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# ESTABLISHMENT OF SECOND ORDER CONTROLS FROM OLORUNSOGO COMMUNITY IN AWE TOWN TO IDI-MANGORO VILLAGE ALONG OYO-IWO ROAD, AFIJIO LOCALGOVERNMENT AREA, OYO STATE OF NIGERIA

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## ABSTRACT

The study established Second Order Controls from Olorunsogo Community in Awe town to Idi- Mangoro village along Oyo-Iwo Road, Afijio local government area of Oyo State. The study extended the already established Second Order Controls from Olorunsogo community Awe townto Idi-Mangoro village along Oyo/Iwo road with approximate distance of 5Km. The study is necessary due to development activities; and also the problem of insufficient controls within the area. These factors necessitated the need to establish Second Order Control so as to provide the relevant controls in which subsequent lower order jobs can be tied around the area and also for proper mapping of the area. The study was carried out by adopting the specifications for Second Order Control extension using GPS. The field data were downloaded from Trimble R6 GPS instrument into computer system using Trimble data transfer software. The data from reference and the rover were downloaded. After downloading, Hi-Target Geomatic Office software was used for processing of downloaded data. The results were obtained and sorting out for data transformation from Geodetic Coordinates to Universal Traverse Mercator (UTM). The downloaded data were converted to Rinex Format such that it can be handled by Hi-Target Geomatic Office for further processing. The result of data obtained from the adjusted data was analyzed and the result proved reliable as the unit variance and standard error values fall within allowable limits. Back computation was done from the final adjusted coordinates in order to obtain corrected bearings and distances in-between successive controls. The results obtained from the Excel program and HI-Target Geomatics Office software were compared and the discrepancies were negligible. With the various results generated in the course of the study, it is an indication that the linear accuracy was reliable.

**KEYWORDS:** Second Order, Controls, Satellites, Geodetic, Traversing, HI target.

## 1.0 INTRODUCTION

Surveying has been in existence from the beginning of human race. It is generally known that surveying is the bedrock of every meaningful development on or above the earth's surface. Robillard, Wilson and Brown (2006) believed Surveying has to do with the determination of the relative spatial location of points on or near the surface of the earth. They buttressed the above definition by saying that it is the art of measuring horizontal and vertical distances between objects, measuring angles between lines, determining the direction of lines, and establishing points by predetermined angular and linear measurements. Generally, Controls are used for orientation in any survey operation and must be of high degree of accuracy. Control serves as a basis for orienting or checking subordinate survey work regardless of its order of accuracy.

Punmia (2009) defined control points as identifiable positions on the surface of the earth whose coordinates are determined with respect to a defined reference system with a national, state or local origin. Subsequently, control itself is a system of relatively precise measurements by triangulation, traversing and leveling to determine distances, directions and difference in elevation between points on the earth's surface. Controls can be horizontal or vertical. Other types of controls are ground controls, photo controls etc. The provision of such control points depends on the surveying method employed and the equipment used. Geodetic networks basically involve two types of controls; the horizontal and vertical controls, each having its own set of monument points and method of establishment. Generally, controls are also classified according to their degree of accuracy. They are:

i. First order controls (Primary)

ii. Second order controls (Secondary)

iii. Third order controls (Tertiary).

However, the advent of digital surveying equipment and satellite positioning system has brought a convenient of methods that facilitates and simplifies the observational methods in today's surveying. The classical method embraces the traditional methods of obtaining planimetric information of control points using Traversing, Triangulation and Trilateration. With the advent of the new technology in surveying, the planimetric and height information of control points can be obtained through the use of Global Positioning System (GPS).

Global Positioning System (GPS) are satellites that were primarily designed for use by US military in the early 60's, with a secondary role of civilian navigation as found in the works of Awange & Aduol, (1999); Awange *et al*., (2010). Two carrier signals in the L band denoted by L1 and L2 are generated by integer multiplication of the fundamental frequency $f_0$. These carriers are modulated by codes to provide satellite clock readings measured by GPS receivers. Two types of codes; the coarse acquisition C/A and precise acquisition P/A are emitted. This study was carried out using Global Positioning System (GPS) equipment. GPS is based on accurate ephemeris data for the real-time location of each satellite and on precisely kept time. It uses satellite signals, accurate time and sophisticated algorithms to generate distances to ground receivers and thus provide "resection" positions anywhere on earth.

A minimum of four satellites must be tracked according to Awange *et al*., (2010) to solve the positioning intersection equations dealing with position (x, y and z coordinates) which later can be translated to easting, northing and elevation and with clock differences between the satellites and ground receivers. In reality, five or more satellites are tracked to introduce additional redundancies and to strengthen the geometry of the satellite array. Additional satellites (more than the required minimum) can provide more accurate positioning and can also reduce the receiver occupation time at each survey station. The establishment of the second order control is significant because they can be used as a reliable platform for the extension of third order jobs; they will equally assist in township mapping and for public and private uses; also can be used in the production of accurate maps and geographic features; the controls established can be used for any job that requires second order controls; they can serve as bedrock for precise engineering jobs; can also help in assuring the unambiguous location of all parcel of land control area of occupancy and also provides for the subsequent lower order jobs to be tied.

The aim of the study is to establish Second Order controls from Olorunsogo Community in Awe town to Idi-Mangoro village along Oyo-Iwo Road, Afijio Local Government area of Oyo State, so as to assist in township mapping and for public and private uses. The study is necessary due to development activities like private, commercial and industrial along the route in the study area and to solve the problem of insufficient controls within the area. These factors necessitated the need to establish Second Order control from Olorunsogo community in Awe town to Idi- Mangoro village along Oyo-Iwo road, Oyo state so as to provide the relevant controls in which subsequent lower order jobs can be tied around the area and also for proper mapping of the area. The study extended the already established Second Order controls from Olorunsogo community in Awe town to Idi-Mangoro village along Oyo/Iwo road, Afijio local Government Area of Oyo State with approximate distance of 5Km. The study area site is geographically situated from latitudes $07^0$ 46’ 38.92’’N to $07^0$ 48’ 29.60’N and longitudes $03^0$ 58’ 56.76’’E to $04^0$ 00’ 35.51’’E. The study area is shown in Figure 1.

