AN EVALUATION OF UNIVERSITY OF NIGERIA ENUGU CAMPUS (UNEC) CORS STATION

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Abstract

Global Navigation Satellite System (GNSS) has revolutionized almost all applications that require high-accuracy positioning, navigation and timing. This development has now seen the implementation of high accurate stations positioned around the world. For this reason, office of the Surveyor General of the Federation in 2008 embarked on the establishment and implementation of Continuously Operating Reference Station (CORS) stations in Nigeria. A total number of 11 CORS stations were established. Technological improvements in GNSS receivers have made GNSS surveying to achieve centimeter-level accuracy positioning in real time without the need to establish base stations. Users can now take advantage of ground infrastructure of permanent Continuously Operating Reference Stations (CORS) to meet the needs of mapping, geodesy, Engineering, geosciences, navigation, etc.

In this study, the accuracy of positioning using University of Nigeria Enugu Campus (UNEC) CORS station was carried out with Hi-Target V30 dual frequency GNSS receivers. Three campaigns were carried out in order to evaluate the accuracy of the UNEC Enugu CORS station. The first campaign involved observation between one unknown and the CORS. The second campaign involved observation between existing 1st order control points and the three unknown control points using the UNEC CORS station as reference station.

The results revealed a discrepancy of 11m between the results obtained using the 1st order control points and the CORS station while a discrepancy of 00˚ 06' 20" occurred in the horizontal angle between that obtained from the 1st order control coordinates and the CORS coordinates. It can therefore be concluded that there exist systematic errors in the Enugu CORS coordinates, and these is the need to further investigate the source of this error before the station can be used for GNSS control densification.

Key words: CORS, GNSS, Static, Angles and integer ambiguities

Introduction

Continuous Operating Reference Station (CORS) have become a major method of establishing controls for Geodetic Surveys, Mapping in Engineering and other applications whose precise 3D positioning are required. Nickolav (2010) defined CORS as Continuously Operating Reference Stations which can take the place of traditional base stations used in differential GNSS positioning. This means that instead of having a reference receiver in some ground known points, the COR station, some kilometres away becomes the reference station for other roving receivers. CORS can give an instant high positional accuracy of ± 20mm (Nagib and Ibrahim, 2014).

CORS are permanent reference networks equipped with GNSS (i.e. GPS, GLONASS etc) receivers and provide the fundamental infrastructure required to meet the needs of Surveyors, Engineers, Geo-scientists, and Environmentalists etc. The widespread use of the GNSS- RTK technique means that such reference stations receivers will also have to support ever expanding real time application of high accuracy precision in engineering, machine guidance, precision agriculture etc. (Rizo and Satirapod, 2011).

Currently, many governments, private sectors and academic organizations around the world are involved in the developments of CORS facilities (Stone, 2014). In developing a CORS, a variety of issues pertaining to the configuration of the hardware must be addressed. These issues include the characteristics of the GNSS receiver, model and type, the selection of an on-site computer, peripheral equipment such as an uninterruptable power supply, a weather station, an accurate timing reference and miscellaneous sensors, and the mechanism for connecting the facilities to users such as modem and telephone lines or network connection (Sunantyo, 2009). Issues of redundancy and reliability must be carefully considered as they will have a significant impact on many hardware-related decisions (Stone 2009, Sunantyo 2009).

In Nigeria, the Office of the Surveyor-General of the Federation (OSGOF in 2008) initiated the NIGNET Project that derives the establishment of 11 CORS stations in various locations in the country (Nwilo et al 2013, Iyiola et al 2013). The 11 CORS network in the country are linked with the International Terrestrial Reference Frame, ITRF 2008 by acquiring GPS data from nine international GNSS service stations (IGS) (Iyiola et al 2013, Nagib and Ibrahim 2014).

In designing the CORS network in Nigeria, the objective was to cover Nigeria with a relative homogenous distribution in order to optimize the densification of the network in the future. Simultaneously, it was decided to locate most of the CORS in Universities and research centres in order to link the NIGNET to the scientific community and foster the use of this network by more applications. In addition, the selection of these partners also offer more guarantee of institutional support for the installation and maintenance of these networks (Jatau and Fernandez, 2010). It is as a result of these that all the COR stations in the south are located in Universities notably: University of Lagos, Obafemi Awolowo University, Ile-Ife, University of Nigeria, Enugu Campus, Rivers State University of Science and Technology and University of Calabar.

