CONFORMAL TRANSFORMATION OF CO-ORDINATES IN NIGERIA

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ABSTRACT

In 1975, the Universal Transverse Mercator (UTM) was introduced in Nigeria by Federal Surveys Department for surveying and mapping. It was to replace the Nigeria Transverse Mercator (NTM) hitherto used since 1926. The old Ondo State (now Ondo and Ekiti States) is yet on the NTM system. Since there is no official method yet in the country, a comparative study of direct and indirect methods was made, with a view to recommending a method to the nation.
Results yield identical values at 95% confidence limit with the indirect method being more accurate and recommended. Now that Nigeria had gone over to the UTM system, it is recommended that the obsolete "Notes on Projection" be updated for Surveyors and Cartographers' usage.

1. INTRODUCTION

Maps are graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes or events in the human world. Maps also facilitate the comparison of the presence, absence or the degree of intensity of a particular variable or variables in different regions of the world or of a country (Adalemo, 1990). The demand for up-to-date maps and other reliable geographical information products is growing rapidly. The pressure of urbanization, resource exploitation and management, and the development of agriculture cause this. Other influencing factors include the protection of the environment and the need for security and political stability. At the same time planning and decision making processes have become more and more complex and increasingly decentralized. These require more, faster, current and specific geographical information on the one hand, and the more complex types of geographical information (correlation between information categories, modeling to indicate consequences of actions, etc.) on the other. These demands are forcing national mapping agencies to extend their range of activities to the supply of geo-information products in addition to traditional map production.

The earth, like a globe, is spherical in shape. According to Olomo (1997), a globe is "naturally" an accurate map. Map users want maps in folios, atlases and on separate sheets to work with either in the office or in the field. For practical purposes, the globe is unsuitable. It is cumbersome to handle, expensive to produce and reproduce, difficult to measure on the surface being a three-dimension body. The first task that confronts a cartographer is how to transform the spherical surface into a plane. The system of transforming from spherical to the plane surface is called map projection. Map projection is very important because it is the bedrock of map based construction.

Map base construction, the first stage of map-making processes, involves the projection and co-ordinate systems on which compilation, the second stage will take place. Other stages are generalization, production and revision (when necessary) (Olomo and Ufuah, 1991). The importance of projection and co-ordinate system cannot be over-emphasized. Notes concerning geodetic data (projection, spheroid, datum, origin and false co-ordinates of the origin) usually appear at the South East lower right margin of topographic sheets in a conspicuous manner. For cadastral plans, the origin is boldly written on the title. The geodetic data plays vital role during map revision exercise or re-establishment of lost property beacons.

2. PROBLEM OF THE STUDY

In 1926, Nigeria decided to conform with the practice in the practice in the neighbouring French territories. The decision was to coordinate surveys in the whole of Africa with a view to producing surveys and mapps that would be easy to assemble to form a whole map series of Africa (Adalemo, 1990 and Adewola, 1990). The Nigeria Transverse Mercator (NTM) was adopted. Federal Surveys thereafter published "Notes on Projection" for surveyors and cartographers' use. In 1975, the Universal Transverse Mercator (UTM) was introduced in Nigeria by Federal Surveys Department for surveying and mapping (Uzodinma and Ezenwere, 1993). It was to replace the MTM hitherto used because of its worldwide application.

The aim of this study therefore is to transform Nigerian Traverse Mercator co-ordinates (NTM) to the Universal Tranverse Mercator (UTM) equivalents for Ondo and Ekiti States. Since there is no official method in the country nor there is an equivalent "Notes on Prjection" for the UTM system, a comparative study of two methods by Arinola (1987) and Ajibade (2001) was made with a view to recommending a method to the nation. The recent Global Positioning System (GPS) acquired coordinates would also use the method to convert to the UTM.