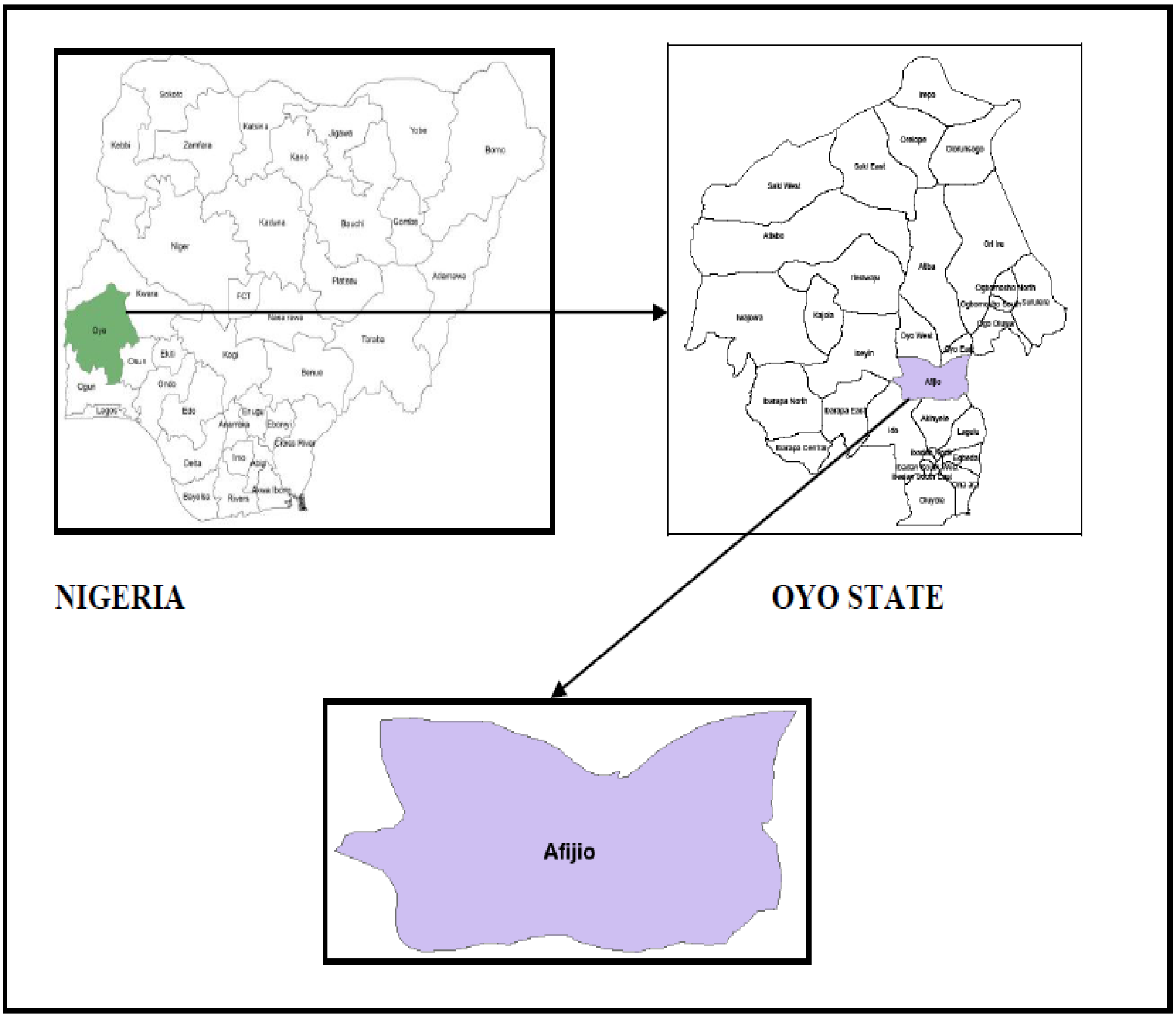


**Figure 1: Location diagram of the Study Area.**

## 2.0 METHODOLOGY

The specifications for the study were referenced to the Specifications for Second Order control extension using GPS which was sourced from the Surveyors Council of Nigeria (SURCON) pamphlet on specification for Geodetic Survey in Nigeria. The specifications includethe following:-

i. Dual frequency GPS receivers – Compulsory;
ii. Minimum of two (2) GPS receivers required for two simultaneous observations for baseline solution;
iii. Minimum number of Datum control required – Two (2);
iv. Spacing between any adjacent station should not be shorter than 0.2Km and survey beacons should be of dimensions 40cm x 40cm x 110cm (L x B x H) respectively;
v. The concrete of beacons should be mixed in ratio 3:2:1 of sharp sand, gravel and cement;
vi. The beacons should be in-situ and reinforced with iron pipes, each consisting of prefix andpillar number;
vii. Geometric Dilution of Precision (GDOP) at the beginning and the end of the observation should be within 0 and 8;
viii. Period of observation with visibility to minimum of four (4) satellites – 90minutes;
ix. Data sampling rate (Epoch) – maximum time interval between observations – 30 seconds,with cut off angle of 15º;
x. Poor baseline vector should be discarded from participating in further adjustment; and
xi. Independent plumb line centering with maximum centering error of 3mm is required.

The methodology adopted in order to acquire a reliable and accurate data needed for computing and plotting the information to have a plan of the study is the principle of working from whole to part. The first thing that was done is the Office Planning which required acquisition of instrument to be used. This also involves the acquisition of the area to be surveyed from existing map i.e. topographical map of the area in order to determine where the study area falls. At this stage, the available data for the study were examined i.e. the data of the existing controls on which the study was tied. The reconnaissance survey of the study area was done to see the general overview of the study area and to plan adequately for the acquisition and processing of the data. The ground control coordinates (primary) were obtained from SIWES and Practical Unit of Federal School of Surveying, Oyo, Oyo State (Table 1).

**Table 1: Coordinates of Primary Controls.**

| PILLAR PREFIX | NORTHING(m) | EASTING(m) | HEIGHT(m) |
|---|---|---|---|
| XSN07 | 866879.146 | 604755.785 | 309.972 |
| FSS1/28/96(YZN) | 869917.170 | 603299.247 | 275.183 |
| FSS1/17 | 863523.698 | 601051.694 | 312.957 |

The next step taken was to consider the locations where the stations were to be established in the course of carrying out the study. The following factors were considered.

i. Intervisibility between two points;
ii. Good horizon for GPS observation; and also
iii. Points to be located where they will not be disturbed.

