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Second order control extension in Millennium City, Chikun Local Government Area, Kaduna State, Nigeria

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Abstract

GNSS control establishment is a continuous exercise in the field of Geomatics. This forms the basis upon which other surveys and engineering works geared toward development are referenced. This study employed the use of Hi-Target GNSS to extend and establish control stations within the study area in static mode. The control points were situated in such a way that they are free from disturbances, multipath and open for satellite acquisition. Observations were made between 90 to 120 minutes depending on the baseline length. To extrapolate this, three existing primary controls were selected for connection, checked for in-situ, and found to be in good condition for use. A minimum of fifteen (15) satellites were acquired by the GNSS receivers during observation with a dilution of precision (PDOP) value range of 1.2 to 2.8. The recorded data were downloaded and processed with the Hi-target Geomatics Office software. Network adjustment, for the newly established control stations, was carried out while the master station was held fixed. The final coordinates from the post-processing were plotted using QGIS 2.18.23. In conclusion, further research should be carried out in the study area to break the network of the control points established into shorter distances.

1. Introduction

Control survey provides consistent and accurate horizontal and vertical control for all subsequent project surveys, it covers an extensive area where long distances are involved and provides the standard of accuracy for subsequent and subordinate surveys to be attained (Olayanju, 2017). All projects, including route surveys, photogrammetric mapping, topographical mapping, planning, design, construction, and right of way, are made up of a series of vertical and horizontal field surveys. These secondary surveys are dependent on the control for position and relative accuracy (Basak, 2002).

For surveying to operate effectively, there is a need to have a reference framework that will be used for orientation. A control station is a small mark set immovably into the ground, such that an instrument (e.g., a total station or GNSS receiver) or optical target can be set up above it, to an accuracy of about 1 mm in the horizontal plane (Johnson, 2004).

Control extension is important in surveying because every survey practiced either in a large or small area requires a set of control frameworks to fit into, i.e. vertical and horizontal controls. The vertical controls deal with the determination of the height of points, the process employed is known as leveling. In achieving the elevation of a point above a given datum, classical methods employed are Bathymetric, trigonometric, reciprocal, and spirit leveling. However, in the recent past, the total station and Global Navigation Satellite System (GNSS), have been used for height determination (Johnson, 2004).

In the determination of the horizontal control framework, controls can be established using various conventional methods like triangulation, trilateration, and traversing. These methods are used to determine the coordinates of a point, that is, the position of the point. However, due to the time spent in the production of a network of control and the huge amount expended on the course of creating this framework using the conventional method, this led to the rise of modern surveying instruments and techniques, so we have the advent of GNSS in surveying which is a satellite-based radio

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navigation system, or we call it satellite surveying (Johnson, 2004).

Satellite surveying relies on a lot of systems such as the Global Positioning System (GPS), GLONASS, GALILEO, and more. By using differential GPS (DGPS), in which data recorded by a receiver at a 'known' station are combined with data recorded simultaneously by a second receiver at a new station which might be 30 km away, it is possible to find the position of the second receiver to within about 5 mm. The advantage of GNSS compared to all earlier methods of surveying is that the two stations do not need to have a line of sight between them.

Studies on control establishment and extension have been carried out in the recent past. Jolaoso (2016) used the traditional method of traversing to obtain planimetric coordinates of the points using south digital theodolite for angular observation on four Zeroes, while the south distance measurer was used for the distance measurement. The coordinates obtained were analyzed, represented, presented, and structured in a database after the application of necessary correction.

Similarly, Ahmadu (2016) carried out a second order control densification from Sambam-Kwoi junction, Jaba Local Government Area of Kaduna State. The researcher covered a length of 7.637km and established 24 control points that were inter-visible. The instrument used for observations was three numbers of Promark 3 differential GNSS receivers. The researcher concluded that Azimuth observation to control the bearing was not needed because GNSS observation uses satellites of which each position is independent of the other.