3. THE STUDY AREA

Owo, a State Polytechnic town, is the headquarters of Owo Local Government Area, Ondo State of Nigeria. It is bounded within Latitude (Φ) 07°09' and 07°15' North and Longitude (λ) 05°30'and 05°40' East. Owo is about 50km east of Akure, the State Capital and 320km South West of Abuja, the Federal Capital. The nine communities in Owo apart from the township are Ipele, Iyere, Igbe, Upo, Idasen (a conglomeration of seven settlements of Ilale-Ile, Illale-Keji, Ujegunma, Isijogun, Ulema, Amuren Oganyin and Ujelu), Emure-Ile, Isuada, Ode-Iya and Upemen. It has an area of about $24km^2$. The settlement dates back to the middle of 12^{th} Century (Ondo State Polytechnic, Owo; Prospectus for 1992-1995). The average elevation is about 309m above sea level. Its particular location on top of a hill suggests defence strategy. The people of Owo are Yoruba speaking people who have traveled North East from the Ile-Ife, the home of their ancestors.

The town is the commercial center of Owo Local Government Area, with an excellent layout and good roads, linking it with the State Capital, Akure, in the West and Benin in the South. It is situated in the humid tropical region of Nigeria and enjoys abundant rainfall of over 1,500mm annually and the Southwesterly winds blow most of the year. From the months of December to February, the cooler continental winds from the interior of the continent of Africa prevail. The rainy season lasts from March to October every year. The weather is generally warm with temperature reaching 24°C during the peak of the hot season and cool during the evening.

Farming is the primary economic activity of the entire population. Most farmers are subsistent farmers with very smallholdings on the average of 10-20 hectares of land. The major commercial crops are cocoa, yam, cassava with melon, orange, cash and vegetables as subsidiary products. Farming activities are for the immediate consumption of the farmers and only a small proportion go into commodity exchange channels.

There is no large-scale industry yet. Most commercial activities take the form of trading. There are two main markets where traders display their wares, mainly food and clothing items. There are varieties of entertainment and leisure spots in the township. These include the town hall, privately owned hotels, guest houses, restaurants and super markets. With the take-off of the Ondo State Polytechnic, many more attraction spots are further springing up in the township either owned by private entrepreneurs or government agencies. The town has a big Federal Medical Centre with about 400 beds. There are also a number of private clinics and local government health/maternity centres. There are three major commercial banks: Omega Bank, Co-operative Bank and First Bank. At the three banks are centrally located and fairly spread-out. The State-owned Insurance Company, the Confidence Insurance, is located in the township.

4. RESEARCH METHODS

The secondary source of data is the co-ordinates in the Co-ordinate Register of the Survey Department, Ministry of Lands, Housing and Environment, Akure. The available 224 primary and 89 secondary points were obtained from the Surveyor-General of Old Ondo State. The ground control points were established in 1966, air photography that was carried out by Hunting Surveys Limited, London, for photgrammetric mapping. The ground controls (before the air photography), field completion, map compilation and publishing were carried out by the Ministry of Lands and Housing, Survey Division, Ibadan, 1972. Fifteen (15) primary points were selected. Twelve (12) points were selected along the perimeter of Owo

Township Control at intervals of about 2.5 kilometres; while the remaining three (3) points was along the old Akure/Benin highway that divided the town into two equal areas approximately (Fig. 1.).

Computation of data was carried out with the kind permission of the Deputy Rector, Federal School of Surveying, Oyo, on his official Computer. Analysis of the data computed from the two approaches involved the closeness in magnitude of the differences of the methods. The comparison also included the Student's 't' statistical test.

5. NIGERIAN TRANSVERSE MERCATOR (NTM)

In 1926, Nigeria decided to conform with the practice in the neighbouring French territories. The Clarke 1858 "Polyconic Projection" hitherto used was dropped and the Clarke 1880 modified Transverse Mercator projection was adopted in the same year (Adalemo, 1990 and Adewola, 1990). The decision was to co-ordinate surveys in the whole of Africa with a view to producing surveys and maps that would be easy to assemble to form a whole map series of Africa. It is a modified form of Transverse Mercator Projection based on Clarke 1880 spheroid chosen with the origin somewhere in the Bight of Benin far South of Cotonou, capital of the Republic of Benin.
This origin was chosen so that Nigeria entirely lies North East in the first quadrant. These National coordinates are easily distinguishable because they are usually large numbers, often running over hundreds of thousands of metres. The NTM has a synchronized origin whose geographical, are 04^o 00'N and 02^o 30'E approximately with the rectangular coordinates Om N, Om E. It is therefore not mandatory to identity the NTM coordinates with the Belt of its locus, although it is convenient in transformation.

