Journal of Science and Technology, Vol. 38, Nos. 1, 2 &3 (2020), pp11 –20 11

http://dx.doi.org/10.4314/just.v38i1.2

RESEARCH PAPER

GOOGLE EARTH AS IMAGE SOURCE IN PHOTOGRAMMETRIC MAPPING OF KNUST CAMPUS

A. B. Agyemang[1], **J. A. Quaye-Ballard**[2*], **R. Y. Ohemeng**[3] and **E. Y. Asante**[3]
Department of Geomatic Engineering, Faculty of Civil and Geo-Engineering,
College of Engineering, KNUST, Kumasi
[1]*abagyemang.coe@knust.edu.gh;* [3]*ryohemeng@yahoo.com;* [4]*emmanuel.asante@outlook.com*
[*]*Corresponding author: quayeballard.soe@knust.edu.gh*

ABSTRACT
The increasing demand for maps resulting from the unending and ever-increasing activities of man has made the provision of maps a subject of considerable importance. This paper describes a practical application of Google Earth satellite images for the production of a planimetric map of the Kwame Nkrumah University of Science and Technology (KNUST) campus using the Delta Digital Photogrammetric Workstation (DDPW). The satellite images obtained at the scale of 1:2500 from the internet through the Google Earth software were loaded into the DDPW. Georeferencing was performed on each abstracted image using ground controls obtained with a geodetic standard Global Position System (GPS) receiver and, finally, map features were digitized in the DDPW. The digitized work was then exported into Computer Aided Design (CAD) software for further editing. Closed-loop traversing was done with a Total Station to provide base data for accuracy checks. The Relative Positional Errors (RPE) were analysed for three scenarios as Google-derived map versus Ground Survey, Survey and Mapping Division (SMD) map versus Ground Survey, and Google-derived map versus SMD map. The results demonstrated efficiency of mapping with Google images at the scale of 1:2500 for planimetric features at ground level only, and in respect of mapping at 1:5000 for features at ground level and up to the level of a single-storey building.

Keywords: *Satellite images, photogrammetry, GPS, GIS, maps*

INTRODUCTION
Maps are a universal medium for communication, and are easily understood and appreciated by most people, regardless of language or culture (Kraak and Ormeling, 2013; Peuquet and Kraak, 2002). Incorporated in a map is the understanding that it is a "snapshot" of an idea, a single picture, and a selection of concepts from a constantly changing database of geographic information (Merriam, 1996). For any project to commence, maps are sought in order to get acquainted with the situation existing on the ground (Dickinson, 1979). Maps are one means by which scientists distribute their ideas and pass them on to future generations (Merriam, 1996). The increasing demand for maps from various walks of life, which include individuals, groups and commercial enterprises as well

as value additions to geographic data for use by various disciplines, has become necessary. The need for up-to-date maps for land-based research and projects cannot be underestimated. It is in this interest that this paper seeks to address the convenience, feasibility, accuracy, speed and the cost at which maps could be revised or even produced with the use of Google Earth satellite images.

The Survey and Mapping Division (SMD) of the Lands Commission of Ghana, which has branches in all the regional capitals of Ghana, is responsible for the making and revision of maps (SMD, 2008). The Division is supposed to carry out map revision every five years by photogrammetric methodology. Due to the cost involved in carrying out this activity, and the time and effort involved in the supplementary ground survey work, map revision is not carried out as frequently as required. These deficiencies have over the years resulted in inadequate and outdated geographic data, multiple land-use problems and delays in both major and minor land projects. Maps are valuable assets in the making and implementation of decisions that drive the economies of countries. With increasing demand from various walks of life including individuals, groups and commercial enterprises. Therefore value additions to geographic data for use by various parties have become even more imperative.