COORDINATES REFERENCE FRAME

WGS84 is an Earth-centered, Earth-fixed terrestrial reference system and geodetic datum. WGS84 is based on a consistent set of constants and model parameters that describe the Earth's size, shape, gravity and geomagnetic fields. WGS84 is the standard U.S. Department of Defense definition of a global reference system for geospatial information and is the reference system for the Global Positioning System (GPS). It is compatible with the International Terrestrial Reference System (ITRS) (Ehiorobo 2008, Ehigiator et al, 2011)

WGS84 (G1674) is aligned to ITRF2008 with the same epoch of 2005.0. The purpose of this alignment is to ensure scientific integrity and follow best practices. The ITRF incorporates multiple methods to realize the reference system such as satellite laser ranging and very-long baseline interferometry that NGA does not include. Adjusting WGS 84 to ITRF allows the reference frame to take advantage of those methods without directly incorporating them into the coordinate determination software.

WGS 84 (G1674) adopted the values of NGA stations coordinates in the ITRF2008 reference frame with the exception of its stations located in Bahrain and Korea. Computations were performed to align the remaining WGS 84 reference stations to this network. For WGS 84 (G1674), all WGS 84 reference stations adopted ITRF2008 velocities of the station or nearby sites. The estimated accuracy of WGS 84 (G1674) is better than one centimeter overall for each of the reference frame station coordinates. The 7-parameter transformation from WGS 84 (G1674) to ITRF2008 is zero in all components. This is by design since WGS 84 (G1674) adopted ITRF2008 coordinates and velocities in common stations between the two reference frames in all but two exceptions. This process ensures that WGS 84 is aligned to ITRF2008 to better than one centimeter at initial WGS 84 (G1674) release.

3.0 GNSS DATA ACQUISITION

For the purpose of investigating the positional accuracy of Enugu CORS station, three (3) new GNSS stations (Urora_GPS_01, Urora_GPS_02 and Urora_GPS_03) respectively were established at Urora along Benin – Auchi road. Three independent GNSS observations were conducted using Hi Target V30 GNSS dual frequency receivers.

For the first observation, the GNSS receiver was setup only on Urora_GPS_02 and the observation span for 07hr: 34' 25" and the date of observation was 2nd of August, 2014. The RINEX online data for ENUGU CORS station was downloaded from NIGNET and a least squared adjustment was carried out using Hi – Target Geomatics office using ENUGU CORS as reference station.

A second campaign was carried out on the 8th of august 2014. This time, three receivers were set up at URORA GPS 01, URORA GPS 02 and URORA GPS 03 respectively. Data were collected for a period of 11hours 20minutes. As in the first campaign, Enugu CORS RINEX data were downloaded from NIGNET online and processed using HI- Target GEOMATICS OFFICE software.

A third campaign was conducted using 1st order GNSS control points XSU92

and XSU100 located in Benin City. The purpose of this campaign was to calibrate and cross validate the first and second observations as well as the integrity position of three new controls at Urora as determined with reference to Enugu CORS station. In this campaign, Hi-Target GNSS receivers were set up on XSU100 and XSU92. XSU100 was held fixed while XSU92 was regarded as unknown.
The data were processed and the adjusted coordinates of XSU 92 was compared with the known coordinate of the station, table 5 represent the integrity check. With the stability of the control points established they were used as reference points to coordinates URORA GPS 01, URORA GPS 02 and URORA GPS 03 respectively.

4.0 RESULTS AND DISCUSSIONS

The adjusted coordinates using UNEC CORS as reference point in both WGS84 and NTM coordinates system are presented in Table 1 - Table 4

Table1: Adjusted Points in WGS84 (BLH)

ĬPMPÒŎŌ Name	Lat.	Lon.	H(m)	Std.Dev_ N(mm)	Std.Dev_ E(mm)	Std.Dev_ H(mm)
UNEC	006:25:29.30400N	007:30:17.97100E	254.3050	0.0	0.0	0.0
URORA GPS 02	006:22:31.43870N	005:41:36.96486E	120.8800	0.0	0.0	0.0

Table 2: Adjusted Points in Target System (NTM coordinate system)

ĬPMPÒŎŌ Name	N(m)	E(m)	U(m)	Std.Dev_N(mm)	Std.Dev_E(mm)	Std.Dev_U(mm)
UNEC	268977.8159	563310.7089	255.1660	0.0	0.0	0.0
URORA GPS 02	262693.6387	362847.9879	119.4479	0.0	0.0	0.0