The following are the major characteristics of the Nigerian modified transverse Mercator projection.

a. **Property:** It is conformal.

b. **Belts:** The country is divided into 3 belts each 4^o wide. The central meridians of the belts are made parallel to one another in the National (Grid) plane so as to have one set of coordinates axis for the 3 belts the false Easting. The (E_o) of the three central meridians are: West Belt: 230738.266m; Mid Belt: 67553.984m; East Belt: 1110369.702m

c. **Latitude:** The three belts are bounded in the North by the 14^o N parallel and in the south by 4^oN. Hence, the false origin of the Nothings is at latitude 4^oN and false northing (N_o = 0.000m).

d. **Scale:** The scale factor at the central meridian of each belt is reduced from unity to 0.99975. The scale error therefore ranges from –1/4000 at the central meridian of the belt to +1/2900 at its extreme ends. The scale factor is unity at a distance of about 142.133km on either side of each central meridian.

e. **Grid System:** A rectangular metric grid is superimposed on the three belts such that they intersect along the 9^oN parallel. The central meridian 0_2 of the mid belt is made to be 670553.984 metres east of the false origin, 0, which is in the south-west corner of the grid. The central meridians of the west and east belts are fixed at 0_1 and 0_3 respectively to be 439815.718 metres west and east of the central meridian of the mid belt along the 9^oN parallel. In the grid system, X-axis represents Northings while Y-axis represents Eastings.

6. UNIVERSAL TRANSVERSE MERCATOR (UTM)

The UTM projection was introduced in Nigeria by Federal Surveys Department around 1975 for mapping and surveying (Uzodinma and Ezenwere, 1993). It was to replace the Nigeria (modified) Transverse Mercator (NTM) Projection. The UTM projection is a transverse Mercator projection, which has been modified for universal application. It is used between Latitudes 80^oN and 80^oS (Army Map Service, 1958). Both polar regions are covered by the UPS (Universal Polar Stereographic) projection which complements the UTM but is quite independent of it. There is an overlap area along the boundary of the two systems. In the UTM, the world is divided into 60 zones each 6^o wide in longitude. The zones are numbered consecutively from one to sixty beginning with the zone between 180^oW and 174^oW and continuing eastwards.

Nigeria is covered by three UTM zones, namely: Zones 31, 32 and 33. Each central meridian has the rectangular coordinates (0mN, 500,000mE). It can now be seen that it is MANDATORY to identity any UTM rectangular coordinates with the Zone of its locus. The UTM is not modified, so, the scale factor remains 0.9996 or 2499/25 00 at the C.M. Apart from this factor, the formulae for scale error and bearing distortion (arc-to-chord) are practically the same for NTM and UTM. The following are thus the major characteristics of the Universal Transverse Mercator Projection:

a. Property: It is conformal.

b. Zones: There are 60 zones, each 6^o of longitude in width (3^o on either side of the CM). Zone I lies between 180^oW and 174^oW, while the rest continue Eastwards. The longitude λ_o of the central meridian of a zone is given as:
λ_o = - 6 (30 –n) – 3, where n = Zone number, +ve λ_o means east longitude. Longitudes of West and East bounds of a zone are given respectively by $\lambda_o -3^o$ and $\lambda_o +3^o$.

c. Scale: A scale factor 0.9996 exactly is applied along the central meridian of each zone. The scale error therefore ranges from –1/2500 at the central meridian of a zone of about +1/1100 at its 3^o extreme end. The scale factor is unity at a distance of about 179.765km on either side of the central meridian of each zone on the Clarke 1880 ellipsoid.

d. Latitude: UTM projection is used between 80^o South and 80^o North latitude. The Polar Regions are covered by the Universal Polar Stereographic (UPS) with 30 arc minutes overlap along the boundary of the two systems.

e. UTM Grid System (UTM National Grid): A rectangular metric grid is superimposed on each zone – one system for northern hemisphere and another for southern hemisphere. In the northern hemisphere, the false origin is on the equator and 500,000 metres west of the central meridian. On the other hand, the false origin in the southern hemisphere is 10,000,000 metres south of the equator and 500,000 metres west of the CM.

f. Overlaps: A grid overlaps of about 30’ is allowed on either side of each zone boundary.