The Google Earth resource has been successfully employed by different users all around the globe in surveillance (Chang *et al.*, 2009), modern Cartography (Arman, 2010), interactive maps (Boulos, 2005), explorations (Yu and Gong, 2012), participatory and community mapping (Lefer *et al.*, 2008), reconnaissance surveys (Kennedy and Bishop, 2011), execution of projects (Kaimaris *et al.*, 2011), teaching (Lamb and Johnson, 2010), 3D Visualizations (Yu and Gong, 2012), etc. Photogrammetric techniques provide elementary methods of planimetric mapping for Geographic Information System (GIS), digital image processing, ground control points for aerial surveys, aerotriangulation, project planning, etc. (Wolf and Dewitt, 2000). It is in this interest that this research is undertaken to investigate the convenience, feasibility, accuracy, speed and cost at which maps could be revised or even produced with the use of Google Earth satellite images. The aim of this research is, therefore, to derive a topographic line map from Google Earth satellite images at the scale of 1:2500. It is investigated how the appropriate images could be captured and map features extracted from Google Earth to produce a planimetric map of Kwame Nkrumah University of Science and Technology (KNUST) using the Delta Digital Photogrammetric Workstation (DDPW) and, finally, to investigate whether the resulting map would meet the mapping accuracy standards of the SMD.

MATERIALS AND METHODS

Study area

The campus of KNUST occupies about $19km^2$ land area of the Kumasi Metropolis, Ashanti Region of Ghana (Fig 1). KNUST is very well known for academic excellence. The campus has well-organized institutional and residential facilities. These include administrative offices, halls of residence, hostels, lecture halls, lecturers' residences, sports arenas, roads, banks, a botanical garden, a museum, and other buildings for commercial purposes.

Data and equipment

The research employed satellite images from Google Earth for the extraction of map features by use of photogrammetric mapping principles. Selected points on the acquired images were coordinated with a GPS receiver for georeferencing. The DDPW was used for the extraction of the image features and the final editing done with a Computer Aided Design (CAD) package. Field verification was done to help in the analysis of the work. A Geodetic Sokia GPS was used for the coordination of ground controls. Spectrum survey software was used to process the GPS data. A Total Station was used for field verification. The DDPW was used to extract features from the Google Earth images. High-speed internet was used to download the Google Earth satellite images. Existing topographic map of KNUST was used as a guide for extracting features from the Google Earth images.

Data extraction and processing

The images were downloaded and saved at a

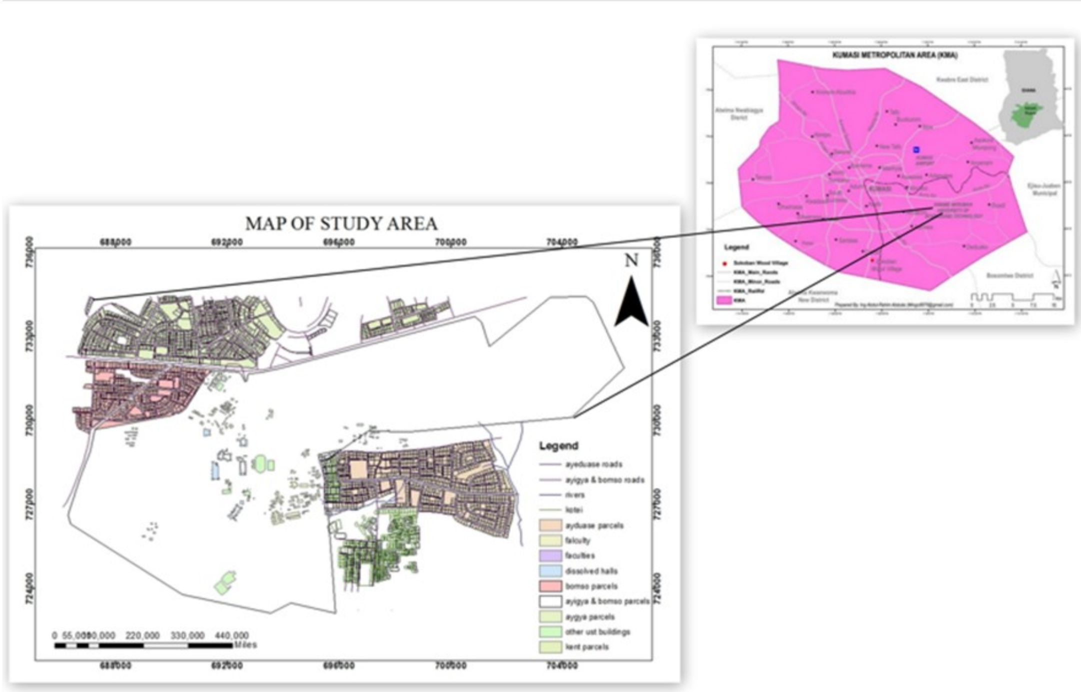

Fig. 1: Study Area – KNUST campus

Table 1: Matrix structure of the relative positions of abstracted images

	a	b	c	d	e	f
1	1a	1b	1c	1d	1e	1f
2	2a	2b	2c	2d	2e	2f
3	3a	3b	3c	3d	3e	
4		4b	4c	4d	4e	

scale of 1:2500. Care was taken to allow some amount of overlap between the various images so as to ensure a continuum of images such that one big image covering the entire study area could be obtained. In all, twenty-one different pages were downloaded resulting in twenty-one different images for the research. The relative positions of the saved images in rows and columns are as shown in Table 1 and Fig. 2.

