Investigation of the Use of GPS in Georeferencing Satellite Images of Awka, Anambra Nigeria

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Keywords: GPS, Georeferencing, Investigation, Satellite Images.

SUMMARY

This is a summary on the paper Investigation of the use of GPS in Georeferencing Satellite Images of Awka in Anambra State Nigeria. This is a new trend in georeferencing of satellite images to compare results of affine georeferencing methods. Eight first order GPS controls were identified on ground, their values known and used to re-georeference the imagery. **G**eoreferencing can be seen as assigning geographic information to an image; it will allow the usage of the image and its location in the geographic space. GPS is used in many applications such as sea navigation, air navigation, positioning, GIS/ Surveying, precision agriculture, recreation and vehicle tracking, therefore georeferencing with GPS is the area of interest in this research. Satellite imagery has been widely used in different applications which depend on different professional approaches. This study presents a detailed analysis on the investigation of the use of GPS in georeferencing of satellite imagery using awka and its environs as the study area. Three images with different resolutions were acquired from the Nigerian Center for Remote Sensing, the images acquired were processed before delivery and eight different GPS coordinates in awka were used to regeoreferenced the imagery, very high resolution (VHR) i.e. Quickbird, high resolution (HR) i.e. SPOT_5 and medium resolution (MR) i.e. NigeriaSat_x, georeferencing was performed with four coordinate points first, secondly with six coordinate points, and finally with eight coordinate points and got the following results. Four coordinates gave Standard Deviation **= 0.0022978** and coefficient of variation of **37.344 %,** six coordinates gave Standard Deviation **= 0.0012** and coefficient of variation of **1. 981%** and finally, eight coordinates gave Standard Deviation **= 0.0052933** and coefficient of variation **6.958%** for the average of the three resolutions. It is therefore, strongly recommended that georeferencing be performed using six GPS coordinates, for optimum performance of GIS analysis of satellite imagery. This information is required for very high precision satellite image analysis.

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1. INTRODUCTION

1.1 Background of Study

GPS is used in many applications such as sea navigation, air navigation, positioning, GIS/ Surveying, precision agriculture, recreation and vehicle tracking this is the area of interest of this study. Georeferencing can be seen as assigning geographic information to an image; it will allow the usage of the image and its location in the geographic space. Knowing where a point is located in the world allows information about the features contained in it to be determined. Satellite imagery has been widely used in different applications which depend on different professional approaches. There has been much advancement in satellite imagery this will be relevant for the purpose of this study. This study presents a detailed analysis on the investigation of the use of GPS in Georeferencing of Satellite Imageries using Awka and its environs as the study area. Some studies carried out on using different methods on the above and related topics have been highlight and their needs. Data requirement for the study and techniques for data acquisition, processing and presentation is highlighted.

This research is centered on georeferencing with Global Position System (GPS) generated coordinates. Though we have many types of GNSS we will concentrate on GPS which was established by the US department of defence (DOD) in Colorado ab-initio to monitor their military base before it was allowed for public use. Its operation started on the 8th December 1993 and fully operational by 27th April 1995. Since then it has developed with lots of research interest to a point where it can give us our exact position with very high precision and accuracy which is in centimeters. On the other hand the theory of georeferencing is centered on coordinate transformation and image resampling Igbokwe (1995). Many researchers have worked on GPS, satellite imagery and georeferencing independently, but this research will be focusing on investigating accuracy of the use of GPS in georeferencing satellite imagery/ digital imagery altogether.

According to NIS, MCPD (2011) georeferencing refers to the location of a layer or coverage in space as defined by a known coordinate referencing system. Georeferencing is aligning geographic data to a known coordinate system so it can be viewed, queried, and analysed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some areas warping, rubber sheeting, or orthorectifying the data. Rao (2010). Georeferencing is a basic tool for GIS analysis. Before any analogue map is converted to digital map via rasterization to be digitized, it must be georeferenced so that the interest in the map can be digitize, to perform image enhancement, and map embellishment i.e inserting grids, map legend, scale bar, North arrow, map title and text. In the recent times, when satellite image is acquired, it need to georeferenced to enable digitization and other GIS analysis according to the purpose of the project at hand. Raster / Vector based GIS analysis to be done is Buffering, Watershed / Viewshed analysis, neighbourhood functions, and calculation of area polygon features. The use of GPS (GNSS) generated points in georeferencing satellite imagery is not common and is a new area of research. This study is to investigate the accuracy of using GNSS generated points in georeferencing imagery and compare its difference with three different satellite imagery / digital images. It is now widely accepted that the US based GPS can be applied to georeferencing.

1.2 Statement of the Problem

In surveying we try as much as possible to follow specifications and economy of accuracy. Georeferencing is an essential part of digital image processing, but it has been made common, forgetting that for we to complete image processing there is need to carefully observe these rules governing georeferencing which determine the accuracy of the satellite image produced. This has reduced the accuracies of many digital images since the principle of georeferencing depends on coordinate transformation and image resampling. Georeferencing requires well distributed points. Unfortunately, these control points are not readily available where they are needed; resulting in the use of GPS generated control points in georeferencing of satellite imageries. These form the rationale to investigate the accuracies of the use of GPS generated control points in Georeferencing of satellite imageries. These needs triggered the research and with various parameters to be employed, we will complete this study.