6.1 Comparison of NTM and UTM

From the foregoing, apart from the universal applications of UTM, some of the major technical differences between the UTM and the NTM are as follows (Agajelu, 1980; Ufuah, 1994):

First, the UTM has the scale factor at the central meridian as 0.9996 while the NTM has the value of 0.99975.
Second, the central meridians in the UTM system in Nigeria are 3^oE, 9^oE and 15 corresponding to Zones 31, 32 and 33 respectively, while those of NTM are 4^o30’E, 8^030^1E and 12^o30’E for the West, Mid and East Belts respectively. Third, in the UTM, the Eastings of the Central Meridians are fixed at a false value of 500,000 metres while in the NTM system; the three central meridians have the values 230738.266m, 670553.984m and 1110369.702m respectively. Fifth, in the UTM, the maximum angular distance of a point in a belt from the central meridian of the belt is 3^o while in the NTM, it is 21^o. Thus, UTM will likely lead to greater scale distortions than hitherto known in Nigeria at the areas far away from the Central Meridians.

7. TRANSFORMATION OF CO-ORDINATES

Transformation of co-ordinates such as the NTM to UTM in the study or vice-versa or the conversion of co-ordinates from grids to geographical co-ordinates or vice-versa may be performed by a variety of techniques, depending on the facilities that are available. The methods include the use of tables, formulae or computer programmes. The simplest, of course, is to use the computer programmes. As a result of advances in computer technology, surveying and mapping have been totally revolutionized. In the study, the use of computer programme was adopted.

7.1 Direct Method (Arinola, 1987)

The direct transformation method of Arinola (1987) involved the use of tables of contain co-efficient of polynomials. He divided Nigeria into 37 map blocks and developed co-efficient for each of the 37 blocks (1/100,000 series) which transform directly from NTM to UTM and vice versa without the intermediary of geographical coordinates.

7.1.1. Main Features

The main features of the Handbook by Arinola (1987) are the tabulation of:

(i) **Topo-Sheet and Block Number Correspondence:** To facilitate the location of the blocks in which points to be transformed fall, a one to one table of correspondence of Topo-sheet number and block number was presented in the Handbook. It is necessary to have the knowledge of the Topo-sheet number 1:100,000 (or 1:50,000) to use the tables.

(ii) **Towns and Blocks Correspondence:** For cases where the topographical map sheets are not available, the table on pages 17-22 in the Handbook lists the major towns of the country and the blocks in which these towns fall.

(iii) **Coefficients of transformation:** The coefficients of transformation are listed on pages 24 to 35 in the Hardbook, each page contains:

a). Coefficients of transformation used in transforming coordinates from NTM to UTM.

b). Coefficients of transformation used in transforming co-ordinates from UTM to NTM

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7.1.2 Computational Procedure (The Use of Computer Programmes):

Owo lies in Block Number 8 from Arinola (1987) and the original format designed for the computation is given in equation 1:

a_1= 4.358,565,891	b1= -4.369,827,819	
a_2= 4.418,170,827	b_2= -4.421,397,558	
a_3= 0.999,248,012	b_3= 1.002,539,462	
a_4= 0.001,821,825	b_4= -0.000,020,825	
a_5= 0.000,205,343	b_5= -0.000,205,024	
a_6= 0.000,001,657	b_6= 0.000,000,309	-------------------------- 1

Using the data in Equation 1, the direct transformation of coordinates was carried out: NTM to UTM and UTM to NTM to ascertain that there is no gross error from equations 2 and 3 respectively.

i. NTM to UTM Conversion: The formular is:

$$E_{UTM} = (a_1 + ea_3 – na_4 + pa_5 – qa_6)\ 10^5$$
$$N_{UTM} = (a_2 + na_3 + ea_4 + qa_5 – pa_6)\ 10^5 \ldots\ldots\ldots\ldots \qquad 2$$

Where N_{UTM}, E_{UTM} = UTM nothing and easting respectively in metres.