The DDPW works with images in tiff format. To make the images compatible with this system, all the images which were in jpeg format were converted into tiff format.

Establishing ground controls

Provision of *Ground Control* involves getting points whose positions are known in object-space reference coordinate system and whose

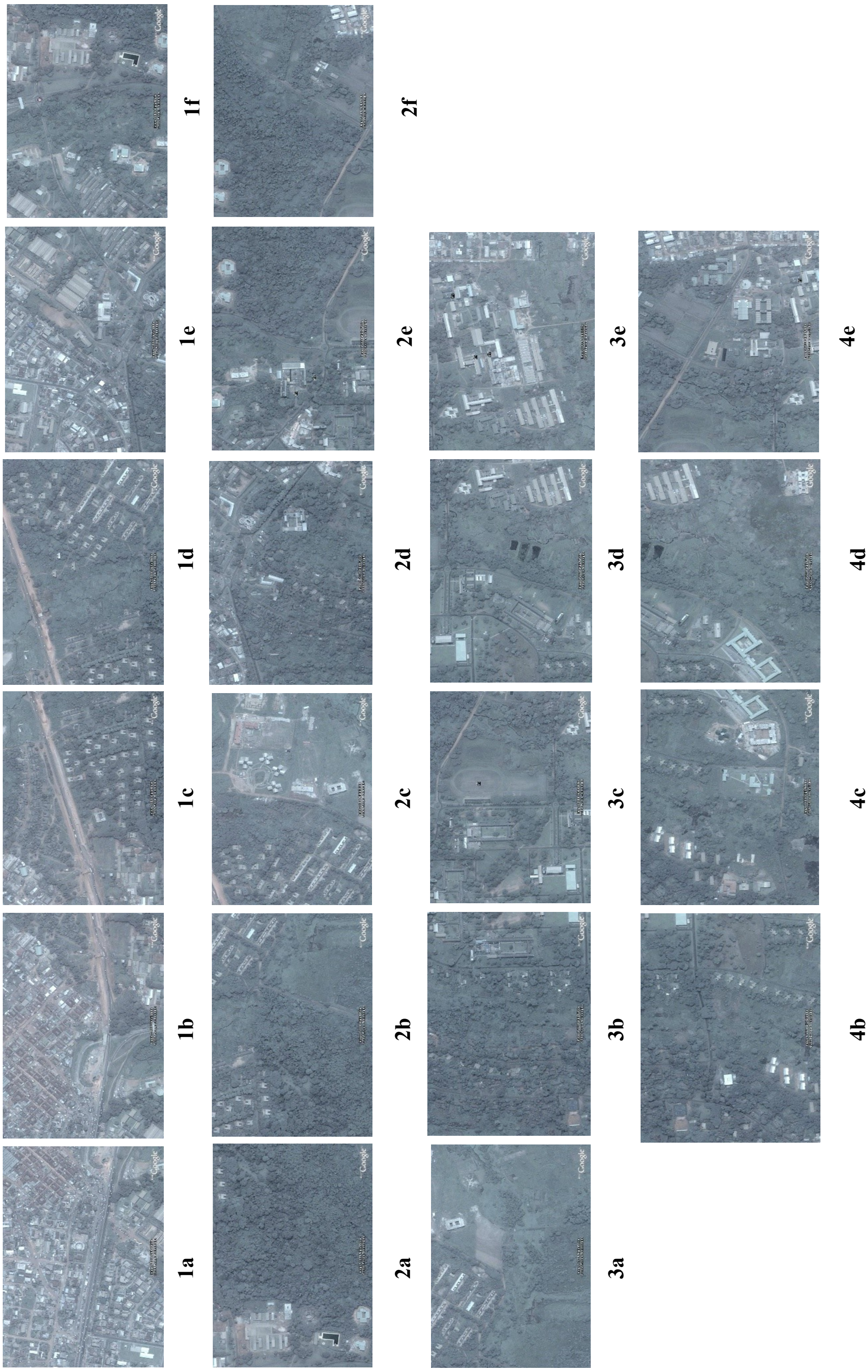

Fig. 2: The downloaded Images in their relative positions

images can be positively identified on the images or photographs. This stage helps to orient or relate satellite images to the ground. In this work, planimetric controls were established and used. The accuracy of a finished map can be no better than the ground control upon which it was based (Wolf, 1983). In the selection of the image controls, two basic requirements were satisfied - points were selected to be sharp, well -defined in planimetry, and positively identifiable on the images; and points were chosen to lie in favourable locations on the images. After careful study of the images, four points were selected on every image, with pairs common to adjacent images. Corners of buildings and intersections of roads were the preferred point types.

Data extraction and processing using DDPW on Google Earth

In entering ground control points in the DDPW software, the main MODEL window was selected. The four ground controls of a particular image were loaded in the ground point list window. After this process, georeferencing was performed on the image. In the absolute orientation startup window, the options suitable for the work were selected. Under *survey method*, the option *map* was selected and for the *orientation method*, *single image* was selected because only one image was dealt with at a time. These ground control points were then registered at their respective positions on the image. The *mapping* tab was selected for digitizing in the DDPW software. On the menu bar, *Raster* tab was clicked and the *open* option selected. The image on which absolute orientation was performed was then loaded. This activated the *collection or construction mode*. At this stage, five different layers under which the various features were to be digitized were created. Each layer was given a unique colour to distinguish it from the other layers. The layers included buildings, roads, untarred roads, pavements and uncompleted buildings.