1.3 Aim and Objectives

This study is aimed at carrying out investigation on the use of GPS in georeferencing of satellite images. This will be achieved through the following objectives.

1. To process the image to correct errors that might be in the image and enhance visual quality of the image,

2. To identify suitable and clearly defined points from the image that will serve as control points for georeferencing,

3. To georeference the satellite image using the reference first order GPS coordinates of identified points on the image obtained from GPS, and

4. To perform statistical evaluation of the results obtained.

1.4 Study Area

The study area is awka and environs in Anambra state Nigeria. Anambra state is one of the South Eastern states of Nigeria Figure 1.0 below shows the study area. The state lies between coordinates 6^o35'E - 7^o30'E and 5^o40'N – 6^o48N. It was created on 27 August 1991 and has an approximate area of 4,844 km^2 (1,870.3 sq mi). Awka is the capital of Anambra state geographical coordinate of 6˚12' 25" N and 7˚ 04' 04" E. Awka has a certain kind of aura about it, because it was the place of the blacksmiths that created implements which made agriculture possible. Chinua Achebe. Based on 2006 population census, the population of Awka is about 301657 (three hundred and one thousand six hundred and fifty-seven) people. Awka lies below 300 metres above sea in a valley on the plains of the Mamu River. It is sited in a fertile tropical valley but most of the original Rainforest has been lost due to clearing for farming and human settlement. It is one of the oldest settlements in Igbo land established at the center of the Nri civilization which produced the earliest documented bronze works in Sub-Saharan Africa around 800 AD and was the cradle of Igbo civilization. Awka is in the tropical zone of Nigeria and experiences two distinct seasons brought about by the two predominant winds that rule the area: the south-western monsoon winds from the Atlantic Ocean and the north-eastern dry winds from across the Sahara desert. The monsoon winds from the Atlantic creates seven months of heavy tropical rains, which occur between April and October and are followed by five months of dryness (November - March). The Hamattan comes December or in the early part of January. The temperature in Awka is generally 27-30 degrees Celsius to 32-34 degrees. The economy of Awka city revolves primarily around government since many state and federal institutions are located there. Awka hosts the State

Governor's Lodge, State Assembly and State Ministries for Health, Education, Lands, and Water. The largest market in the town is Eke Awka, named after one of the four market days.