Equipment used in the execution of the study included but not limited to the following:

i. One (1) Trimble differential GPS and its accessories (GNSS/R6/58000);
ii. One (1) Tripod stand;
iii. Three (3) Ranging poles;
iv. One (1) 50m Steel tape;
v. One (1) 5m pocket tape;
vi. One (1) Hand held GPS;
vii. One (1) Carrier & Tribrach;
viii. One (1) Circular web;
ix. One (1) Prismatic Compass;
x. Mobile phones for effective communication;
xi. Others include Digger, Hand trowel, Crowbar Shovel, Cutlass, Head pan, Iron rod, Mould, Gravel, Sand, Water and Cement.

### 2.1 Data Downloading/Transformation

The acquired data from the field were downloaded from Trimble R6 GPS receivers into the Computer System using Trimble Data Transfer Extension of Trimble Business Centre (TBC-5). The download was done for both reference and rover receivers while the downloaded base line vector map was displayed by the Trimble Business Centre software as shown in Figure 2.

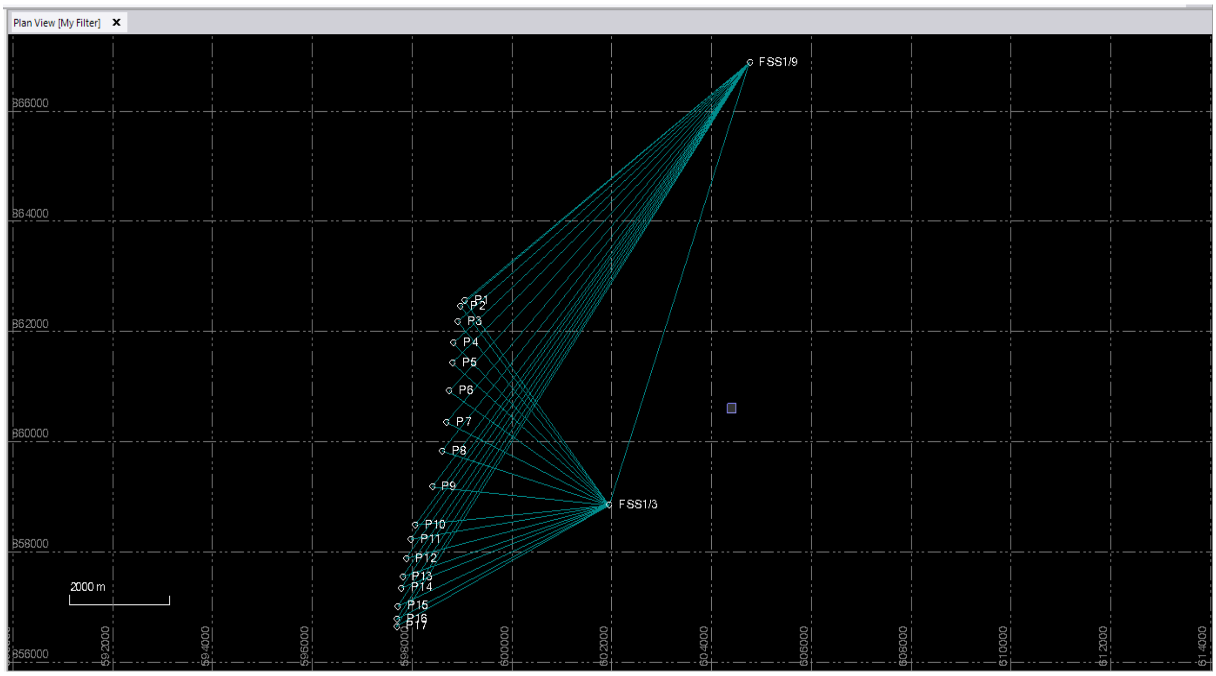


**Figure 2: Downloaded Base Line Vector Map of Controls Established.**

Also, the processed data were well sorted out for further processing using Hi-Target Geomatics Office software (See Table 2).

**Table 2: Results obtained from the processed data in WGS84.**

| Station Name | NORTHING(M) | EASTING(M) | HEIGHT(M) |
|---|---|---|---|
| FSS2/HND/2016/001 | 6304463.032 | 438734.0292 | 860965.3028 |
| FSS2/HND/2016/002 | 6304486.699 | 439032.1862 | 860639.4351 |
| FSS2/HND/2016/003 | 6304491.661 | 439187.9027 | 860448.7009 |
| FSS2/HND/2016/004 | 6304494.823 | 439261.2514 | 860382.1904 |
| FSS2/HND/2016/005 | 6304522.38 | 439443.6591 | 860165.0873 |
| FSS2/HND/2016/006 | 6304551.68 | 439947.1992 | 859618.1631 |
| FSS2/HND/2016/007 | 6304557.855 | 440068.1167 | 859465.0338 |
| FSS2/HND/2016/008 | 6304556.322 | 440176.6585 | 859367.2618 |
| FSS2/HND/2016/009 | 6304564.514 | 440242.0038 | 859274.5386 |
| FSS2/HND/2016/010 | 6304577.83 | 440452.0616 | 859061.8035 |
| FSS2/HND/2016/011 | 6304589.398 | 440642.5468 | 858831.5763 |
| FSS2/HND/2016/012 | 6304600.18 | 440813.812 | 858659.8523 |
| FSS2/HND/2016/013 | 6304619.281 | 440970.8209 | 858470.5029 |
| FSS2/HND/2016/014 | 6304627.847 | 441170.4185 | 858265.2433 |
| FSS2/HND/2016/015 | 6304638.582 | 441344.1411 | 858059.4284 |
| FSS2/HND/2016/016 | 6304642.422 | 441458.9902 | 857952.7831 |
| FSS2/HND/2016/017 | 6304658.455 | 441609.5524 | 857767.4669 |
| FSS2/HND/2016/018 | 6304671.969 | 441782.8123 | 857591.5312 |
| FSS2/HND/2016/01 | 6304462.951 | 438734.0472 | 860965.2749 |
| FSS2/HND/2016/03 | 6304491.698 | 439187.874 | 860448.6941 |
| FSS2/HND/2016/04 | 6304494.859 | 439261.2447 | 860382.1997 |
| FSS2/HND/2016/05 | 6304522.49 | 439443.653 | 860165.0996 |
| FSS2/HND/2016/07 | 6304557.865 | 440068.1278 | 859465.0304 |
| FSS1/HND/2106/09 | 6304564.514 | 440242.0038 | 859274.5386 |
| FSS2/HND/2016/11 | 6304589.473 | 440642.5794 | 858831.5742 |
| FSS2/HND/2016/12 | 6304600.22 | 440813.8212 | 858659.8254 |
| FSS2/HND/2016/13 | 6304619.303 | 440970.8483 | 858470.4708 |
| FSS2/HND/2016/14 | 6304627.91 | 441170.4233 | 858265.2553 |
| FSS2/HND/2016/15 | 6304638.586 | 441344.1562 | 858059.4244 |
| FSS2/HND/2016/16 | 6304642.281 | 441459.8186 | 857952.7192 |
| FSS2/HND/2016/17 | 6304648.547 | 441608.8332 | 857766.1097 |
| FSS2/HND/2016/18 | 6304671.899 | 441782.7915 | 857591.5212 |
| FSS2/HND/2016/6 | 6304551.68 | 439947.1992 | 859618.1631 |
| FSS2/HND/2016/8 | 6304556.322 | 440176.6585 | 859367.2619 |
| YCY 0249 | 6304480.745 | 438915.7503 | 860746.4481 |
| YCY 0252 | 6304530.31 | 439593.9062 | 860018.7552 |
| YCY 0253 | 6304546.783 | 439822.204 | 859734.8755 |
| YCY 249 | 6304480.751 | 438915.744 | 860746.4475 |
| YCY 252 | 6304530.326 | 439593.9116 | 860018.7519 |
| YCY253 | 6304546.802 | 439822.1962 | 859734.8665 |