After all the features had been collected in the mapping mode, the entire digitized work was saved in the CAD recognizable format *dxf+ dbf* (drawing interchange format). The saved file in dxf format was opened in the CAD package. In the CAD application window, a grid at intervals of 200m was put on the digitized features. A border was created around the entire work. The various collected features were named. A legend box was created below the main border around the work. Here, all attribute data was entered. After all necessary editing had been performed the finished work was saved for printing. The entire workflow in the extraction of map features from the Google images is as shown in Fig. 3.

Field work

At this stage, discrete points on the ground and at corners of buildings were randomly selected. A Total Station was used to carry out a traverse survey to obtain the planimetric coordinates of all the selected points on the ground and at building corners at various elevation levels.

RESULTS AND DISCUSSIONS

The product planimetric map of KNUST, derived after the extraction of map features from the Google images is as shown in Fig. 4. To check positional accuracies of points on the derived map, discrete points on the ground and at corners of buildings of varying heights were selected and their respective co-ordinates recorded. The co-ordinates of these points were then compared to the co-ordinates of the same points from two different sources – co-ordinates obtained from survey with the Total Station, and from a 1:2500 topographic map of KNUST obtained from SMD. To check the reliability of the co-ordinates from the ground survey, the ground survey co-ordinates were compared with the same co-ordinates on the SMD map. The points were grouped into four categories - discrete points on the ground i.e., road intersections, etc.; points at roof corners of single-storey buildings; points at roof corners of two-storey buildings; and points at roof corners of buildings three-storey or higher. The deviations in the Northings and Eastings for the four categories in respect of Google Map versus Ground Survey (G vrs GS), SMD Map versus Ground Survey (SMD vrs GS), and Google Map versus SMD Map (G vrs SMD), which resulted from the comparisons, were used to calculate the Relative Positional Error (RPE) summarised in Table 2.