Table 3: Adjusted Points in WGS84 (BLH)

ĬPMPÒŎŌ Name	Lat.	Lon.	H(m)	Std.Dev_ N(mm)	Std.Dev_E (mm)	Std.Dev_H(mm)
UNEC	06:25:29.30400N	07:30:17.97100E	254.3050	0.0	0.0	0.0
Urora_01	06:22:31.20282N	05:41:37.10424E	122.7970	31.5	45.5	110.7
Urora_03	06:22:31.30114N	05:41:36.01424E	122.1885	37.1	50.5	129.9
Urora_02	06:22:31.43856N	05:41:36.96592E	122.9271	33.2	47.0	112.9

Table 4: Adjusted Points in Target System (NTM coordinate systems)

Ĭ PMRŎŎŌ Name	N(m)	E(m)	U(m)	Std.Dev_N (mm)	Std.Dev_E (mm)	Std.Dev_U(mm)
UNEC	268980.5755	563311.2120	255.1680	0.0	0.0	0.0
Urora_01	262685.4707	362852.9062	121.3644	31.5	45.5	110.7
Urora_03	262688.4129	362819.4026	120.7555	37.1	50.5	129.9
Urora_02	262692.7020	362848.6386	121.4944	33.2	47.0	112.9

Table 5 presents results of integrity check for the control points while in table 6, the baseline residuals are presented.

Table 5: Integrity check on XSU100 and XSU92 1st order controls

Ĭ PMRŎŎŌ Name	Given Coordinates			Obtained Coordinates			Remark
	N(m)	E(m)	H(m)	N(m)	E(m)	H(m)	
XSU100	252357.6434	356143.0429	77.9475	252357.6434	356143.0429	77.9475	
XSU92	257998.988	357763.364	103.988	257998.992	357763.350	103.986	ok

Table 6: Baseline Residuals

ĘMŎŎŎŎŃ Name	Tau	VDX(m)	VDY(m)	VDZ(m)	Std.Dev_VDX (mm)	Std.Dev_VDY (mm)	Std.Dev_VDZ (mm)	dVDX (mm)	dVDY (mm)	dVDZ (mm)
Urora_01 to Xsu100	True	0.0116	0.0201	0.0013	59.4	28.7	17.9	0.0	0.0	0.0
Urora_02 to Urora_01	True	0.0121	0.0076	0.0036	8.5	7.6	4.4	0.0	0.0	0.0
Urora_02 to Xsu100	True	-0.0344	-0.0668	-0.0376	91.0	33.4	28.0	0.0	0.0	0.0
_ Urora_01 to Xsu100	True	-0.0063	0.0156	0.0061	69.3	30.7	33.6	0.0	0.0	0.0
Urora_03 to Urora_02	True	-0.0004	-0.0069	-0.0052	39.0	36.5	12.0	0.0	0.0	0.0
_ Xsu92 to Urora_01	True	-0.0166	-0.0101	-0.0056	29.6	24.6	12.5	0.0	0.0	0.0
Xsu92 to Urora_ 02	True	0.0113	-0.0127	0.0014	48.9	22.5	29.4	0.0	0.0	0.0
Xsu92 to Xsu100	True	0.0079	0.0178	0.0065	10.3	8.6	3.9	0.0	0.0	0.0

The post adjustment results for the GNSS Network consist of the baseline vector components and their covariance. A summary of the constraints adjustments results for the survey observation are presented in Tables 7- 10.

Table 7: Baseline Residuals

ĘMŐĞŐŐÑ Name	Tau	DX(m)	DY(m)	DZ(m)	Std.Dev_ DX(mm)	Std.Dev_ DY(mm)	Std.Dev_ DZ(mm)	Length(m)	Relative Error
UNEC TO URORA_02	True	23503.3353	-199009.7300	-5444.8096	0.0	0.0	0.0	200466.7687	0.0