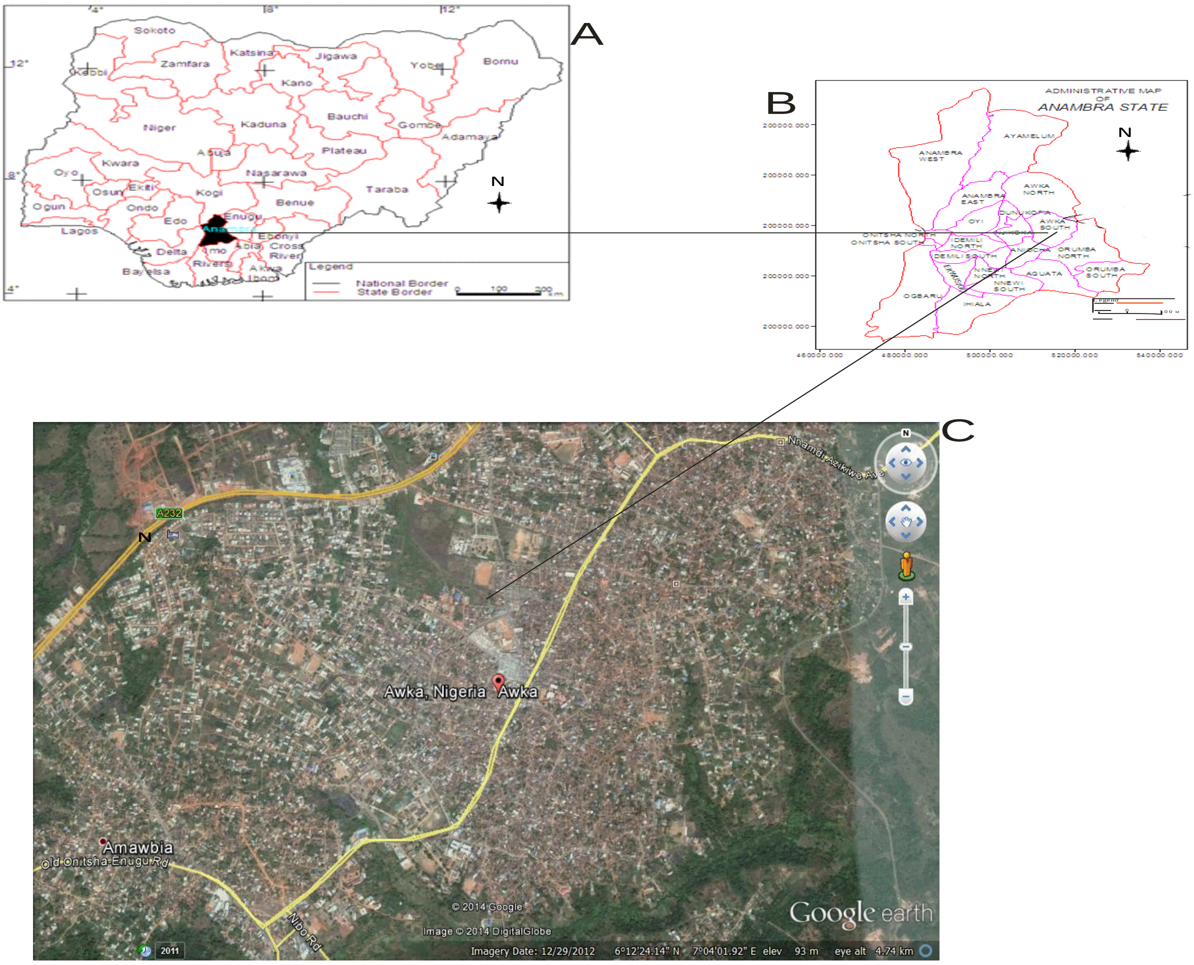

Fig. 1.0 A is Map of Nigeria showing Anambra State, B is Map of Anambra State showing Awka, C is satellite imagery of study area Awka and environs. (Not to scale).Source: Ministry of Lands and Survey, Awka.

2. THEORY OF GEOREFERENCING OF SATELLITE IMAGERY

The theory of georeferencing is centered on transformation of the coordinates and resampling of the image. Let’s assume now that we want to transform coordinates between the WGS84 (G1150) ≡ ITRF2000 and NAD83 (CORS96). The first thing that we need to keep in mind is that, in theory, the WGS84 (G1150) or ITRF2000 coordinates are the first one computed by the receiver software. However, they are originally obtained at the time of the observation, that is, the epoch corresponding to the mid-point of the observation window during the GPS data were collected. Consequently, we cannot compare coordinates from a set of observations taken today to results we determined one year ago. These two sets of coordinates must be reduced to a common epoch before the comparison is made. Let's assume that we want to compare the coordinates we obtained today referred to the ITRF2000 to the ones at epoch 1997.0. Some receivers may be already doing this transformation from epoch to epoch and the final result may be already expressed in the frame WGS84 (G1150) ≡ ITRF2000 at epoch 1997. This will simplify the work involved; otherwise we should know the velocity of the GPS station due to the rotation of the tectonic plate on which is located. These velocities are not rigorously known until we have constantly monitored the point for a number of years. This is not generally the case and we must rely on geophysical models. The most common model used these days for correcting for plate rotations is called NNR-NUVEL-1A. This model provides the parameters required to correct for plate motion for all major plates (macroplates) forming the crust of the earth. When we explicitly change the number of pixels in the image, the process is called Resampling, in this case as we are reducing size. To do this in Photoshop, you need to select the Resample Image option at the bottom of the Image Size dialog which then lets you change the Width and Height settings to the exact number of pixels required (this can also be set as a percentage of the current dimensions). When you click OK, after some processing, the new smaller version of the image will appear. Figure 2.7 below shows the window for image resampling.

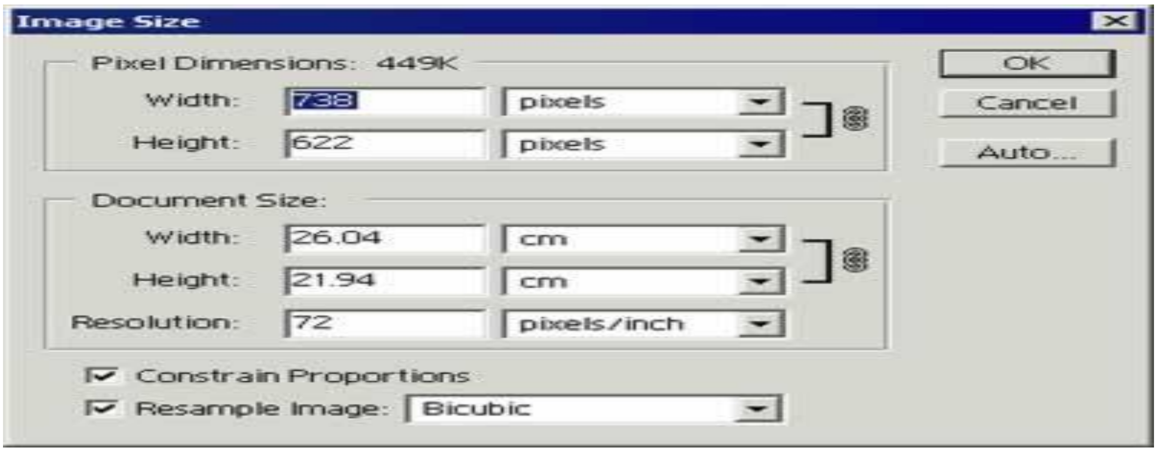

Fig. 2.1 Image resampling, Source: Tom Arah (2002)

3. METHODOLOGY

3.1 Introduction

This section focuses on the methodology adopted in execution of the research project. This is subdivided into various steps such as: Data need data source, data processing and analysis and so on. The contents of the flowchart will be discussed below.