For the basis of this study, the processed results obtained were well sorted out and transformed from geodetic coordinate system with reference Ellipsoid WGS84 into UTM with reference ellipsoid of Clarke 1880 using Hi-Target Coordinate Tool Converter as shown in Table 3.

**Table 3: Results showing processed data in MINNA Datum (Clarke 1880).**

| Station Name | NORTHING(M) | EASTING(M) | HEIGHT(M) |
|---|---|---|---|
| FSS2/HND/2016/001 | 863261.445 | 608229.8345 | 312.9995 |
| FSS2/HND/2016/002 | 862933.3676 | 608526.3032 | 312.6385 |
| FSS2/HND/2016/003 | 862742.6788 | 608681.6972 | 302.3602 |
| FSS2/HND/2016/004 | 862675.8544 | 608754.7831 | 301.5056 |
| FSS2/HND/2016/005 | 862455.7955 | 608935.2942 | 311.8319 |
| FSS2/HND/2016/006 | 861906.5495 | 609436.7141 | 301.2852 |
| FSS2/HND/2016/007 | 861753.1866 | 609557.2332 | 294.9585 |
| FSS2/HND/2016/008 | 861655.7844 | 609665.8154 | 287.6727 |
| FSS2/HND/2016/009 | 861562.3724 | 609730.6323 | 287.7044 |
| FSS2/HND/2016/010 | 861348.3717 | 609939.6949 | 286.5239 |
| FSS2/HND/2016/011 | 861117.4205 | 610129.4001 | 279.9058 |
| FSS2/HND/2016/012 | 860944.6577 | 610299.8552 | 279.1249 |
| FSS2/HND/2016/013 | 860753.4127 | 610455.5564 | 283.2011 |
| FSS2/HND/2016/014 | 860547.5319 | 610654.4998 | 277.6651 |
| FSS2/HND/2016/015 | 860340.9903 | 610827.4892 | 272.4211 |
| FSS2/HND/2016/016 | 860234.0254 | 610942.0109 | 269.724 |
| FSS2/HND/2016/017 | 860047.235 | 611091.4864 | 270.9055 |
| FSS2/HND/2016/018 | 859869.9159 | 611263.751 | 272.4471 |
| FSS2/HND/2016/01 | 863261.4283 | 608229.8582 | 312.916 |
| FSS2/HND/2016/03 | 862742.6672 | 608681.666 | 302.3943 |
| FSS2/HND/2016/04 | 862675.8588 | 608754.7738 | 301.5422 |
| FSS2/HND/2016/05 | 862455.7928 | 608935.2804 | 311.9423 |
| FSS2/HND/2016/07 | 861753.1818 | 609557.2435 | 294.9684 |
| FSS2/HND/2016/8 | 861655.7845 | 609665.8154 | 287.6727 |
| FSS2/HND/2016/11 | 861117.4081 | 610129.4275 | 279.9818 |
| FSS2/HND/2016/12 | 860944.6256 | 610299.8617 | 279.1615 |
| FSS2/HND/2016/13 | 860753.3778 | 610455.5823 | 283.2199 |
| FSS2/HND/2016/14 | 860547.5351 | 610654.5002 | 277.7296 |
| FSS2/HND/2016/15 | 860340.9857 | 610827.504 | 272.4254 |
| FSS2/HND/2016/16 | 860233.9753 | 610942.847 | 269.6332 |
| FSS2/HND/2016/17 | 860047.2351 | 611091.4614 | 260.879 |
| FSS2/HND/2016/18 | 859869.9157 | 611263.7352 | 272.3746 |
| FSS2/HND/2016/6 | 861906.5495 | 609436.7141 | 301.2852 |
| YCY 0249 | 863040.9915 | 608410.3461 | 313.2753 |
| YCY 0252 | 862308.72 | 609084.9256 | 310.1614 |
| YCY 0253 | 862023.6986 | 609312.1248 | 303.6579 |
| YCY 249 | 863040.99 | 608410.3394 | 313.2808 |
| YCY 252 | 862308.7146 | 609084.9299 | 310.1768 |
| YCY253 | 862023.6871 | 609312.1157 | 303.6754 |

The adjusted results as processed by Hi-Target software were tabulated against the input observed data as shown in Table 4. Also, a customized observation equation Least Squares program written in Excel was used for the Least Square Adjustment solution. The results of the two adjusted programs (Excel and Hi-Target) were compared and displayed as in Table 5.