Table 8: Baseline Residuals

Baseline Name	Tau	DX(m)	DY(m)	DZ(m)	Std.Dev_ DX(mm)	Std.Dev_DY(mm)	Std.Dev_D Z(mm)	Length(m)	Relative Error
UNEC TO URORA_02	True	23505.4848	-199005.0664	-5451.8058	107.5	49.5	36.1	200462.5811	0.6
URORA_01 TO URORA_03	True	2.3162	-33.4113	2.9246	89.8	33.0	29.0	33.6189	2974.3
URORA_01 TO URORA_02	True	-0.2553	-4.2859	7.2142	38.1	16.8	17.0	8.3952	5357.8
UNEC TO URORA_01	True	23505.6525	-199009.9367	-5444.5509	109.6	51.0	38.0	200467.2386	0.6
UNEC TO URORA_03	True	23507.7754	-199038.9204	-5448.8455	126.3	55.5	42.1	200496.3772	0.7
URORA_02 TO URORA_03	True	-2.6770	29.1049	4.2662	87.2	32.5	28.5	29.5375	3296.3

Table 9: Baseline Residuals

ĘMŐĞŐŐÑ Name	Tau	VDX(m)	VDY(m)	VDZ(m)	Std.Dev _VDX(mm)	Std.Dev_VDY(mm)	Std.Dev_VD Z(mm)	Dvdx(mm)	dVDY(mm)	dVDZ(mm)
UNEC TO URORA_02	True	-0.0610	0.0663	-0.0040	85.8	31.9	25.3	0.0	0.0	0.0
URORA_01 TO URORA_03	True	-0.0358	0.0076	-0.0047	150.8	42.9	34.8	0.0	0.0	0.0
URORA_01 TO URORA_02	True	-0.0028	0.0056	0.0015	10.7	5.2	6.2	0.0	0.0	0.0
UNEC TO URORA_01	True	0.1477	-0.2204	0.0178	203.0	142.2	81.7	0.0	0.0	0.0
UNEC TO URORA_03	True	-0.1096	-0.1475	0.0092	201.6	101.4	70.0	0.0	0.0	0.0
URORA_02 TO URORA_03	True	-0.0197	-0.0123	-0.0056	63.2	26.9	24.6	0.0	0.0	0.0

Table 10: Baseline Residuals

Baseline Name	**Tau**	**DX(m)**	**DY(m)**	**DZ(m)**	**Std.Dev_DX(mm)**	**Std.Dev_DY(mm)**	**Std.Dev_DZ(mm)**
Urora_01 to Xsu100	True	1756.5864	-6589.5470	-10266.3371	65.6	33.1	21.2
Urora_02 to Urora_01	True	0.5324	4.3217	-7.1811	18.8	13.6	9.3
Urora_02 to Xsu100	True	1757.0607	-6585.3199	-10273.5608	93.8	36.5	30.1
_ Urora_01 to Xsu100	True	-2.5440	33.4118	-2.9378	77.8	40.3	37.9
Urora_03 to Urora_02	True	-3.0584	29.0753	4.2357	53.4	44.9	22.2
_ Xsu92 to Urora_01	True	-1005.4668	5023.0984	4659.4145	39.5	28.7	16.8
Xsu92 to Urora_ 02	True	-1005.9592	5018.7817	4666.6062	55.2	26.2	31.2
Xsu92 to Xsu100	True	751.1326	-1566.4408	-5606.9119	25.3	15.9	8.9

In order to carry out a comparative analysis, the coordinates of the points from two different observations were summarized as presented in Tables 11- 18.

Table 11: Coordinates Obtained for Urora_GPS_02 for two observations

S/N	Source of Coordinates & Reference System		Resulting Coordinate	
			UNEC CORE (WSG84)	Remark/ Date of observation
1	UNEC Cores	Latitude, (ϕ)	6:25:29.30400N	UNEC Cores
		Longitude, (λ)	7:30:17.97100E	
		Ellips. Ht, (h) m	254.3050	
2	Urora_GPS _02	Latitude, (ϕ)	6:22:31.43870N	2/8/2014
		Longitude, (λ)	5:41:36.96486E	
		Ellips. Ht, (h) m	120.8800	
3	Urora_GPS _02	Latitude, (ϕ)	6:22:31.43856N	8/8/2014
		Longitude, (λ)	5:41:36.96592E	
		Ellips. Ht, (h) m	122.9271	
NTM (MINNA DATUM				
4	Urora_GPS _02	Northing, N, m	262693.6387	2/8/2014
		Easting, E, m	362847.9879	
		Elevation, H, m	119.4479	
5	Urora_GPS _02	Northing, N, m	262692.7020	8/8/2014
		Easting, E, m	362848.6386	
		Elevation, H, m	121.4944	