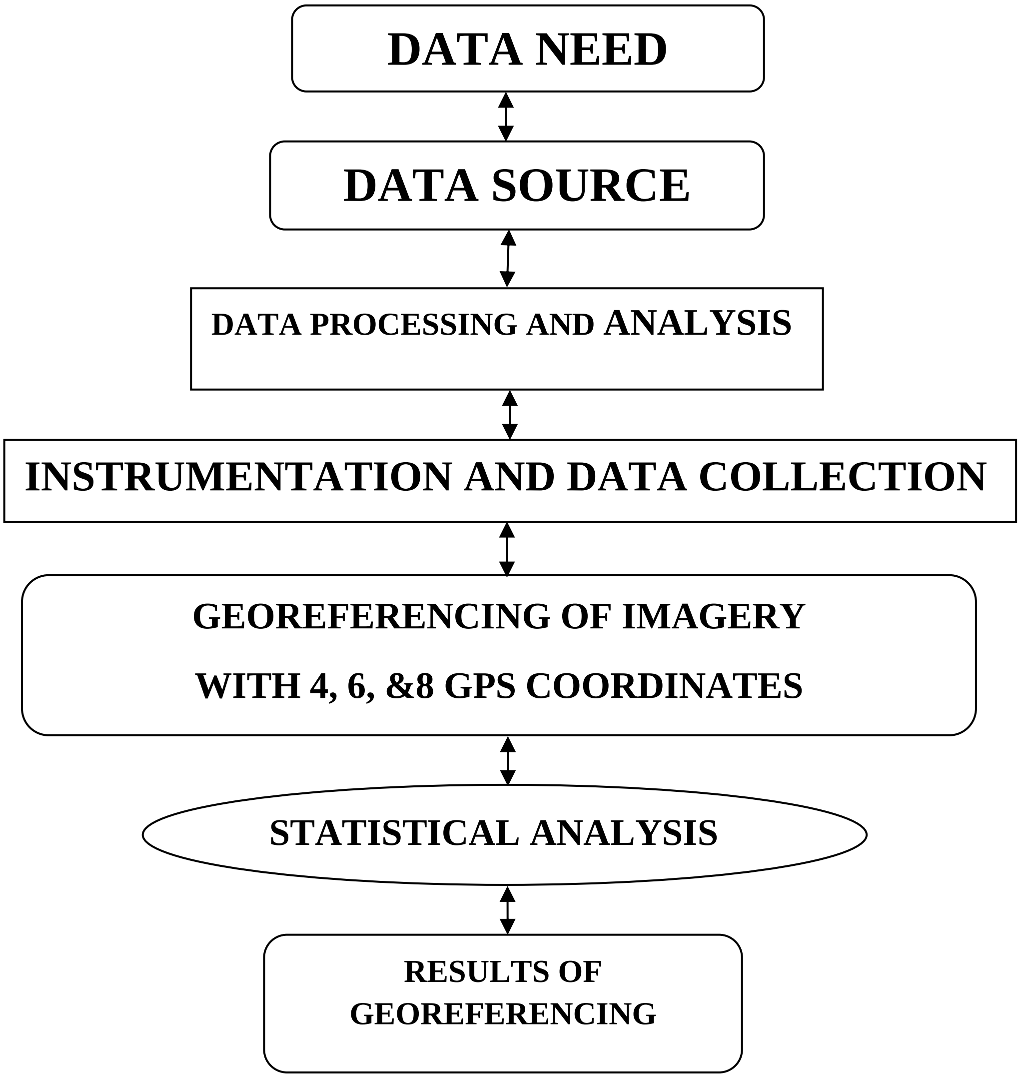

Fig 3.0 - Flow Chart

3.2 Data Need

From the flowchart above, the data needed for the success of this study are listed below.

1. Scanned Awka and environs Topographic map updated (2002) at 1:50,000.
2. Satellite Imagery of Awka and Environs consisting of
    a. Very high resolution imagery e.g Quick bird of 1m.
    b. High resolution imagery e.g SPOT 5 of 5m.
    c. Medium resolution Imagery e.g NigeriaSat-X of 22m.
3. GPS coordinates of some controls.

3.3 Data Source

1. The processed image data of the study area were gotten from National Center for Remote Sensing (NCRS) Jos, Plateau State.
2. The Topographic map of Awka was obtained from the Ministry of Lands and Survey Awka, Anambra State.
3. The Garmin 76 GPS receiver is gotten from the Department of Surveying and Geoinformatics Federal Polytechnics Oko.
4. Other ancillary data such as Street Guide Map that will aide in feature identification, GPS control coordinates was obtained from Ministry of Lands and Survey Anambra State.

3.4 Data Processing and Analysis

This imagery was processed at the National Center for Remote sensing Jos before releasing to clients, and when gotten in a CD-Rom it was taken to the Laptop to store it in the C-drive of the computer where it was recalled to the GIS software Arc Gis 9.3a, it was later analysed to know if it met the accuracies they were acquired for. After which it was added to the software environment to view it for further noise, but none was found. The following gadgets will be used adequately to process, analyze and finally present this data.

3.4.1 Hardware's: The minimum system configuration used for this project is listed below

(i) CPU Intel Pentium of 500G Capacity, 4 G RAM and 3G Processor Speed.
(ii) A3 HP coloured Printer.
(iii) A0 HP scanner
(iv) Handheld GPS (Geodetic GPS) Garmin 76.
(v) 4.0 GB Flash drive.