According to National Map Accuracy Stand-

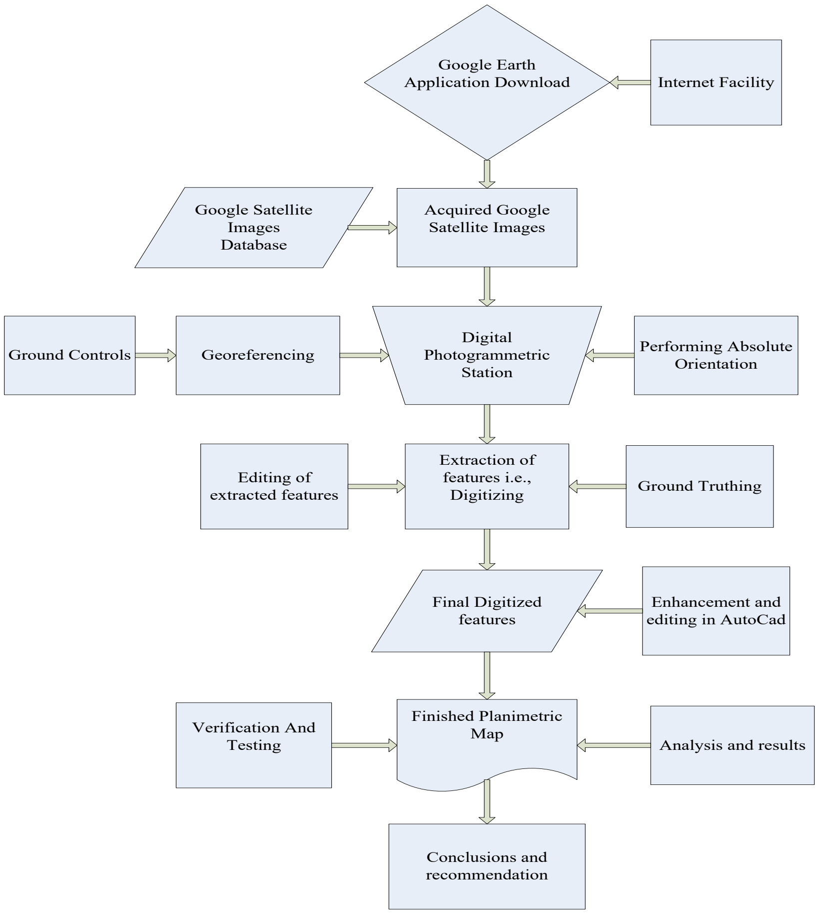

Fig. 3: Diagrammatic representation of work flow

ards, for a map produced by photogrammetric techniques, it is required that 90% of the principal planimetric features be plotted to within 1/30 in or 0.08 cm of their true positions for map scales of 1:20000 or larger (Wolf, 1983). With reference to the preceding statement, the map produced from Google satellite images at the scale of 1:2500 is, therefore, expected to not have more than 10% of its points tested to be in error by more than 2m of their true positions on the ground. The National Map Accuracy Standards of SMD of the Ghana Lands Commission stipulates that for scales larger than 1:20000, not more than 10% of plotted positions should be in error by 0.08cm (SMD, 2008). This means planimetric error should not exceed 2m for mapping at a scale of 1:2500, and should not exceed 4m for mapping at 1:5000. Table 3 shows the Compliance Percentages of the various scenarios for mapping at 1:2500 and 1:5000. Table 3 shows that if mapping is to be done at a scale of 1:2500 using unrectified Google images, then only points on ground level can be reliably mapped or have their coordinates reliably assigned on map. For mapping at a scale of 1:5000, however, derived or