**Table 4: Adjusted coordinates of the newly established points.**

| OBSERVED DATA | | | | ADJUSTED DATA | | | DISCREPANCY | | |
|---|---|---|---|---|---|---|---|---|---|
| STATION | NORTHING (M) | EASTING (M) | HEIGHT (M) | NORTHING (M) | EASTING (M) | HEIGHT (M) | NORTHING (M) | EASTING (M) | HEIGHT (M) |
| FSS2/HND/2016/001 | 863261.445 | 608229.8345 | 312.9995 | 863261.4367 | 608229.8548 | 312.9182 | 0.00835 | -0.0203 | 0.08132 |
| YCY 249 | 863040.99 | 608410.3394 | 312.6808 | 863040.9915 | 608410.3461 | 312.6263 | -0.0015 | -0.0067 | 0.0545 |
| FSS2/HND/2016/002 | 862933.3676 | 608526.3032 | 313.2392 | 862933.3576 | 608526.3021 | 313.2721 | 0.01 | 0.0011 | -0.03285 |
| FSS2/HND/2016/003 | 862742.6788 | 608681.6972 | 302.3602 | 862742.6747 | 608681.6782 | 302.3855 | 0.00415 | 0.01905 | -0.0253 |
| FSS2/HND/2016/004 | 862675.8544 | 608754.7831 | 301.5056 | 862675.8578 | 608754.7782 | 301.5266 | -0.00335 | 0.00495 | -0.021 |
| FSS2/HND/2016/005 | 862455.7955 | 608935.2942 | 311.8319 | 862455.793 | 608935.2866 | 311.8919 | 0.00255 | 0.00765 | -0.05995 |
| YCY 252 | 862308.7146 | 609084.9299 | 310.1768 | 862308.7175 | 609084.9304 | 310.1793 | -0.0029 | -0.0005 | -0.0025 |
| YCY253 | 862023.6871 | 609312.1157 | 303.6754 | 862023.6924 | 609312.1178 | 303.6582 | -0.0053 | -0.00205 | 0.01725 |
| FSS2/HND/2016/006 | 861906.5495 | 609436.7141 | 301.2852 | 861906.5568 | 609436.7508 | 301.286 | -0.0073 | -0.0367 | -0.0008 |
| FSS2/HND/2016/007 | 861753.1866 | 609557.2332 | 294.9585 | 861753.1824 | 609557.2407 | 294.9606 | 0.00425 | -0.00745 | -0.0021 |
| FSS2/HND/2016/008 | 861655.7844 | 609665.8154 | 287.6727 | 861655.7671 | 609665.8228 | 287.7165 | 0.0173 | -0.0074 | -0.0438 |
| FSS2/HND/2016/009 | 861562.3724 | 609730.6323 | 287.7044 | 861562.4013 | 609730.6783 | 287.7032 | -0.0289 | -0.046 | 0.0012 |
| FSS2/HND/2016/010 | 861348.3717 | 609939.6949 | 286.5239 | 861348.3834 | 609939.6851 | 286.5337 | -0.01165 | 0.00985 | -0.00975 |
| FSS2/HND/2016/011 | 861117.4205 | 610129.4001 | 279.9058 | 861117.4225 | 610129.4137 | 280.0069 | -0.002 | -0.01355 | -0.1011 |
| FSS2/HND/2016/012 | 860944.6577 | 610299.8552 | 279.1249 | 860944.6395 | 610299.8549 | 279.149 | 0.01825 | 0.00035 | -0.02405 |
| FSS2/HND/2016/013 | 860753.4127 | 610455.5564 | 283.2011 | 860753.3611 | 610455.1347 | 283.2145 | 0.0516 | 0.42175 | -0.0134 |
| FSS2/HND/2016/014 | 860547.5319 | 610654.4998 | 277.6651 | 860547.5286 | 610654.4982 | 277.6914 | 0.00335 | 0.0016 | -0.02625 |
| FSS2/HND/2016/015 | 860340.9903 | 610827.4892 | 272.4211 | 860340.9916 | 610827.498 | 272.4318 | -0.0013 | -0.00875 | -0.01065 |
| FSS2/HND/2016/016 | 860234.0254 | 610942.0109 | 269.724 | 860234.0028 | 610942.8137 | 269.5686 | 0.0226 | -0.80275 | 0.1554 |
| FSS2/HND/2016/017 | 860047.235 | 611091.4864 | 270.9055 | 860047.2333 | 611091.4715 | 270.8956 | 0.0017 | 0.0149 | 0.00995 |
| FSS2/HND/2016/018 | 859869.9159 | 611263.751 | 272.4471 | 859869.9317 | 611263.7072 | 272.5231 | -0.0158 | 0.0438 | -0.07595 |

Back computation was done from the final adjusted coordinates in order to obtain corrected bearings and distances in-between successive controls. The result obtained is given in Table 5.