3.4.2 Software's

(a) ArcGIS 9.3 version.

(b) El-Shayal smart web online map editor.

(c) Microsoft Notepad.

(d) Microsoft Word.

3.5 Instrumentation and Data Collection

The major survey instrument used during the ground surveying was the Garmin 76 GPS receiver. The GPS device was used to check the in-situ of the GPS control used to know if the value obtained has any disparity with the value obtained ab-initio using differential GPS and to certify that the controls has not been moved. This is the survey content of this study, when gotten it was used to check on the GPS controls acquired by very precise instrument (Differential GPS), since the present is of lower accuracy it was just used to check conformity of the values.

3.5.1 Steps Employed on the Ground Survey Methods

The value of the controls obtained from the Ministry of Lands and Survey Awka was checked considering the Survey basic principles of independent check. The GPS controls points used was visited to know if they were in-situ, when found the GPS device was used to check it's conformity with the one obtained from the Ministry. If the values obtained were correct to the whole number, it was ascertained correct because the instrument used in obtaining the former is of higher accuracy since it was Differential GPS. This was done for each ground control points at different locations to verify if it is In-situ.

3.5.2 Procedure for Georeferencing

The first order GPS coordinates gotten from Ministry of Lands and Survey were used to perform georeferencing using ArcGIS 9.3 on the each of the processed image i.e. very high resolution image (VHR) Quick bird, high resolution image (HR) SPOT-5 and medium resolution (MR) NigeriaSat_X. The imagery above are the three different resolutions, the coordinate points and its positions as used for the georeferencing. The image was georeferenced first with four GPS coordinates and its positional error noted, secondly with six GPS coordinates and it's positional error noted and finally with eight GPS coordinates and the positional error. The positional errors or root mean square errors as the case maybe were determined and shown in the following tables below.

3.6 Georeferencing the Imageries with 4, 6, & 8 GPS Coordinates

This is the major aspect of this study, the imageries acquired were georeferenced with the GPS generated coordinates and these was done systematically with a set of four control points firstly, and the performance were noted and recorded, further more with six GPS generated coordinates and its performance was recorded and finally a set of eight GPS generated coordinates was employed and it gave yet another sets of values.

3.7 Statistical Analysis

The set of values from each satellite imagery, Very High Resolution (VHR) High Resolution (HR) and Medium Resolution (MR) were now summed up to find their averages for each set of four, six and eight control points and used to carry out two independent statistical analysis which is Standard Deviation (SD)/ Variance and Coefficient of Variation (COV).

3.8 Results of Georeferencing

The results of the georeferencing procedures will be presented below as it were and after the analysis their values will be summarized as my research findings.

Table 3.0 FIRST ORDER GPS COORDINATES USED FOR GEOREFERENCING

STN ID	EASTINGS	NORTHINGS	DECIMALDEG(LONG)	DECIMALDEG(LAT)	DEG MINS SEC	DEG MINS SEC
ANSGPS 4	288120.240	688768.873	7.085012254	6.227786177	7°05'06.04411"	6°13'40.03024"
ANSGPS 15	291001.175	692154.871	7.110930995	6.258493804	7°06'39.35158"	6°15'30.57769"
ANSGPS 22	284508.538	691631.933	7.052286452	6.253551596	7°03'08.23123"	6°15'12.28575"
ANSGPS 27	285240.437	685050.308	7.059117586	6.194071454	7°03'32.82331"	6°11'38.65723"
ANSGPS 32	286034.749	688005.342	7.066195910	6.220814321	7°03'58.30528"	6°13'14.93156"
ANSGPS 34	283297.414	693613.172	7.041277294	6.271423129	7°02'28.59826"	6°16'17.12326"
ANSGPS 35	287727.537	691850.219	7.081362927	6.255632152	7°04'52.90654"	6°15'20.27575"
ANSGPS 37	291767.267	689603.596	7.117938323	6.235451755	7°07'04.56716"	6°14'07.62632"

Table 3.1 FOUR COORDINATES OF V. H. R GEOREFERENCING

283297.365860	693613.235191	283297.414000	693613.172000
287727.381072	691850.214316	287727.537000	691850.219000
291766.949697	689603.517828	291767.267000	689603.596000
286034.252069	688005.196427	286034.749000	688005.342000

POSITIONAL ERROR =0.00327m Transformation type:1st order polynomial (Affine)

Table 3.2 FOUR COORDINATES OF H. R GEOREFERENCING

283297.495576	693613.088753	283297.414000	693613.172000
287727.596740	691850.162948	287727.537000	691850.219000
291767.365285	689603.588089	291767.267000	689603.596000
286035.454999	688005.657205	286034.749000	688005.342000

POSITIONAL ERROR = 0.00960m Transformation type: 1st order polynomial (Affine)

Table 3.3 FOUR COORDINATES OF M. R GEOREFERENCING

283297.290235	693613.087314	283297.414000	693613.172000
287727.656420	691849.659535	287727.537000	691850.219000
291767.176032	689602.225264	291767.267000	689603.596000
286031.900659	688002.305509	286034.749000	688005.342000