Table 12: Comparison of NTM (Minna Datum) Coordinates for two observations

S/N	Source of Coordinates & Reference System		Coordinate	
			UNEC CORE (NTM)	Resultant $R = (\Delta X^2 + \Delta Y^2 + \Delta Z^2)^{1/2}$
1	Urora_GPS_02	ΔN, (m)	0.9367	2.3429m
		ΔE, (m)	0.6507	
		ΔH, (m)	2.0465	

Table 13: Coordinates Obtained for Urora_GPS_01 to 03

S/N	Source of Coordinates & Reference System		Resulting Coordinate	
			UNEC CORE (WSG84)	Remark/ Date of observation
1	UNEC Cores	Latitude, (ϕ)	6:25:29.30400N	UNEC Cores
		Longitude, (λ)	7:30:17.97100E	
		Ellips. Ht, (h) m	254.3050	
2	Urora_GPS_01	Latitude, (ϕ)	6:22:31.20282N	8/8/2014
		Longitude, (λ)	5:41:37.10424E	
		Ellips. Ht, (h) m	122.7970	
	Urora_GPS_02	Latitude, (ϕ)	6:22:31.43856N	
		Longitude, (λ)	5:41:36.96592E	
		Ellips. Ht, (h) m	122.9271	
	Urora_GPS_03	Latitude, (ϕ)	6:22:31.30114N	8/8/2014
		Longitude, (λ)	5:41:36.01424E	
		Ellips. Ht, (h) m	122.1885	
NTM (MINNA DATUM				
3	Urora_GPS_01	Northing, N, m	262685.4707	8/8/2014
		Easting, E, m	362852.9062	
		Elevation, H, m	121.3644	
	Urora_GPS_02	Northing, N, m	262692.7020	8/8/2014
		Easting, E, m	362848.6386	
		Elevation, H, m	121.4944	
	Urora_GPS_03	Northing, N, m	262688.4129	8/8/2014
		Easting, E, m	362819.4026	
		Elevation, H, m	120.7555	

Table 14: In-situ check was carried out for Urora_GPS_01 to 03

Station	Measured Angle	Computed Angle	Measured Distance	Computed distance	Remark
Urora_GPS__01			8.425m	8.397	Ok
Urora_GPS__02	112^0 05' 44"	112°12'04"			Not ok
Urora_GPS__03			29.593m	29.549	Ok

Table 15: Adjusted Points in WGS84 (BLH)

ĬPMPÒÕ ÍMÖÑ	IMPB	Lon.	H(m)	Std.Dev_N(mm)	Std.Dev_E(mm)	Std.Dev_H(mm)
URORA_01	006:22:31.54073N	005:41:37.04209E	120.0187	12.0	20.0	32.9
URORA_02	006:22:31.77659N	005:41:36.90408E	119.8767	13.1	19.3	34.3
URORA_03	006:22:31.63882N	005:41:35.95259E	119.5625	20.3	31.6	53.9
XSU100	006:16:55.44003N	005:37:58.05178E	79.3775	0.0	0.0	0.0
XSU92	006:19:58.97922N	005:38:51.17077E	105.4412	8.2	14.5	23.9

Table 16: Adjusted Points in Target System (NTM**)**

ĬPMPÒÕ ÍMÖÑ	ÍÄÖÅ	E(m)	U(m)	Std.Dev_ N(mm)	Std.Dev_ E(mm)	Std.Dev_U(mm)
URORA_01	262696.7784	362850.3540	118.5866	12.0	20.0	32.9
URORA_02	262704.0136	362846.0963	118.4445	13.1	19.3	34.3
URORA_03	262699.7143	362816.8656	118.1301	20.3	31.6	53.9
XSU100	252357.6434	356143.0429	77.9475	0.0	0.0	0.0
XSU92	257998.9916	357763.3503	103.9855	8.2	14.5	23.9

Table 17: In-situ check was carried out for Urora_GPS_01 to 03

Station	Measured Angle	Computed Angle	Measured Distance	Computed distance	Remark
Urora_GPS __01			8.420m	8.395	Ok
Urora_GPS __02	112^0 05' 44"	112°06'30"			Ok
Urora_GPS __03			29.593m	29.545	Ok

