Grids & Datums

Federal Republic of Nigeria

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The earliest settlements in what is now Nigeria are indicated by stone tools dating back 12,000 years. "Microlithic and ceramic industries were developed by pastoralists in the savanna from at least the fourth millennium *B.C.* and were continued by grain farmers in the stable agricultural communities that subsequently evolved there. To the south, hunting and gathering gradually gave way to subsistence farming on the fringe of the forest in the first millennium *B.C.* The cultivation of staple foods, such as yams, later was introduced into forest clearings. The stone ax heads, imported in great quantities from the north and used in opening the forest for agricultural development, were venerated by the Yoruba descendants of Neolithic pioneers as "thunderbolts" hurled to earth by the gods. The primitive iron-smelting furnaces at Taruga dating from the fourth century *B.C.* provide the oldest evidence of metalworking in West Africa, while excavations for the Kainji Dam revealed the presence of ironworking there by the second century *B.C.* The transition from Neolithic times to the Iron Age apparently was achieved without intermediate bronze production. Some scholars speculate that knowledge of the smelting process may have been transmitted from the Mediterranean by Berbers who ventured south. Others suggest that the technology moved westward across the Sudan from the Nile Valley, although the arrival of the Iron Age in the Niger River valley and the forest region appears to have predated the introduction of metallurgy in the upper savanna by more than 800 years. The usefulness of iron tools was demonstrated in the south for bush cutting and in the north for well digging and the construction of irrigation works, contributing in both regions to the expansion of agriculture. The earliest culture in Nigeria to be identified by its distinctive artifacts is that of the Nok people. These skilled artisans and ironworkers were associated with Taruga and flourished between the fourth century *B.C.* and the second century *A.D.* in a large area above the confluence of the Niger and Benue rivers on the Jos Plateau. The Nok achieved a level of material development not repeated in the region for nearly 1,000 years. Their terra-cotta sculpture, abstractly stylized and geometric in conception, is admired both for its artistic expression and for the high technical standards of its production" (*Library of Congress Country Study – 2008*).

"British influence and control over what would become Nigeria grew through the 19th century. A series of constitutions after World War II granted Nigeria greater autonomy; independence came in 1960. Following nearly 16 years of military rule, a new constitution was adopted in 1999, and a peaceful transition to civilian government was completed. The government continues to face the daunting task of reforming a petroleum-based economy, whose revenues have been squandered through corruption and mismanagement, and institutionalizing democracy. In addition, Nigeria continues to experience longstanding ethnic and religious tensions. Although both the 2003 and 2007 presidential elections were marred by significant irregularities and violence, Nigeria is currently experiencing its longest period of civilian rule since independence. The general elections of April 2007 marked the first civilian-to-civilian transfer of power in the country's history" (*CIA World Factbook, 2008*). Bordered by Benin 773 km (*PE&RS*, July 2003), Cameroon 1,690 km (*PE&RS*, May 2007), Chad 87 km, Niger 1,497 km, and the Gulf of Guinea 853 km; the lowest point is the Atlantic Ocean (0 m), and the highest point is Chappal Waddi (2,419 m). The border with Benin, formerly Dahomey, is a curious combination of physical monuments and riparian calls consisting of both *Rule of the Thalweg* (thread of the stream) and of *medium filium acquae* (geographic center of the stream) principles. Slightly more than twice the size of California and Africa's most populous country, Nigeria is composed of more than 250 ethnic groups; the following are the most populous and politically influential: Hausa and Fulani 29%, Yoruba 21%, Igbo (Ibo) 18%, Ijaw 10%, Kanuri 4%, Ibibio 3.5%, Tiv 2.5%.

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The first geodetic surveys of Nigeria were performed by the British Royal Engineers in 1910-1912 (*TM 5-248, Foreign Maps 1963*). The majority of geodetic work in Nigeria was performed beginning in 1928, and most of the older work done was discarded with the exception of the four bases at Eruwa, Kano, Naraguta, and Udi. The azimuths at Eruwa, Kano, and Naraguta were re-observed in 1928 and Kano again and Udi were re-determined in subsequent years. Difficulties with local fauna "can be illustrated by the fact that during the survey of one of the reserves a locally engaged laborer was charged by a herd of elephants and, being unable to blaze his trail whilst escaping, was bushed for two days." The following portions of triangulation executed prior to 1931 with the 6-inch Troughton & Simms micrometer theodolite were retained, with base nets being excluded from the percentages quoted: Naraguta – Kano 1929 – 1931, 11 stations or 36% of the chain; Minna – Udi 1930, 17 stations or 30% of the chain; Ilorin – Eruwa 1927 – 1928, 26 stations or 100% of the chain. The ellipsoid of reference chosen for Nigeria was the Clarke 1880, where a = 20,926,202 feet, $^1/_f$ = 293.465, and the meter = 1.09362311 yard. The mean datum was obtained at the North Terminal of the

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Minna Base by projecting the values of latitude and longitude obtained at Kano, Naraguta, Lafia, Beri Beri, and Zaria through the triangulation and obtaining the resulting mean value at Minna. Of the above-mentioned points two lie to the east of Minna and the other two to the north – northeast. A better mean value at Minna would have been obtained if it had been possible to carry up coordinates from the south and west also, but at the time the datum was adopted in 1928 no triangulation to the south and west of Minna was available. The values of Latitude and Longitude projected to the North Terminal of the Minna base are as follows:

	Latitude	Longitude
Observed at Minna L 40	9 ° 38' 11".700	6 ° 30' 53".850
From Kano K 2	07".278	31' 00".278
" Naraguta N 1	12".768	31' 00".370
" Lafia Beri Beri N 26	03".940	30' 56".713
" Zaroa N 144	08".665	31' 02".580
Mean	9 ° 38' 08".87	6 ° 30' 58".76
Adopted values	9 ° 38' 09".000	6 ° 30' 59".000

The points at Lafia Beri Beri and Zaria are not now part of the primary framework; both are classed as secondary points. The geoid height of Minna, L 40 is H_o = 279.6 meters.