**Table 5: Back computation of established stations.**

| FROM STN | D(o) | M(') | S('') | DISTANCE | ΔN(m) | ΔE(m) | NORTHING | EASTING | TO STN |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 866879.146 | 604755.800 | XSN 07 |
| XSN 07 | 136 | 30 | 58.2 | 5015.663 | -3617.709 | 3474.055 | 863261.437 | 608229.855 | FSS2/HND/2016/01 |
| FSS2/HND/2016/01 | 140 | 41 | 29.6 | 284.904 | -220.443 | 180.485 | 863040.993 | 608410.340 | YCY 0249 |
| YCY 0249 | 132 | 52 | 2.8 | 158.200 | -107.624 | 115.950 | 862933.369 | 608526.290 | FSS2/HND/2016/02 |
| FSS2/HND/2016/02 | 140 | 49 | 29.6 | 245.988 | -190.694 | 155.389 | 862742.675 | 608681.678 | FSS2/HND/2016/03 |
| FSS2/HND/2016/03 | 132 | 25 | 43.7 | 99.036 | -66.817 | 73.100 | 862675.858 | 608754.778 | FSS2/HND/2016/04 |
| FSS2/HND/2016/04 | 140 | 38 | 22.7 | 284.626 | -220.065 | 180.508 | 862455.793 | 608935.287 | FSS2/HND/2016/05 |
| FSS2/HND/2016/05 | 134 | 30 | 14.6 | 209.820 | -147.075 | 149.644 | 862308.718 | 609084.930 | YCY 0252 |
| YCY 0252 | 141 | 26 | 32.7 | 364.491 | -285.025 | 227.187 | 862023.692 | 609312.118 | YCY 0253 |
| YCY 0253 | 133 | 13 | 25.6 | 171.038 | -117.136 | 124.633 | 861906.557 | 609436.751 | FSS2/HND/2016/06 |
| FSS2/HND/2016/06 | 141 | 50 | 49.5 | 195.042 | -153.374 | 120.490 | 861753.182 | 609557.241 | FSS2/HND/2016/07 |
| FSS2/HND/2016/07 | 131 | 53 | 49.5 | 145.876 | -97.415 | 108.582 | 861655.767 | 609665.823 | FSS2/HND/2016/08 |
| FSS2/HND/2016/08 | 145 | 12 | 52.8 | 113.681 | -93.366 | 64.856 | 861562.401 | 609730.678 | FSS2/HND/2016/09 |
| FSS2/HND/2016/09 | 135 | 40 | 43.3 | 299.145 | -214.018 | 209.007 | 861348.383 | 609939.685 | FSS2/HND/2016/10 |
| FSS2/HND/2016/10 | 140 | 35 | 51.9 | 298.898 | -230.961 | 189.729 | 861117.423 | 610129.414 | FSS2/HND/2016/011 |
| FSS2/HND/2016/011 | 135 | 23 | 27.3 | 242.702 | -172.783 | 170.441 | 860944.639 | 610299.855 | FSS2/HND/2016/012 |
| FSS2/HND/2016/012 | 140 | 55 | 49.1 | 246.372 | -191.278 | 155.280 | 860753.361 | 610455.135 | FSS2/HND/2016/013 |
| FSS2/HND/2016/013 | 135 | 54 | 52.8 | 286.553 | -205.833 | 199.364 | 860547.529 | 610654.498 | FSS2/HND/2016/014 |
| FSS2/HND/2016/014 | 140 | 2 | 59.1 | 269.419 | -206.537 | 173.000 | 860340.992 | 610827.498 | FSS2/HND/2016/015 |
| FSS2/HND/2016/015 | 132 | 51 | 17.5 | 157.303 | -106.989 | 115.316 | 860234.003 | 610942.814 | FSS2/HND/2016/016 |
| FSS2/HND/2016/016 | 141 | 28 | 56.0 | 238.709 | -186.770 | 148.658 | 860047.233 | 611091.472 | FSS2/HND/2016/017 |
| FSS2/HND/2016/017 | 135 | 49 | 49.2 | 247.186 | -177.302 | 172.236 | 859869.932 | 611263.707 | FSS2/HND/2016/018 |

Comparative Analysis of adjusted data from Excel program and HI-Target Geomatics Office software is shown in Table 6. The discrepancies of -0.0158 to 0.0516 were observed on the Northings, -0.00995 to 0.24585 on the Eastings and the heights by -0.6545 to 0.64905. The discrepancies were negligible and within the allowable distances.

**Table 6: Comparative Analysis of adjusted data from Excel program and HI-Target GeomaticsOffice software.**

| | ADJUSTED DATA USING HI-TARGET | | | ADJUSTED DATA USING EXCEL | | | DESCREPANCY | | |
|---|---|---|---|---|---|---|---|---|---|
| STATION ID | NORTHING (m) | EASTING (m) | HEIGHT (m) | NORTHING (m) | EASTING (m) | HEIGHT (m) | NORTHING (m) | EASTING (m) | HEIGHT (m) |
| FSS2/HND/2016/01 | 863261.44 | 608229.85 | 312.91818 | 863261.43 | 608229.86 | 312.916 | 0.00835 | -0.0034 | 0.002175 |
| YCY 249 | 863040.99 | 608410.35 | 312.6263 | 863040.99 | 608410.34 | 313.2808 | 0.0015 | 0.0067 | -0.6545 |
| FSS2/HND/2016/02 | 862933.36 | 608526.30 | 313.27205 | 862933.37 | 608526.29 | 312.623 | -0.0112 | 0.0121 | 0.64905 |
| FSS2/HND/2016/03 | 862742.67 | 608681.68 | 302.3855 | 862742.68 | 608681.68 | 302.3828 | -0.00075 | -0.00415 | 0.0027 |
| FSS2/HND/2016/04 | 862675.86 | 608754.78 | 301.5266 | 862675.86 | 608754.78 | 301.5277 | -0.00045 | 0.00075 | -0.0011 |
| FSS2/HND/2016/05 | 862455.79 | 608935.29 | 311.89185 | 862455.79 | 608935.28 | 311.9111 | 0.00135 | 0.00565 | -0.01925 |
| YCY 0252 | 862308.72 | 609084.93 | 310.1793 | 862308.72 | 609084.93 | 310.1614 | -0.0025 | 0.0048 | 0.0179 |
| YCY 0253 | 862023.69 | 609312.12 | 303.65815 | 862023.70 | 609312.12 | 303.6579 | -0.0062 | -0.00705 | 0.00025 |
| FSS2/HND/2016/06 | 861906.56 | 609436.75 | 301.286 | 861906.55 | 609436.71 | 301.2852 | 0.0073 | 0.0367 | 0.0008 |
| FSS2/HND/2016/07 | 861753.18 | 609557.24 | 294.9606 | 871753.18 | 609557.24 | 294.9623 | -0.00115 | -0.00065 | -0.0017 |
| FSS2/HND/2016/08 | 861655.77 | 609665.82 | 287.7165 | 861655.78 | 609665.82 | 287.6727 | -0.0174 | 0.0074 | 0.0438 |
| FSS2/HND/2016/09 | 861562.40 | 609730.68 | 287.7032 | 861562.37 | 609730.63 | 287.7044 | 0.0289 | 0.046 | -0.0012 |
| FSS2/HND/2016/10 | 861348.38 | 609939.69 | 286.53365 | 861348.37 | 609939.70 | 286.5163 | 0.01485 | -0.00995 | 0.01735 |
| FSS2/HND/2016/11 | 861117.42 | 610128.41 | 280.0069 | 861117.41 | 610129.41 | 279.988 | 0.0084 | 0.00265 | 0.0189 |
| FSS2/HND/2016/12 | 860944.64 | 610299.85 | 279.14895 | 860944.64 | 610299.85 | 279.1374 | -0.00515 | 0.00465 | 0.01155 |
| FSS2/HND/2016/13 | 860753.36 | 610455.13 | 283.2145 | 860753.53 | 610454.89 | 281.9667 | -0.1675 | 0.24585 | 1.2478 |
| FSS2/HND/2016/14 | 860547.53 | 610654.50 | 277.69135 | 860547.54 | 610654.50 | 277.7156 | -0.01425 | 0.0016 | -0.02425 |
| FSS2/HND/2016/15 | 860340.99 | 610827.50 | 272.43175 | 860340.99 | 610827.5 | 272.4262 | 0.0047 | -0.00495 | 0.00555 |
| FSS2/HND/2016/16 | 860234.00 | 610942.81 | 269.5686 | 860233.99 | 610942.79 | 269.6274 | 0.0118 | 0.02575 | -0.0588 |
| FSS2/HND/2016/17 | 860047.23 | 611091.47 | 270.89555 | 860046.82 | 611091.29 | 270.6438 | 0.4155 | 0.1829 | 0.25175 |
| FSS2/HND/2016/18 | 859869.93 | 611263.71 | 272.52305 | 859869.96 | 611263.72 | 272.3866 | -0.0241 | -0.014 | 0.13645 |