$n = 10^{-5} N_{UTM}$

$e = 10^{-5} E_{UTM}$

$p = e^2 - n^2$

$q = 2en$

N_{NTM}, E_{NTM} = NTM northing and easting respectively in metres.

a_1, a_2, a_3, a_4, a_5 and a_6 are coefficients extracted from Arinola (1987).

ii. UTM to NTM Conversion: The formular is:

$$E_{UTM} = (b_1 + eb_3 – nb_4 + pb_5 – qb_6)\ 10^5$$
$$N_{UTM} = (b_2 + nb_3 + eb_4 + qb_5 + pb_6)\ 10^5 \qquad \text{-------------} \qquad 3$$

N_{NTM}, E_{NTM}, N_{UTM} and E_{UTM} are as in equation 2.

b_1 b_2 b_3 b_4 b_5 and b_6 are coefficients extracted from Arinola (1987).

Ajibade (2002) assisted in the development of a Computer Programme that was used on the SAMSUNG Model Sync Master 450 b personal computer in his office at Federal School of Surveying, Oyo. Table 1 is the original NTM co-ordinates, while Table 2 contains NTM to UTM, Table 3 shows UTM to NTM.

7.2 Indirect Method (Ajibade, 2001).

7.2.1 Grid to Geographical Co-ordinates:

Grid to Geographical Co-ordinates: Thomas (1952), derived the following formulae working with angles in radians: Latitude:

$$N_r = ([\ (2+r)\ 45_t + 61\}\ \frac{U^2}{30} + (4\eta - 1)\eta + (3\eta-1)\ 3t – 5]\ \frac{U^2}{12} +1)\ x\ \frac{U^2}{2}\ (1 +\eta)\ \tan N_f + N_f \ldots\ldots. 4a$$

Longitude:

$$\lambda_p = \{[\{(4t+3)2\eta+(6t+7\}4t+5\}\frac{U^2}{20}-\eta-2t-1]\frac{U^2}{12}+1\} x\, U.\sec N + \lambda_o \ldots\ldots\ldots 4b$$

where $V_p = (\lambda_p - \lambda_o)$ radians. Cos N_p

$$V_p = \frac{K_o a}{(1 - e^2 \mathrm{Sin}^2 N_p)^{1/2}}$$

$$\eta_p = \frac{e^2 \mathrm{Cos}^2 N_p}{(1 - e^2)}$$

$$t = \tan 2N_p$$

$$U = \frac{(E_p - FE)}{V_r}$$

FE/FN = False Easting/Northing

K_o = Grid Scale Factor

M_p = Meridian Arc.

Table 1: Original NTM Co-ordinates

S/N	Beacons	Northings	Eastings
1.	OCS 116P	346730.712	356280,538
2.	OCS 133P	349941.642	357388.689
3.	OCS 146P	351171.956	359219.765
4.	OCS 169P	354088.704	358978.466
5.	OCS 186P	355559.860	355781.584
6.	OCS 200P	356119.809	353007.695
7.	OCS 17P	355046.861	350353.106
8.	OCS 224P	353524.765	351737.873
9.	OCS 23P	350751.244	351008.234
10.	OCS 38P	348498.247	352024.330
11.	OCS 46P	347788.587	353681.391
12.	OCS 54P	347369.003	354978.979
13.	OCS 1P	348686.117	354436.715
14.	OCS 6P	350693.634	353670.242
15.	OCS 13P	350714.354	352479.810

Source: Ondo State Surveys, 1986.

Notes: OCS: Owo Cadastral Survey, P: Primary.

Table 2: NTM to UTM (Arinola's Model)

S/N	Stations	Easting	Northing
1.	OCS 116P	781659.6031	798968.5578
2.	OCS 133P	784869.0184	800088.0400
3.	OCS 146P	786094.1122	801924.4197
4.	OCS 169P	789013.6545	801692.6058
5.	OCS 186P	790496.3844	798498.3730
6.	OCS 200P	791065.8476	795724.3805
7.	OCS 17P	790000.8536	793064.4251
8.	OCS 224P	788473.1698	794445.1642
9.	OCS 23P	785700.1464	793705.9396
10.	OCS 38P	783442.3051	794715.3355
11.	OCS 46P	782726.7331	796371.1708
12.	OCS 54P	782302.6035	797668.2403

13.	OCS 1P	783622.3782	797129.9488
14.	OCS 6P	785633.7648	796369.5600
15.	OCS 13P	785658.4076	795178.3906

Source: Office Computation, 2002.