Table 18: Coordinate Sources and Reference Stations

S/N	Source of Coordinates & Reference System		HI – Target GNSS Dual Frequency	
			Enugu Cores Station	XSU100
1	URORA_ GPS_01	Latitude, (ϕ)	6:22:31.20282N	6:22:31.54073N
		Longitude, (λ)	5:41:37.10424E	5:41:37.04209E
		Ellips. Ht, (h) m	122.7970	120.0187
2	URORA_ GPS_02	Latitude, (ϕ)	6:22:31.43856N	6:22:31.77659N
		Longitude, (λ)	5:41:36.96592E	5:41:36.90408E
		Ellips. Ht, (h) m	122.9271	119.8767
	URORA_ GPS_03	Latitude, (ϕ)	6:22:31.30114N	6:22:31.63882N
		Longitude, (λ)	5:41:36.01424E	5:41:35.95259E
		Ellips. Ht, (h) m	122.1885	119.5625
	URORA_ GPS_01	Northing, N, m	262685.4707	262696.7784
		Easting, E, m	362852.9062	362850.3540
		Elevation, H, m	121.3644	118.5866
3	URORA_ GPS_02	Northing, N, m	262692.7020	262704.0136
		Easting, E, m	362848.6386	362846.0963
		Elevation, H, m	121.4944	118.4445
4	URORA_ GPS_03	Northing, N, m	262688.4129	262699.7143
		Easting, E, m	362819.4026	362816.8656
		Elevation, H, m	120.7555	118.1301

The results in table 12 shows a displacement of 0.9367m in northings, 0.6507m in Eastings and 2.04655m in elevation based on coordinates comparisons from two sets of observation for URORA GPS 02 from Table 14. There was a displacement of 06˚ 20" between the horizontal angle from coordinates computed using 1st order control points in Benin City and the Enugu CORS. This means that whereas there was consistency in the coordinates of URORA GPS 01, URORA GPS 02 and URORA GPS 03 obtained from the GNSS observation using the 1st order control point, the same cannot be said of the observation carried out using the Enugu COR Station as reference. Table 19 presents the difference in coordinates obtained from the GNSS survey for the three control points URORA GPS 01, URORA GPS 02 and URORA GPS 03 using Enugu CORS as reference station and that using the 1st order control XSU92 as control. We see that the displacements in Northings, Easting and Elevation for the three points are consistent.

Table 19: Study of Displacement

Station Name	Coordinate Differences	
URORA_GPS_01	Δφ (sec) Δλ (sec) Δh (m)	0.33791" 0.06215" 2.7783m
URORA_GPS_02	Δφ (sec) Δλ (sec) Δh (m)	0.33803" 0.06184" 3.0504m
URORA_GPS_03	Δφ (sec) Δλ (sec) Δh (m)	0.33768" 0.06161" 2.626m
URORA_GPS_01	ΔN, (m) ΔE, (m) ΔH, (m) Total Displacement (m)	11.0377 -2.5522 2.7778 11.664
URORA_GPS_02	ΔN, (m) ΔE, (m) ΔH, (m) Total Displacement (m)	11.3116 -2.5423 3.0499 11.988
URORA_GPS_03	ΔN, (m) ΔE, (m) ΔH, (m) Total Displacement (m)	11.3014 -2.537 2.6254 11.876

4.0 CONCLUSION

This study has evaluated the positional accuracy of Enugu CORS with the establishment of three new stations. A comparison was made revealing lager angular misclosure. From the study, the following conclusions can be drawn:

1. There is a total (or 3-D) discrepancy of over 11m between two sets of observations for the three new stations with reference to Enugu CORS and XSU100

established by the same OSGOF.

2. The angular differences between the observed and the measured using Enugu CORS as reference angular difference of station gave 00^0 06' 20", linear differences of 0.023m, and 0.082m respectively an indication that the reliability of Enugu CORS is in doubt and need further investigations.
3. The angular differences with reference to XSU100 gave 00^0 00' 46", linear differences of 0.025m, and 0.048m giving us confidence that XSU100 is stable and reliable.

The abnormally high discrepancy (outlier) in the coordinates obtained with Enugu CORS may be indicative of the existence of systematic errors in the CORS Station acquired data. We are calling on the relevant authorities to investigate Enugu CORS station with a view to providing answers relating to the integrity of the station.

From the above inferences, it can finally be concluded that there is need for further study of the above with other processing techniques using other Continuously Operating Reference Stations (CORS) in Nigeria as reference points. The CORS in Nigeria is inadequate, we therefore call on the relevant authorities to expand the prospect of CORS stations nation – wide to compliment AFREF project in which Nigeria is a participant.

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