The linear accuracy of the products was calculated and the result is presented in Table 7. With the results, it is an indication that the linear accuracy was reliable. Figure 3 shows the interface of AutoCAD Software showing the plan as the final draft for the study.

**Table 7: Linear Accuracy.**

| POINT ID | NORTHING | EASTING | MISCL. IN NORTHIG | MISCL. IN EASTIN G | TOTAL DIST. FRM. XSN 07 | TOTAL DIST. FRM. FSS1/17 | LINEAR ACCURAC Y FRM. XSN 07 | LINEAR ACCURA CY FRM. FSS1/17 | MEAN |
|---|---|---|---|---|---|---|---|---|---|
| FSS2/HND/2016/1 | 863261.4284 | 608229.858 | | | | | | | |
| | 863261.4449 | 608229.851 | -0.017 | 0.007 | 5015.68 | 7182.95 | 1/281049 | 1/402490 | 1/341769 |
| FSS2/HND/2016/2 | 862933.3667 | 608526.281 | | | | | | | |
| | 862933.3712 | 608526.298 | -0.005 | -0.02 | 5457.64 | 442.169 | 1/300429 | 1/412738 | 1/356583 |
| FSS2/HND/2016/3 | 862742.6671 | 608681.666 | | | | | | | |
| | 862742.6822 | 608681.69 | -0.015 | -0.02 | 5702.89 | 7497.88 | 1/199336 | 1/262077 | 1/230707 |
| FSS2/HND/2016/4 | 862675.8588 | 608754.774 | | | | | | | |
| | 862675.8567 | 608754.782 | 0.0021 | -0.01 | 5801.68 | 7669.86 | 1/662628 | 1/875998 | 1/769313 |
| FSS2/HND/2016/5 | 862455.7928 | 608935.281 | | | | | | | |
| | 862455.7931 | 608935.293 | -3E-04 | -0.01 | 6085.58 | 7749.61 | 1/502786 | 1/640267 | 1/571526 |
| FSS2/HND/2016/6 | 861906.5668 | 609436.746 | | | | | | | |
| | 861906.5468 | 609436.756 | 0.02 | -0.01 | 6829.2 | 7955.6 | 1/305411 | 1/355785 | 1/330598 |
| FSS2/HND/2016/7 | 861753.1817 | 609557.244 | | | | | | | |
| | 861753.183 | 609557.238 | -0.001 | 0.006 | 7023.5 | 8539.58 | 1/162538 | 1/1413481 | 1/128801 0 |
| FSS2/HND/2016/8 | 861655.7821 | 609665.82 | | | | | | | |
| | 861655.7521 | 609665.826 | 0.03 | -0.01 | 7168.82 | 8687.86 | 1/287447 | 1/283972 | 1/285710 |
| FSS2/HND/2016/9 | 861562.4072 | 609730.706 | | | | | | | |
| | 861562.3954 | 609730.651 | 0.0118 | 0.054 | 7281.31 | 113.656 | 1/130806 | 1/159845 | 1/145236 |
| FSS2/HND/2016/10 | 861348.3981 | 609939.675 | | | | | | | |
| | 861348.3686 | 609939.695 | 0.0295 | -0.02 | 7580.36 | 8897.81 | 1/213024 | 1/250047 | 1/231535 |
| FSS2/HND/2016/11 | 861117.4082 | 610129.428 | | | | | | | |
| | 861117.4368 | 610129.4 | -0.029 | 0.028 | 7878.68 | 9150.33 | 1/197191 | 1/229018 | 1/213105 |
| FSS2/HND/2016/12 | 860944.6256 | 610299.862 | | | | | | | |
| | 860944.6533 | 610299.848 | -0.028 | 0.014 | 8121.29 | 9391.21 | 1/262801 | 1/303896 | 1/283349 |
| FSS2/HND/2016/13 | 860753.3779 | 610455.582 | | | | | | | |
| | 860753.3443 | 610454.687 | 0.0336 | 0.895 | 8367.36 | 9601.03 | 1/9339 | 1/10716 | 1/10028 |
| FSS2/HND/2016/14 | 860547.5352 | 610654.5 | | | | | | | |
| | 860547.5219 | 610654.496 | 0.0133 | 0.004 | 8653.56 | 9802.61 | 1/620443 | 1/702827 | 1/661635 |
| FSS2/HND/2016/15 | 860340.9858 | 610827.504 | | | | | | | |
| | 860340.9974 | 610827.492 | -0.012 | 0.012 | 8922.63 | 10053.4 | 1/527745 | 1/594628 | 1/561186 |
| FSS2/HND/2016/16 | 860233.9754 | 610942.847 | | | | | | | |
| | 860234.0302 | 610942.78 | -0.055 | 0.067 | 9079.54 | 10280.8 | 1/104991 | 1/118882 | 1/111937 |
| FSS2/HND/2016/17 | 860047.2351 | 611091.462 | | | | | | | |
| | 860047.2315 | 611091.482 | 0.0036 | -0.02 | 9317.5 | 10423.8 | 1/458506 | 1/512946 | 1/485726 |
| FSS2/HND/2016/18 | 859869.9157 | 611263.735 | | | | | | | |
| | 859869.9477 | 611263.679 | -0.032 | 0.056 | 9564.66 | 10624.6 | 1/148294 | 1/164728 | 1/156511 |
| YCY 249 | 863040.9901 | 608410.341 | | | | | | | |
| | 863040.9967 | 608410.339 | -0.007 | 0.001 | 5299.74 | 10845.9 | 1/785513 | 1/1607557 | 1/119653 5 |
| YCY 252 | 862308.7145 | 609084.93 | | | | | | | |
| | 862308.7205 | 609084.931 | -0.006 | -0 | 6295.26 | 7374.46 | 1/1034935 | 1/1212354 | 1/112364 4 |
| YCY 253 | 862023.6893 | 609312.114 | | | | | | | |
| | 862023.6955 | 609312.121 | -0.006 | -0.01 | 6658.5 | 8124.6 | 1/695217 | 1/848293 | 1/771755 |

