyse tidal observations obtained from Eastmole Tide gauge station near Lagos port in the past to establish the relationship between the Mean Sea Level and the Lagos survey datum. The investigation results show that the Lagos survey datum is about 50 cm below the Mean sea level.

II. When levelling covers an extensive area, it must be combined with gravity data in order to obtain approximate orthometric heights. However, some gravity observations were carried out, but not along the level lines. Hence, the Nigerian height systems are not adequate to meet the demand of modern surveying.

III. Uzodinma's (2005) investigations show that the origin of the Minna datum (L40) was omitted from the Africa Doppler Survey (ADOS). This omission has cost the nation vital data that would have helped determine accurate values for δ_n, ξ_o and η_o – thus removing the defects mentioned above at the datum origin.

IV. Another shortcoming of the Nigerian Control System is that the points are sparsely located. There are denser networks in the urban areas while the rural areas have sparsely spaced controls.

3 Way Forward

The proposed solution is based on available techniques to improve and strengthen the existing network and remove difficulties in their usage. There has to be readiness by the concerned authorities to embark on a project to obtain the most accurate and consistence set of coordinates for the control points to upgrade the Nigerian Primary Triangulation network to a precise, geodetic network. Empowering the existing network to maintain what we have will limit the resource requirements for the mass haul of the entire existing networks and make them relevant for future geodetic challenges. The proposed programme mode of action may entail the following:

I. Re-observe the existing network.

II. A new set of computation and adjustments on an entire network of controls that is aligned to a well-defined and suitably chosen system to meet the present and future geodetic positioning needs.

III. The utilisation of satellite-derived data to obtain the absolute coordinates, undulations, and deflection of the vertical as well as any other suitable variable for each control point.

IV. Precise Definition of the Minna Datum Origin: making it a reference point in the satellite reference system and precise definition of the height systems for the geoid model because the geoid and the Clarke 1880 ellipsoid are not coincident and co-planar at the Minna datum origin (station L40)

V. The height systems need to be strengthened, more recent geoid model needs to be used to establish the height.

There is a need to introduce Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), and Global Positioning System (GPS) data into the network. This will eliminate many of the existing distortions and help impart precise inter-convertibility with the global datum. To achieve this, the following strategies could be considered:

I. The national datum origin (Minna datum) should be defined very accurately with SLR (or GPS) technique, and a station should be set at L40.

II. Provide the present network with the control super-structure using VLBI, SLR and GPS data. These will act as precise scale and orientation checks for the network.

III. A precise geoidal height model can be determined for Nigeria if adequate numbers of well-spread GPS observations are taken on the existing primary geodetic network. Fortunately, this has been done by the Federal Surveys. What remains is to carry out a rigorous (least squares) adjustment of the observations and then (if L40 was included in the survey) determine δ_n. If these are done, approximately correct orthometric heights, H_o will be obtained for all stations (Uzodinma, 2005)

$H_o = H_s + \delta_n$

where

H_o is the required approximate orthometric height

H_s is the spirit levelling height

δ_n is the least square adjustment values

This approach should be able to remove the wider discrepancies (up to 12 m) noticed in the models determined by different authors Ezeigbo (1991) and Agajelu (1990). Furthermore, all the existing benchmarks should be identified; horizontal and vertical observation should be carried out on the benchmarks, and then the approximate orthometric height determined. The satellite tracking method can now be used for Nigeria to get the gravity potential model. This will enhance the computation of geoidal undulation for accurate and consistent height measurement and determination of appropriate datum for Nigeria. According to Uzodinma (2005), certain factors, which should be put into consideration in the choice of VLBI stations/baselines, include:

I. The existing/future strategic role played by the station in the network (e.g. Laplace station, Datum Origin, Earth Research station.).

II. Adequate coverage of the country.

III. Inter-convertibility with other space techniques (e.g. ADOS/GPS station).

IV. The Strengthening of weak chains (e.g. discarded Invar Base).

Fig. 6 shows 12 hypothetical VLBI stations whose choices reflect the following:

a. Laplace/scale stations. = 6;
b. ADOS = 6; Extreme corners = 4;
c. Weak chain = 1;
d. National origin = 2;
e. Future Earth station. = 1;

Note that some of them will serve more than one purpose.