POSITIONAL ERROR =0.00559m Transformation type: 1st order polynomial (Affine)

Table 3.4 SIX COORDINATES OF V.H. R GEOREFERENCING

283297.365860	693613.235191	283297.414000	693613.172000
287727.381072	691850.214316	287727.537000	691850.219000
291766.949697	689603.517828	291767.267000	689603.596000
286034.252069	688005.196427	286034.749000	688005.342000
284508.466398	691631.867351	284508.538000	691631.933000
291001.117951	692154.774816	291001.175000	692154.871000

POSITIONAL ERROR = 0.05947m Transformation type: 1st order polynomial (Affine)

Table 3.5 SIX COORDINATES OF H. R GEOREFERENCING

283297.495576	693613.088753	283297.414000	693613.172000
287727.596740	691850.162948	287727.537000	691850.219000
291767.365285	689603.588089	291767.267000	689603.596000
286035.454999	688005.657205	286034.749000	688005.342000
284508.708483	691631.997452	284508.538000	691631.933000
291001.099693	692154.758211	291001.175000	692154.871000

POSITIONAL ERROR = 0.05985m Transformation type: 1st order polynomial (Affine)

Table 3.6 SIX COORDINATES OF M. R GEOREFERENCING

283297.290235	693613.087314	283297.414000	693613.172000
287727.656420	691849.659535	287727.537000	691850.219000
291767.176032	689602.225264	291767.267000	689603.596000
286031.900659	688002.305509	286034.749000	688005.342000
284507.419794	691630.932022	284508.538000	691631.933000
291002.523109	692155.031467	291001.175000	692154.871000

POSITIONAL ERROR = 0.06236m Transformation type: 1st order polynomial (Affine)

Table 3.7 EIGHT COORDINATES OF V. H. R GEOREFERENCING

283297.365860	693613.235191	283297.414000	693613.172000
287727.381072	691850.214316	287727.537000	691850.219000
291766.949697	689603.517828	291767.267000	689603.596000
286034.252069	688005.196427	286034.749000	688005.342000
284508.466398	691631.867351	284508.538000	691631.933000
291001.117951	692154.774816	291001.175000	692154.871000
285239.567759	685050.230891	285240.437000	685050.308000
288119.734961	688768.831236	288120.240000	688768.873000

POSITIONAL ERROR = 0.06813m Transformation type: 1st order polynomial (Affine)

Table 3.8 EIGHT COORDINATES OF H. R GEOREFERENCING

283297.495576	693613.088753	283297.414000	693613.172000
287727.596740	691850.162948	287727.537000	691850.219000
291767.365285	689603.588089	291767.267000	689603.596000
286035.454999	688005.657205	286034.749000	688005.342000
284508.708483	691631.997452	284508.538000	691631.933000
291001.099693	692154.758211	291001.175000	692154.871000

285241.369864	685050.739952	285240.437000	685050.308000
288120.806297	688768.952637	288120.240000	688768.873000

POSITIONAL ERROR = 0.08376m. Transformation type: 1st order polynomial (Affine)

Table 3.9 EIGHT COORDINATES OF M. R GEOREFERENCING

283297.290235	693613.087314	283297.414000	693613.172000
287727.656420	691849.659535	287727.537000	691850.219000
291767.176032	689602.225264	291767.267000	689603.596000
286031.900659	688002.305509	286034.749000	688005.342000
284507.419794	691630.932022	284508.538000	691631.933000
291002.523109	692155.031467	291001.175000	692154.871000
285235.376704	685045.356313	285240.437000	685050.308000
288118.525917	688766.540563	288120.240000	688768.873000

POSITIONAL ERROR = 0.07632m. Transformation type: 1st order polynomial (Affine).

4. PRESENTATION AND DISCUSSION OF RESULTS

This section discussed the procedures adopted in the presentation and discussion of the final results. The procedures to be adopted in the presentation of results was based on the software's operation used, this helped in carrying out required analysis by the step by step method used in its operation. Though the difference made on the imagery after the series of georeferencing done with the GPS coordinates was not noticed because of the accuracy of the coordinates, if not the imagery would have warped and will lose its shape and form, showing that the georeferencing was poorly done. More so, looking at the values Root Mean Square (RMS) gotten during georeferencing one will quickly agree that using GPS coordinates will yield a better result compared with other methods of georeferencing. All the values gotten during this operation were good. The final result solves another research need. It is generally believed that the more the coordinates used the better the accuracy of the imagery georeferenced, these has further proved that for accuracy and best performance of the imagery the number of GPS generated coordinate to be used should be six, though this is subject to review in future research when other factors are considered. This has further demonstrated the readiness to complete the study by fulfilling the aims and objectives of this study.

4.1 Project Products

At the end of the project it is expected to deliver followings;

1. Georeferenced satellite images from the three resolutions and the accuracies of the georeferencing in tabular forms.
2. The positions of the coordinates on each satellite imagery.
3. Statistical analysis of the results of the georeferencing.