Notes: OCS: Owo Cadastral Survey, P: Primary.

Table 3: UTM to NTM (Arinola's Model)

S/N	Stations	Eastings	Northings
1.	OCS 116P	34670.7091	356280.5309
2.	OCS 133P	349941.6390	357388.6816
3.	OCS 146P	351171.9530	359219.7574
4.	OCS 169P	354088.7008	358978.4583
5.	OCS 186P	35559.8564	355781.5764
6.	OCS 200P	356119.8052	353007.6876
7.	OCS 17P	355046.8572	350353.0989
8.	OCS 224P	353524.7914	351735.8659
9.	OCS 23P	350751.2406	351008.2271
10.	OCS 38P	348498.2438	352024.3231
11.	OCS 46P	347369.0000	353681.9719
12.	OCS 54P	347788.5839	353681.3841
13.	OCS 54P	348686.1139	354436.7079
14.	OCS 6P	350693.6307	353670.2349
15.	OCS 13P	350714.3506	352479.8030

Source: Office Computation, 2002

Notes: OCS: Owo Cadastral Survey, P: Primary.

7.2.2 Geographical to Grid

Easting:

$$E_p = \{[\{(2t-58)t + 14\}\eta_p + t - 18)\, t + 5]\frac{Vp^2}{20} + \eta_p - t + 1\}\frac{Vp^2}{6} + 1\}V_p\, V_p + FE \ldots\ldots 5a$$

Northing

$$N_p = \{[\{(t-58)t + 61\}\frac{Vp^2}{30} + (9 + 4\eta_p)\, \eta_p\, t + 5]\frac{Vp^2}{12} + 1\}v_p\frac{Vp^2}{2}\tan N_p + M_p + FN \ldots .5b$$

Based on equations 4 and 5 above, Ajibade developed an iterative procedure (Ajibade, 2001 pp 11-12), Details are contained in Adesina (2002). The SAMSUNG Computer was used to process the data. Table 4 contains NTM to UTM while Table 5 shows UTM to NTM that served as a check. From the original NTM co-ordinates and the derived UTM coordinates; bearing and distances are computed for checks. Results are contained in Table 6.

7.3 Statistical Analysis

Apart from the investigation of the closeness in the magnitude of the differences of the two methods, Student's t Distribution Statistical Test in the form of Equality of Mean Vectors was carried out. This is a multivariate extension of the problem of testing whether a population mean is equal to another (Speigel, 1972; Silk, 1979; Ayeni, 1981). In this study, the equality of mean vectors x_1, y_1 representing the Vector of NTM co-ordinates and x_2, y_2 representing the Vector of UTM.

The null hypothesis in this case is: Ho: $X_1\, Y_1 = X_2\, Y_2$……………….6a

The alternate hypothesis that there is a difference in population mean of NTM and UTM coordinates, i.e.,
$H4_1$: $X_1\, Y_1 \neq X_2\, Y_2$ ……………..6b

The student's 't' Distribution was adopted using computer programme for the computation. The 't' computed is equal to –0.0001. The 't' read from t-table is 2.048. Using two tail test, significant level of 0.05 and the degree of freedom of (n-1) + (n – 1) = (15 – 1) + (15 – 1) = 28. The computed value is less than the table value; the null hypothesis is accepted at 95%

confidence limit. That is to say that there is no significant difference between the population mean of NTM and UTM Co-ordinates. The value calculated falls within the critical region that leads to the acceptance of the null hypothesis.