Furthermore, Oluwaseun (2017) implemented a Second order control extension from Mobolaje junction via Oba Adeyemi Grammar School to Folatyre, Oyo East Local Government Area Oyo, Oyo State. The researcher covered a length of 6.5km and established 20 control points. Two numbers of South H66/68 DGPS receivers were used to carry out observations. The researcher explained that control surveys establish a common, consistent network of physical points that are the basis for controlling the horizontal and vertical positions of transportation improvement projects and facilities.

Additionally, Emeka (2017) executed a project, the establishment of second order horizontal controls along the Umaru Musa Yar'dua expressway, Abuja. The researcher covered a linear length of 7.8km. In his choice of instrument, a lot were at his disposal. The Wild T1, Wild T2, Kern DKM3 and Ashtech Promark 3 DGPS. He opted for the Ashtech Promark3 DGPS because of the terrain and traffic. Although he spent an average of 90mins on each point. The plan for the control points was plotted using AutoCAD 2009 software.

Adamu (2019) performed a project, third order control extension from ABU Main Campus Samaru to College of Aviation Technology, along Zaria-Sokoto Road, Kaduna State. The methodology adopted was the application of the DTM (SET 624R) total station and its accessories for data collection. The researcher used AutoCAD Civil 3D and ArcGIS 10.4.1 for the plotting.

The rapid spring up of infrastructural development within Kaduna State with the Millennium city as a case study, resulted in a shortage of control networks, hence the need for second order controls to be extended to enable Engineers and Land Surveyors to tie their third order jobs to survey control. There had been controls established before, however, these are mostly situated along Umaru Yar'dua Expressway and were not enough. It was difficult for survey activities in the interior because of the distance of the controls. It is against this problem that the researcher decided to come up with a second order control extension network and used modern survey equipment to extend controls to the interiors of the area.

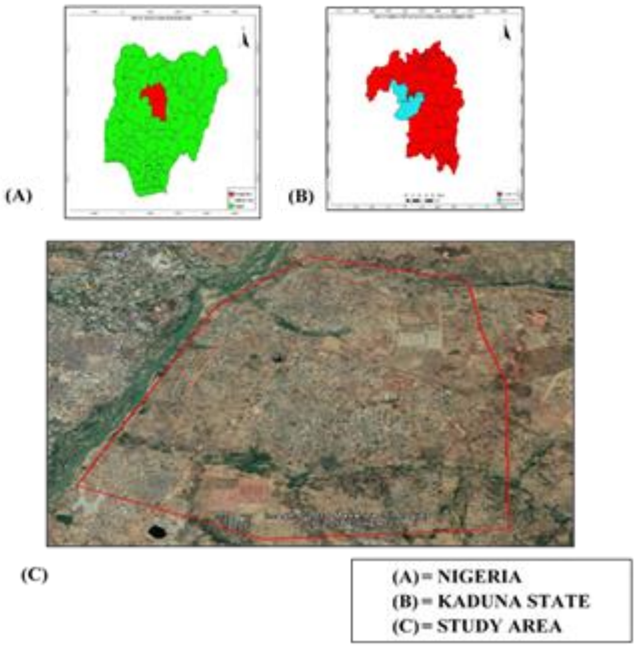

Figure 1. Study Area location

The project is located at Millennium City, Chikun Local Government Area of Kaduna State. The study area lies within Latitude 10° 30' 33" N to 10° 32' 38" N and Longitude 7° 28' 18" to 7° 30' 06" E. The total perimeter length to be covered is approximately 12.8km. Figure 1 shows the map of Nigeria, Kaduna state, and the study area of the project which is a millennium city.

2. Method

The equipment used are arranged in Table 1.

The software used include Hi-Target Geomatics Office; AutoCAD 2010; QGIS; MAPS.ME Navigation on Mobile Phone; Microsoft Office 2016, & Google Earth Pro.

Existing control points that were closer to the site area were accomplished by collecting the coordinates from Kaduna State Geographic Information Service (KADGIS) for easy connection.

A search was made at Kaduna Geographic Information Service (KADGIS) to determine the existing control points that are closer to the project area that had a better accuracy estimate of First Order to serve as a control for the project. Control station FGPKDY139 was closest to the project area.