"The spheroidal (*sic*) tables for the Clarke 1880 figure in use in Nigeria are based on those computed by Morris for the Geodetic Survey of South Africa, and the unit of length of the tables is the British foot. This in identifying the unit of length of the triangulation with the unit of length in the tables as altered scale of the Clarke Spheroid is achieved, the fractional amount, represented by the logarithmic correction 0.00000031, being 1/138,161. Hence for the triangulation of Nigeria all computations of position incorporate this linear change of 1.138,161. It is, however, in conformity with the usage in the greater part of British and French Africa" (Capt. J. Calder Wood, *Empire Survey Review*, Vol. III, No. 21, July 1936).

The geodetic and cadastral surveys of colonial Nigeria appear to be of exceptional quality, particularly considering the enormous financial strains of funding such work during the world-wide Great Depression of the 1930s. With British and other European surveyors providing the technical and supervisory expertise, the local native population was pushed to the background with little education and training provided. Ethnocentrism among the Europeans prevailed for several decades until local Nigerians were able to gain advanced university educations in the UK and other European institutions of higher learning. With local Nigerian universities producing highly educated surveyor professionals, the level of high-quality geodetic surveys gained ground in the latter half of the 20th century. Some resentment of prior survey qualities, both geodetic and cadastral, seemed to be reflected in some of the geodetic literature, but such appears to now be on the wane.

A curiosity of the colonial period is the Nigerian Colony Coordinate System which is based on the "Notes on Projection (NOP)" Modified Transverse Mercator. An excellent paper on the topic is (S. Izundu Agajelu, "On Conformal Representation of Geodetic Positions in Nigeria," *Survey Review*, **29**, 223, January 1987), with the following excerpts quoted: "The 'classical' method of map projection in Nigeria, is based on the Notes on Projection (NOP) published by the Federal Surveys of Nigeria in the 1920s, in which reference is made to examples worked in 1927 on the basis of logarithmic and interpolating tables." "Further the NOP tables were developed in feet, whereas Nigeria went metric early in the 1970s." "The system is discussed in this paper primarily because Nigeria has recently gone over to UTM for representing its control positions. Some of the major differences between the UTM and the Modified Transverse Mercator System (MTM) used in NOP are as follows;

(1) The UTM has the scale factor at the central meridian as 0.9996 while the MTM system has the value of 0.99975.
(2) The central meridians in the UTM system in Nigeria are 3°E. 9°E. and 15°E, corresponding to zones 31, 32, and 33 respectively, while those of MTM are 4° 30', 8° 30', and 12° 30', for the West, Mid and East belts respectively.
(3) In UTM the Eastings of the central meridians are fixed as a false value of 500,000 m while in the Nigerian system, the three central meridians have the values 230,728.266 m, 670,553.984 m, 1,110.369.702 m, respectively.
(4) In the UTM the maximum angular distance of a point in a belt, from the central meridian of the belt is 3° while in the MTM, it is 2°."

In Agajelu's Conclusions he states:

"(1) Contrary to the description at page 10 of NOP, it has been proved conclusively in this paper, that the Nigerian system is based not on the double projection method, but on direct projection from the ellipsoid to the map plane.
(2) The direct projection formulae referred to in 1 above are based on power series expansion truncated at the third term. This truncation limits the accuracy of representation of certain geodetic positions to the order 1 part in 10^8. This is certainly not desirable since we want a representation good to 1 part in 10^9.
(3) For the Nigerian latitude zone, meridional distances can be computed either by the e – series truncated at terms containing e^6 or by the n – series truncated at terms containing n^4.
(4) Assuming the description in page 10 of NOP, the radius of the conformal sphere which is 4,000th part less than the actual radius of the earth (Clarke 1880 ellipsoid) is 6,354,798.792 m. The corresponding mean radius for latitude 9° used in computing the scale corrections in NOP is 6,365,757.688 m."

The solution to the problems enumerated above is simple to state but financially difficult to implement. The United States National Geodetic Survey recomputed all of its horizontal geodetic observations on the new GRS1980 ellipsoid for the North American Datum of 1983. The same solution is available to the Republic of Nigeria if they are interested in doing it the proper way.

The relation of the Minna 1928 Datum to the WGS72 Datum was investigated in (C.U.Ezeigbo, "Definition of Nigerian Geodetic Datum from Recent Doppler Observations," Survey Review, 30, 237, July 1990) where in his conclusion he states the 3-parameter shift is: From Minna 1928 Datum to WGS 72 Datum where: $\Delta X = -92.9$ m, $\Delta Y = -116.0$ m, $\Delta Z = +116.4$ m, and this is based on an 11-station solution good to ±2.5 m. According to TR 8350.2, the 3-parameter shift: From Minna 1928 Datum to WGS 84 Datum is where: $\Delta X = -92$ m ±3m, $\Delta Y = -93$ m ±6m, $\Delta Z = +122$ m ±5m, and this is based on a 6-station solution.

The African Reference Framework (AFREF) project is an African initiative with international support designed to unify the coordinate reference systems in Africa using Global Navigation Satellite Systems and in particular, the GPS as the primary positioning tool. The project is a work in progress as of 2009.