Table 4: NTM to UTM (Ajibbade's Model)

S/N	Beacons	Northings	Eastings
1.	OCS 116P	781659.5966	798968.5633
2.	OCS 133P	78469.0116	800088.0457
3.	OCS 146P	786094.1051	801924.4254
4.	OCS 169P	789013.6473	801692.6109
5.	OCS 186P	790496.3778	798498.3691
6.	OCS 200P	791065.8415	795724.3867
7.	OCS 17P	790000.8481	793064.4311
8.	OCS 224P	788473.1640	794445.1702
9.	OCS 23P	785700.1408	793705.9454
10.	OCS 38P	783442.2993	794715.3411
11.	OCS 46P	782726.7270	796371.1764
12.	OCS 54P	782302.5972	797668.2458
13.	OCS 54P	783622.3720	797129.9544
14.	OCS 6P	785633.7587	796369.5658
15.	OCS 13P	78568.4017	795178.3964

Source: Office Computation, 2002

Notes: OCS: Owo Cadastral Survey P: Primary.

Table 5: UTM to NTM (Ajibade's Model)

S/N	Stations	Eastings	Northings
1.	OCS 116P	346730.7119	356280.5379
2.	OCS 133P	349941.6419	357388.6889
3.	OCS 146P	351171.9559	359219.7649
4.	OCS 169P	354088.7039	358978.4659
5.	OCS 186P	355559.8599	355781.5839
6.	OCS 200P	356119.8089	533007.6949
7.	OCS 17P	355046.8609	350353.1059
8.	OCS 224P	353524.7649	351735.8729
9.	OCS 23P	350751.2439	351008.2339
10.	OCS 38P	348498.2469	352024.3299
11.	OCS 46P	347788.5869	353681.3909
12.	OCS 54P	347369.0029	354978.9789
13.	OCS 54P	348686.1169	354436.7149
14.	OCS 6P	350693.6339	353670.2419
15.	OCS 13P	350714.3539	352479.8099

Source: Office Computation, 2002

Notes: OCS: Owo Cadastral Survey, P: Primary.

Table 6: Comparison of NTM bearing & distances with UTM'S

S/N	LINE		NTM		UTM		DIFFERENCES	
	FRO (OCS	TO (OCS)	BEARINGS	DISTANCES (M)	BEARINGS	DISTANCES	BEARINGS	DISTANCES (M)
1	116P	133P	70o57'31"2	3396.7735	704614.2	3393.0568	+11'20.0"	+3.7167
2	133P	146P	335350.8	2206.0172	334229.2	2207.5191	+11'21.2"	-1.5019
3	146P	169P	944345.3	2926.7122	943223.3	2928.7306	+11'22.0"	-2.0184
4	169P	186P	1551719.8	3519.1412	1550559.3	3521.6009	+11'20.5"	-2.4597
5	186P	200P	1683514.6	2829.8415	1682356.6	2831.8308	+11'18.0"	-1.9893
6	200P	217P	2020028.3	2863.2255	2014912.7	2865.2361	+11'15.6"	-2.0106
7	217P	224P	3121742.7	2057.7551	3120627.5	2059.1888	+11'15.2"	-1.4337
8	224P	23P	2251539.5	2867.8898	2550424.1	2869.8624	+11'15.4"	-1.9726

9	23P	38P	2941630.9	2471.5272	2940515.4	2473.2025	+11'15.5"	-.6753
10	38P	46P	3364858.6	1802.6282	3363742.0	1803.8384	+11'16.6"	-1.2102
11	46P	54P	3420451.7	1363.7395	3415333.8	1364.6526	+11'17.9"	-0.9131
12	54P	116P	3335235.2	1449.6452	3334116.2	1450.6113	+11'19.0"	-0.9661

Source: Office Computation, 2002
Notes: OCS: Owo Cadastral Survey P: Primary.

8. DISCUSSION OF FINDINGS

From the comparison of Direct and Indirect methods, it is evident that the two methods yield identical results, as shown in Table 7.

Table 7: Differences in NTM and UTM

Differences	**Northings (m)**	**Eastings (m)**
Minimum	-0.0055	0.0051
Maximum	-0.0062	0.0072
Spread	0.0007	0.0021

The direct transformation has the following advantages: First, semi-skilled surveyors and cartographers could handle the method when the map blocks and coefficients have been correctly identified. Second, the method can be programmed easily for use on a pocket programmable calculator that has up to 10 stores and 65 programme steps. Third, the method takes less time than the indirect method. The main disadvantages are: First, it does not give geographical co-ordinates as bye-product; hence it is not particularly ideal for use in mapping where geographical co-ordinates are essentially required. Second, from the study, the standard error was –0.000007 whilst that of indirect method was –0.000003. That is, the direct method is less accurate.