The coordinates listed in Table 1, were collected from Kaduna Geographic Information Service (KADGIS), Kaduna state which were used as base stations for the work as well as in situ checks.

Hi-Target V30 dual-frequency GNSS receivers were used for data acquisition. Also, three GNSS receivers were used for simultaneous observation by the baseline solution method. Three datum controls FGPKDY139, KADGISCP101, and KADGISCP102 were used for the project network. During observation, a minimum of 90 minutes and a maximum of 120 minutes were made (to ensure that enough ephemeris data had been gathered) while the cut-off angle during the observation was 15 degrees.

The observed data were transferred and processed using Hi-Target Geomatics Office (HGO) processing software. Finally, a constraint adjustment was carried out to generate the final coordinates. The final coordinates were checked for discrepancies. The result suggested that the control stations are in situ and could be used for the research project.

Table 1. Equipment and materials used

S/ No.	Name	Quantity	Purpose
1	Hi-Target (V30) & its accessories	3	Used to collect static raw data
2	Handheld GPS	1	Used for navigation to proposed points
3	Shovel	2	Used for mixing sand and cement
4	Cutlass	2	Used for Clearing line of sight
5	Pocket Tape	1	Used for measuring Instrument Height
6	Mold	1	Used for Casting of Beacons
7	Head pan	2	Used to carry mixed concrete material
8	12mm Iron Rod	20	Used as station marker
9	Hammer	1	Used in driving the iron rod into the ground

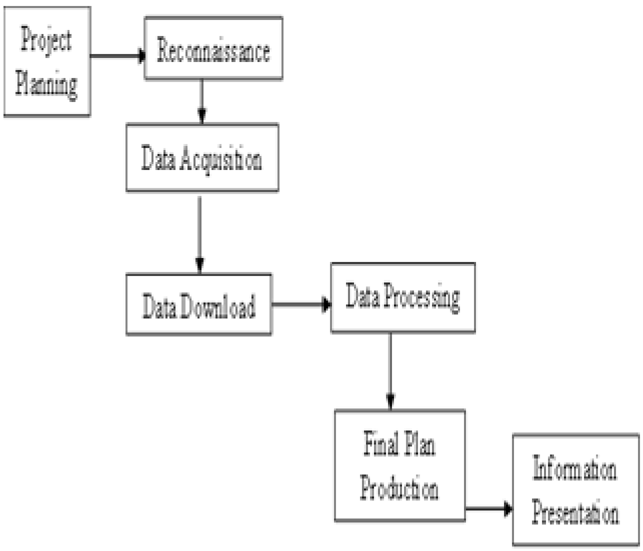

Figure 2. Study workflow diagram

The selected points were noted with safety as a consideration. The suitable location for the new control points position was accomplished effectively by plotting the data with the aid of Ortho-photo, and all the points were connected into a triangular network.

Table 1. Co-ordinate of controls (WGS84 Z32)

Beacon Number	Easting (m)	Northing (m)	Ellipsoidal Height
FGPKDY139	332813.950	1165452.920	613.278
KADGISCP101	332381.890	1165351.120	619.408
KADGISCP102	332402.310	1165316.060	619.996

Figure 3. GNSS Static Mode Observation in Progress

This research project was restricted to part of the millennium city, Kaduna, and a control network was made to cover the project area of 1,128.340 Ha, with a total number of twenty (20) control points established. The control points were limited to static GNSS observation procedures and the accuracy limited second order control survey accuracy in Nigeria. Also, the processing of the raw GNSS data was limited to manual post-processing using the Hi-Target Geomatics Office (HGO) and the final analysis and presentation of results to the scope of the research project.

3. Results and discussion

The result of data in Table 2 obtained from the adjusted data was analyzed and the result proved reliable as the unit variance and standard error values fell within the allowable limit.

Figure 3 shows the access road network to the controls, starting from Umaru Musa Yar'dua Expressway to the first control point (MCCP 106). There were 10 loops of triangles networks that made up the entire project area. The twenty (20) established controls station were plotted, taking into consideration the intervisibility between them. Similarly, a minimum of six (6) controls were established within a community, this was to enable other users with no access to GNSS equipment to have the minimum number of three controls required for in-situ check before embarking on any survey work.