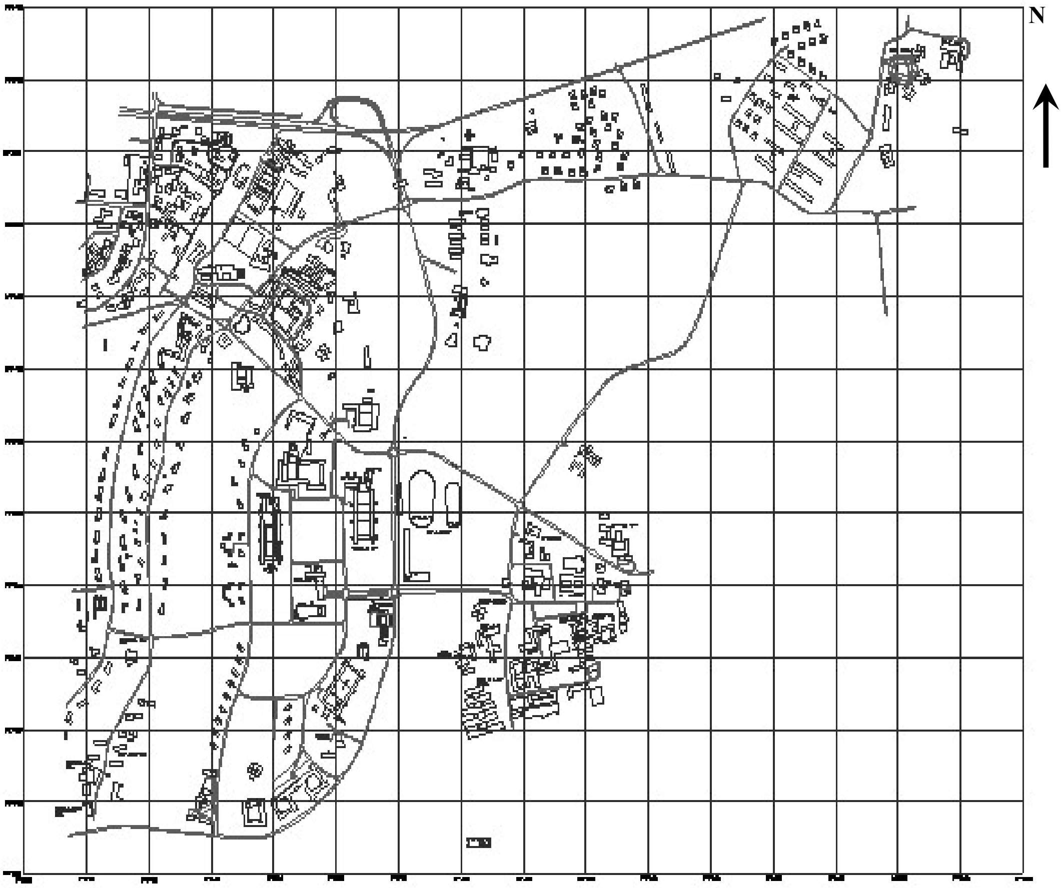

Fig. 4: Map of KNUST obtained using Google satellite images (scale reduced to 1: 20,000)

Table 2: Relative positional errors

Discrete Points	Google Map vrs Ground Survey	SMD Map vrs Ground Survey	Google Map vrs SMD Map
Points on the Ground	0.8	1.2	1.4
Points on Single-Storey Buildings	1.7	1.8	2.8
Points on Two-Storey Buildings	2.5	3.4	2.4
Points on Buildings Three-Storey or Taller	3.0	3.4	2.7

Table 3: Accuracy compliance for various comparisons and scales

Comparison	Accuracy Compliance (%)							
	Point on Ground		Point on Single Storey Level		Point on Two-Storey Level		Point on Three-Storey Level	
	1:2500	1:5000	1:2500	1:5000	1:2500	1:5000	1:2500	1:5000
Google Map vrs. Ground Survey	90	100	69	100	50	85	27	72
SMD Map vrs. Ground Survey	85	100	69	100	30	85	45	81
Google Map vrs. SMD Map	75	100	69	85	40	95	45	72

plotted positions can be reliable for points up to single-storey level. It is also worthy of note that the Google Map versus SMD map fit was best for points on ground at the scale of 1:5000.

In the digitizing of structures with relief displacement, especially very high structures, difficulties were encountered in an attempt to represent them in their true orthographic/ ground positions. This procedure may have resulted in displaced positions of structures. The relief displacement is the shift in the photographic position of an image caused by the relief of the object. With obstruction of details by tree canopies on the Google images, difficulties were encountered in areas where tall trees were prevalent. Single-storey buildings and road-ways in such areas were obstructed, thereby making digitizing imprecise. Ground truthing also helped in various instances to fix or digitize features. With regard to asbestos roofs of some structures on the images, the nature of these roofs made it difficult to differentiate them from the surroundings. Whereas aluminum and coloured roofs were easily noticeable, these asbestos roofs were difficult to delineate and digitize.

Shown in Fig. 5 is a superimposition of the Google map on the SMD map with the two maps represented in red and blue respectively. Most of the roads and several other buildings are practically lying on each other. One of the roads, however, shows considerable deviation between the plots of the two circumstances. This is attributable to the fact that no distinct or identifiable controls were available in this area for georeferencing, and this further confirms the importance of good georeferencing in such work.