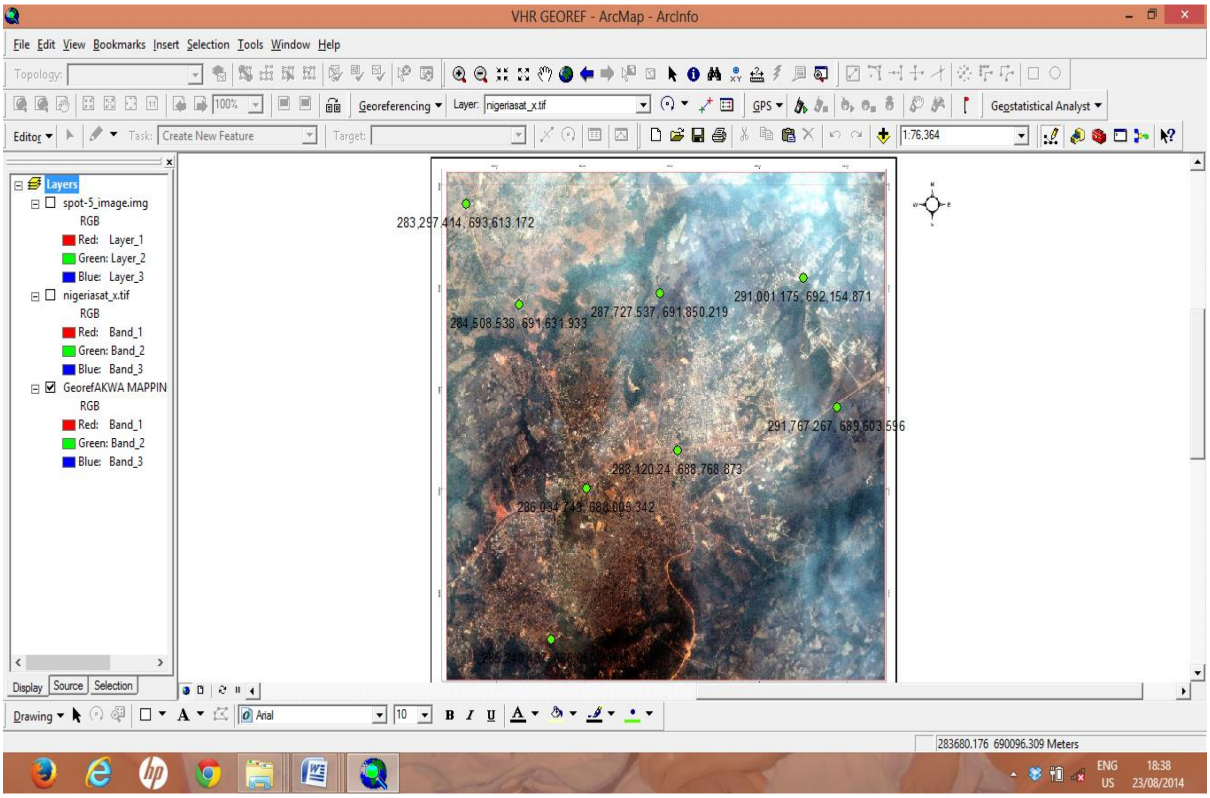

Fig. 3.0 VERY HIGH RESOLUTION IMAGE OF STUDY AREA SHOWING LOCATION OF CONTROL POINTS (QUICKBIRD)