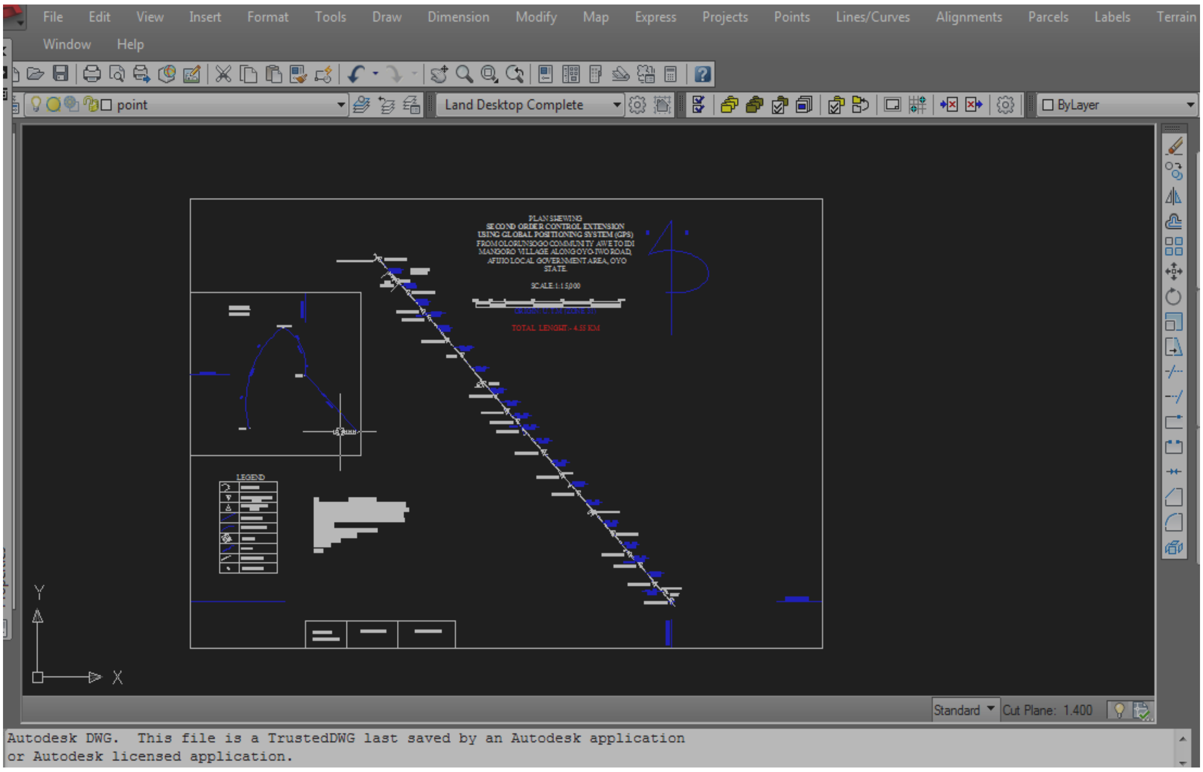


**Figure 3: Interface of AutoCAD Software showing the plan.**

## 4.0 DISCUSSION OF RESULTS

The various results obtained from one step to the other were tabulated in the Tables shown in the last section. The data from the field was downloaded into the computer system using the Trimble data transfer software. The data from the reference and rover receivers were downloaded. The downloaded data needed to be converted to Rinex Format such that it can be handled by Hi-Target Geomatic office for further processing. The data were processed via Hi- Target Geometrics Office software and the result was shown in Table 2. Observation equation method was employed in adjusting the acquired data. The adjusted data was converted from space coordinate to UTM using Hi-Target coordinate tool converter. This is shown in Table 3.

The result of data obtained from the adjusted data was analyzed and the result proved reliable as the unit variance and standard error values fall within allowable limits. The results are as shown in Table 4. Back computation was done from the final adjusted coordinates in order to obtain corrected bearings and distances in-between successive controls. The result obtained is given in Table 5. The results obtained from the Excel program and HI-Target Geomatics Office software were compared and shown in Table 6. The discrepancies were negligible. The linear accuracy of the products was calculated and the result presented as shown in Table 7. With the results, it is an indication that the linear accuracy was reliable. It is also important to state that thevarious results generated are in order and can be used for a Second Order control establishments when further extension of controls are required in the study area.

## 5.0 CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

Having completed the study successfully and the aim and objectives of control establishment were achieved, it is therefore concluded that the establishment of controls from Awe Town to Idi-Mangoro village along Oyo-Iwo Road, Afijio Local Government Area of Oyo state was a huge success. This will assist in township mapping and also serve the public and private organisations when carrying out surveying works along and around the route. The whole study was carried out in accordance with specifications of surveying profession.

### 5.2 Recommendations

It is recommended at the end of the study that Government and the bodies concerned should try as much as possible to establish more controls with higher orders along the route and if such were already on ground, they should be marked and the information should be made available on public domain.

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