CONCLUSIONS AND RECOMMENDATIONS

Superimposition of the Google-derived map on the SMD map showed good overlap by about 70% of the features. This is because the Google map performed well only for features at ground level. The Google Earth satellite images are up-to-date and therefore the map derived from them showed features that had not yet been indicated on the SMD map. In this study, the images were saved at the scale of 1:2500 and digitized. Thus, it is recommended that if mapping is to be done at 1:2500, the images should be saved at a scale larger than 1:2500, digitized and reduced to 1:2500 to improve accuracy. In this instance, for example, the images were saved at 1:2500 and accuracy compliance analysis showed that using them to map at 1:5000

Fig. 5: Superimposition of the Google map on the SMD map: Google map is in red colour and SMD map is in blue colour

would have proved satisfactory for points at elevations from ground level up to single-storey level.

In adopting this methodology where ground controls do not exist, artificial targets should be used. Toward that end, it would be helpful to monitor satellite schedules for imaging and artificial targets mounted to meet such schedules. If relief displacement inherent in these images could be neutralized, the accuracies would be greatly improved; this may require development of suitable algorithms to nullify such image displacements. Such maps derived from Google images should especially be invaluable for mapping at scales of 1:2500 or smaller in instances where maps are unavailable for immediate commencement of projects. The raw images, or line maps derived from them, should also find efficient and effective use in temporal land-use or related studies for an area.

REFERENCES

Boulos, M. N. K. (2005). Web GIS in practice III: creating a simple interactive map of England's strategic Health Authorities using Google Maps API, Google Earth KML, and MSN Virtual Earth Map Control, 22. doi: 10.1186/1476-072X-4-22

Chang, A. Y., Parrales, M. E., Jimenez, J., Sobieszczyk, M. E., Hammer, S. M., Copenhaver, D. J. and Kulkarni, R. P. (2009). Combining Google Earth and GIS mapping technologies in a dengue surveillance system for developing countries. *International Journal of Health Geographics*, *8(1): 49*. doi: 10.1186/1476-072X-8-49

Dickinson, G. C. (1979). Maps and Air Photographs: images of the earth. Edward Arnold Publishers Ltd, Bedford Square, London WC, Pp348.

Farman, J. (2010). Mapping the digital empire: Google Earth and the process of postmodern cartography. New Media & Society, Sage Publications Sage UK: London, England, 12 (6), 869–888. doi: 10.1177/1461444809350900

Kaimaris, D., Georgoula, O., Patias, P. and Stylianidis, E. (2011). Comparative analysis on the archaeological content of imagery from Google Earth. *Journal of Cultural Heritage*, *12(3): 263–269*. doi: 10.1016/ j.culher.2010.12.007

Kennedy, D. and Bishop, M. C. (2011). Google Earth and the archaeology of Saudi Arabia. A case study from the Jeddah area. *Journal of Archaeological Science*, 38(6): 1284–1293. doi: 10.1016/j.jas.2011.01.003.

Kraak, M. J. and Ormeling, F. J. (2013). Cartography: Visualization of Spatial Data. Routledge. Pearson Education Limited, Great Britain. Pp216

Lamb, A. and Johnson, L. (2010). Virtual Expeditions: Google Earth, GIS, and Geovisualization Technologies in Teaching and Learning. *Teacher Librarian*, 37(3): 81.

Lefer, T. B., Anderson, M. R., Fornari, A., Lambert, A., Fletcher, J. and Baquero, M. (2008). Using Google Earth as an innovative tool for community mapping. *Public Health Reports*, 123(4): 474–480. doi: 10.1177/003335490812300408

Merriam, D. F. (1996). Kansas 19th Century Geologic Maps (1903). *Transactions of the Kansas Academy of Science*, 99(3/4): 95-114. doi: 10.2307/3627983.

Peuquet, D. J. and Kraak, M. J. (2002). Geobrowsing: Creative thinking and knowledge discovery using geographic visualization. *Information Visualization*, 1(1), 80 –91. doi: 10.1057/palgrave/ivs/9500007.

SMD (2008). Technical Guidelines for Spatial Data Capture and Presentation in Ghana. Published by the Survey and Mapping Division (SMD), Accra, Ghana. Pp57

Wolf, P. R. and Dewitt, B. A. (2000). Elements of photogrammetry: with applications in GIS,Vol. 3. McGraw-Hill, New York. Pp608

Yu, L. and Gong, P. (2012). Google Earth as a virtual globe tool for Earth science applications at the global scale: progress and perspectives. *International Journal of Remote Sensing*, 33(12): 3966–3986. doi: 10.1080/01431161.2011.636081