The advantages of the indirect transformations are: First, it gives better accuracy than the direct method. Second, geographical co-ordinates, which are very useful and in fact indispensable in mapping, are determined as intermediate results. However, the main disadvantage of indirect method is that it is more cumbersome than the direct method. The use of high-speed computers now reduces this problem.

From Table 6, comparison of NTM bearing and distances with those of UTM, it was observed that the NTM bearings are generally $+11^1$ 18.1" more than the UTM bearings. No similar correlation could be deduced for the distances. Line OCS 116P to OCS 133P, NTM distance is the only one that is longer than UTM distance. The others are shorter with varying magnitude; the longer the distance, the greater the discrepancy.

9. CONCLUSION

NTM co-ordinates had been transformed conformally to UTM in respect of Owo, Nigeria. The results of the direct and indirect approaches had been compared. In the indirect method, the NTM grid co-ordinates were first transformed to their equivalent geographical co-ordinates and then transformed to UTM grid to-ordinates. Thus, GPS acquired geographical co-ordinates after the datum transformation could be transformed to UTM co-ordinates too. The indirect method is thus recommended for the nation because of the enunciated advantages enumerated above.

Now that Nigeria has gone over to the UTM system, it is hereby also recommended that the obsolete "Notes on Projection" be updated for surveyors and cartographer's usage. To accomplish this task, Federal Surveys, the body that is responsible for the control of Surveying and Mapping activities in Nigeria, could set up a Committee of five (5) to include prominent stakeholders in Map Projection in Nigeria, with a Director in Geodetic Surveying or Mapping at Federal Surveys to co-ordinate the project.

Finally, since Nigeria extends from about $2^o40'$ E to about $14^o40'$E, it would be necessary to evaluate the scale and orientation problems on the UTM with a view of not including cadastral surveys of UTM. With the former NTM, the maximum angular distance of a point in a belt was 2^o, while in the UTM it is 3^o. Cadastral Surveyors may likely experience greater discrepancy between measured distance and computed equivalents. Nigerian cadastral law requires a linear discrepancy to be limited to 1 part in 3000.

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Biography of the Presenting Auther

Dr. Matthew Eigbe UFUAH was born on the 11th November, 1960 at Uromi in Edo State, Nigeria. After his primary and secondary education at Ekekhen and Ubiaja respectively, he proceeded to University of Nigeria, Nsukka (UNN) in 1982. In 1986, he obtained his B.Sc. Degree in Geography, while in 1991 he obtained his M.Sc. Degree in Geography with specialization in Cartography. He obtained his Ph.D. Degree also in Geography with specialization in Cartography from Ambrose Alli University (AAU), Ekpoma in 2000.

Meanwhile, in 1989, he joined the staff of A.A.U., Ekpoma as Cartographer in charge of Cartography Laboratory of the Department of Geography and Regional Planning. In 1991, he converted his appointment to lecturing as Assistant Lecturer and rose to Senior Lecturer in October, 2001. Currently, his publications are being assessed for the post of Reader (Associate Professor) of Geography (Cartography). Also, he is the present Sub-Dean of the Postgraduate School, Ambrose Alli University, Ekpoma.

Dr. Ufuah is a member of the Nigerian Geographical Association (NGA) and Nigerian Cartographic Association (NCA). Presently, he is a member of the National Executive Council (NEC) of NCA. He was the Chairman, Committee on Thematic Mapping. Currently, he is the Assistant Editor of the NCA's official Journal, Nigerian Journal of Cartography and GIS. He has participated in several workshops seminars and conferences, including the International Cartographic Conference (ICC 2003) held in Durban, South Africa, where he presented two papers. His main research emphasis is on the application of maps in environmental as well as socio-economic management and development, map production and map prevision. Also, he has special interest in GIS and Remote Sensing applications to land use studies and map updating. He has contributed several articles on cartographic issues especially on Nigerian situation at both local and international levels.