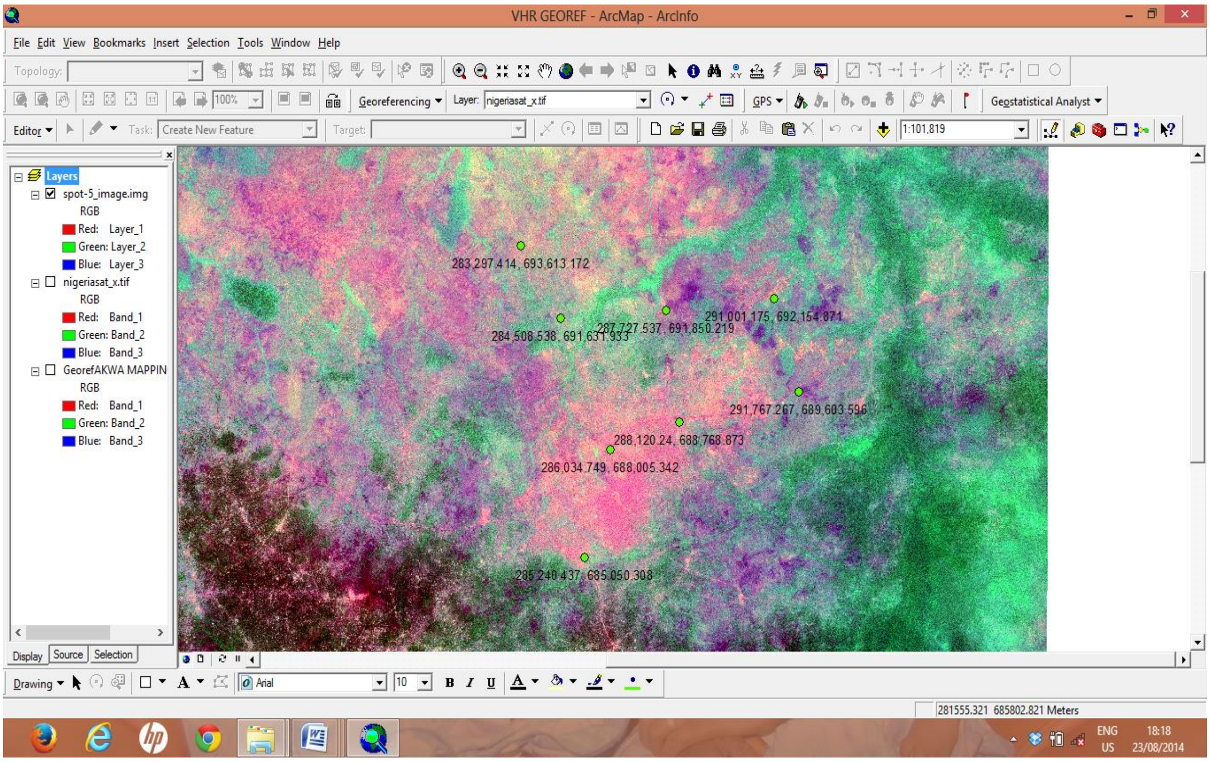

Fig.4 HIGH RESOLUTION IMAGE OF STUDY AREA SHOWING LOCATION OF CONTROL POINTS (SPOT 5)

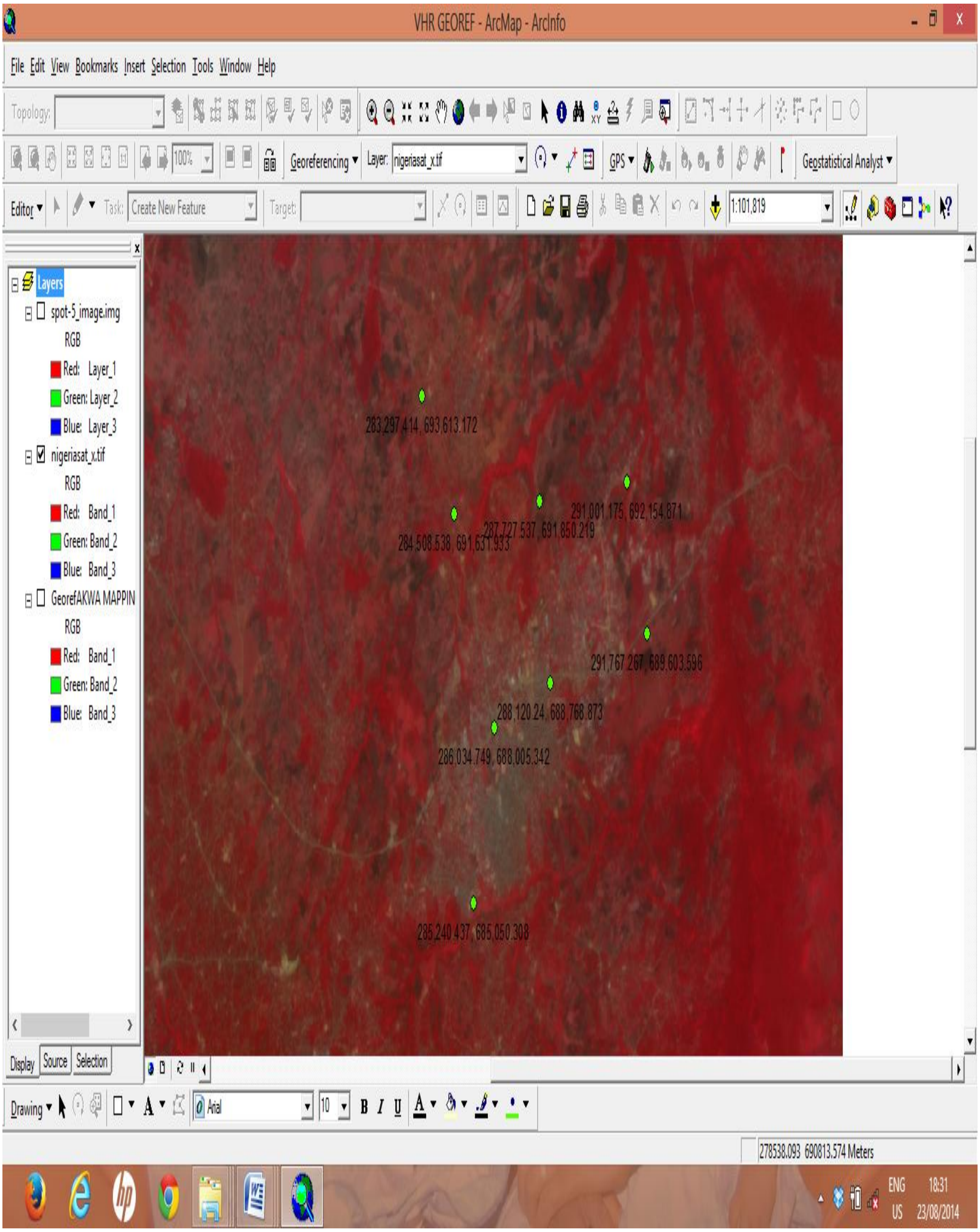

Fig. 5 MEDIUM RESOLUTION IMAGE OF STUDY AREA SHOWING LOCATION OF CONTROL POINTS (NIGERIASAT_X)

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BIOGRAPHY

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