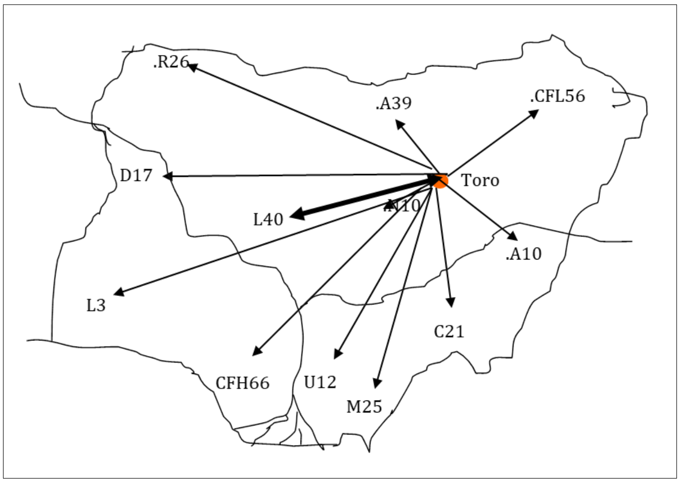

Fig. 6: Twelve hypothetical VLBI stations/ baselines.

VLBI, SLR and GPS origin should be located in Toro, and a baseline should be determined with the Minna datum origin (L40) and carefully tied to the existing primary geodetic network. The IERS (International Earth Rotation Service) gave the translation parameters between it [SSC (GSFC) 90 R 02] and the ITRF89 geocentric system (Tobita, 1994) as:

$$\begin{bmatrix} T_x \\ T_y \\ T_z \end{bmatrix} = \begin{bmatrix} 161.00\ cm \\ -87.70\ cm \\ 51.90\ cm \end{bmatrix}$$

With such a relationship solidly established, the baseline vectors between the L40 - Toro VLBI station and other stations should then be measured with a transportable VLBI antenna and computed in the ITRF system. Since the purpose is to provide super-structure control, the scale and orientation of the network by VLBI baselines, the 3-dimensional is sufficient (Tobita, 1994) in Uzodinma (2005):

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{Minna\ Datum} = s \times \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{ITRF} + \begin{bmatrix} T_x \\ T_y \\ T_z \end{bmatrix}$$

Where:

T_x, T_y, and T_z are translation parameters between the two datums.

r are the rotational elements along X, Y and Z.

s is the scale factor

3.1 Resources Coordination

One of the major problems of the geodetic activities in Nigeria is the lack of coordination. Since the Centre for Geodesy and Geodynamics has been established to study the crustal movements within the context of the Nigerian Older Basement Complex and the West African Craton using telemetric space satellite applications, it is the well-suited centre for the coordination of the Nigerian Geodetic Network. The observatory is located on an immobile Paleozoic craton, on the part of the Basement Complex of Nigeria. It is made-up of older granites and migmatites, which are the surface expression of West African craton (the part of a continent that is stable and forms the central mass of the continent; typically Precambrian) – an ancient stable core of the African continent that has not been deformed over geological time. Therefore, a centre should be well suited for the placement of the GPS, the VLBI system, the SLR systems, Doppler Orbitography by Radio-positioning Integrated on Satellite (DORRIS), Geodetic Time-keeping, Super Conducting Gravity Meter Station, Seismometer Station, Meteorological Station and a Water Vapour Radiometer Station akin to the Transportable Integrated Geodetic Observatory (TIGO) at the Universidad de Conception, Chile Republic (Teme, 2005).

4 Conclusion

The status of the Nigerian Geodetic Networks, comprising triangulation, traversing, trilateration, Doppler, Gravity and GPS stations and levelling networks, were examined. The defects in the origin and the entire network were highlighted. Readiness to embark on a programme or project to obtain the most accurate and consistence set of coordinates for the control points with the availability of space technology and equipment to update and strengthen the networks were proposed to include:

I. Empowering the existing structures is a way of maintaining what we have.

II. Use of Control Superstructure in space strategy for improving the Nigerian Geodetic Network. Since Toro had been identified as the geological fit for the Space Technique, we may need to have another origin in Toro and a Baseline established between Toro and Minna, which will be enhanced with VLBI, SLR and GPS.

We proposed that the Centre for Geodesy and Geodynamics should coordinate the project in collaboration with the Federal Survey Department. We hope this will make the Nigerian Geodetic network capable of serving the functions expected of national control in modern Geodesy.

Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Contributions

Conceptualization, methodology, analysis, writing - original draft preparation, K.F.A., and writing - review and editing, A.F.A. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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