The qualities obtained after adjustment in a GNSS network shows the adjusted baseline vector components, their covariance, and the final coordinates. The baseline adjustment was performed using FGPKDY139 as the master or base control point which was held fixed. Adjustment of the data made it possible for further use in a GIS software environment.

Table 2. Established GNSS coordinate (UTM Minna Z32)

Station Name	Easting (m)	Northing (m)	Ellp_H (m)
FGPKDY139	332890.866	1165333.654	613.278
KADGISCP101	332458.783	1165231.876	619.400
KADGISCP102	332479.211	1165196.806	618.996
MCXT101	333144.364	1165231.854	619.414
MCXT102	332885.189	1163109.782	609.907
MCXT103	333206.120	1162964.613	613.143
MCXT104	333473.500	1163097.548	621.550
MCXT105	333868.285	1163274.886	627.389
MCXT106	333772.199	1162894.176	618.864
MCCP101	336259.490	1164043.913	649.816
MCCP106	333983.893	1164931.016	618.878
MCCP107	335724.455	1165315.584	626.182
MCCP108	334521.403	1165468.996	620.231
MCCP112	334338.943	1163783.478	629.963
MCCP114	333338.655	1163866.929	615.645
MCCP111	334643.066	1163135.566	622.775
MCCP116	335649.891	1162290.101	612.915
MCCP115	334589.411	1162202.006	609.778
MCCP117	333670.778	1162454.478	606.296
MCCP105	335191.044	1164865.017	640.931
MCCP109	335254.304	1164078.384	637.639
MCCP110	335472.478	1163336.933	634.268
MCCP113	334463.632	1164396.381	626.768

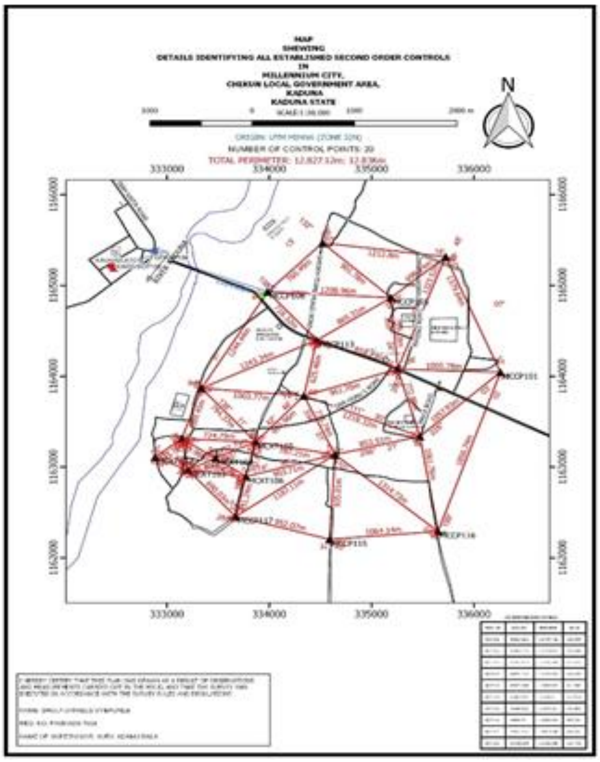

Figure 4. Composite Plan of the established controls

4. Conclusion

GNSS controls were successfully established at Millennium city in Chikun L.G.A. of Kaduna State. These controls can serve as bases for further surveying and mapping exercises around the area. GNSS method of control extension is a versatile, accurate, quick, time saving, and economical way of establishing control points. The data collected was in WGS84 and transformed to UTM Minna Local datum. The data was found to be of very high accuracy. The benefits of the control stations established are numerous to government agencies and the private sector interested in cadastral and engineering surveys along with the project site. It is recommended that existing controls on the ground must be checked, and maintained more frequently to know their conditions; controls should be located where they are not liable to destruction, and awareness campaigns to educate people on the importance of government control pillars and property survey beacon to avoid them being tampered with or destroyed.

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