COLOR INFRARED AERIAL DIGITAL PHOTOGRAPHIC SYSTEM SURVEY OF KUMASI, GHANA – 17 DECEMBER 1997

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1.0 Executive summary

1.1 This project forms part of the Natural Resources Systems Program [NRSP], one of twelve programs funded under the Department for International Development [DFID], Renewal Natural Resources Research Strategy.

1.2 The project complements the Peri-Urban Interface [PUI1] demonstration programme on the use of relatively cheap aerial, digital photography, conducted by Bath Spa University College (R6203), and the development of a user-friendly peri-urban Geographic Information System for natural resource information storage and access, conducted by Geographic Data Support Limited (R6347) in 1995. The programmes demonstrated the potential capability of the systems to provide rapid access to high resolution information suitable for the management of the complex peri-urban environment.

1.3 These two strands of work can now be integrated with work on the incorporation of quantitative and qualitative data derived from Participatory Rural Appraisal and Rapid Rural Appraisal and other socio-economic survey techniques. Bath Spa University College and Geographic Data Support Limited will collaborate with Cranfield University (R6880) to complete this task.

1.4 The aim of this project is to utilize the ADPS [Aerial Digital Photographic System] as a data collection tool for use by the target peri-urban and land/water interface resource managers.

2.0 Project synopsis

2.1 There is a requirement for an effective information base for future peri-urban research and planning in the Kumasi city-region. The major issue in natural resource management is the

capacity of existing management techniques to deal with the process of change. This rapid transition from a rural to urban environment has led to growing pressures on natural resources and has reduced the effectiveness of traditional management strategies. The NRSP has identified the varying ability of individuals and groups in the communities to cope with and manage these changes, in particular a general failure to intensify agriculture, issues of access to land and serious problems of under-development for many villagers. This has identified research issues, which included land management at community, district and regional levels; water supply, especially pollution affecting downstream villages and town supplies; organic waste management with a view to improved disposaland potential for utilization and energy requirements. There is therefore a requirement for the production of an information base which is timely, upgradable, robust and capable of supporting policy makers and planners for long term practical planning purposes.

2.2 Development projects with goals that require increased reliance on information from Geographic Information System [GIS] should target efficient, cost-effective use of digital image data which are capable of complementing the existing archive of analog and digital film and satellite imagery. and other spatial and non-spatial data. The ADPS meets these growing needs, and the system fulfils the requirement that in alternative development strategies, the target population need to 'own' the process and to see specific benefits in co-operating with the monitoring activity. This ensures that the activity is sustained and the results accepted. The ADPS provides from four to sixteen times the ground coverage of conventional digital video sensors and delivers spatial resolutions that are typically one to two orders of magnitude better than those obtained from conventional satellite sensors; these translate into better image interpretability and economies of flight which very often determine an application's uptake and developmental impact. The unique characteristics and capabilities of the ADPS makes it the preferred choice for many well known and evolving applications especially those where flexibility, turnaround time, key information extraction, and rapid delivery are critical.

3.0 Objectives

3.1 To capture at sub-meter resolutions Color Infrared ADPS imagery of target areas defined in Figure 3.1.1.

640000m 650000M 660000m 670000m 680000m

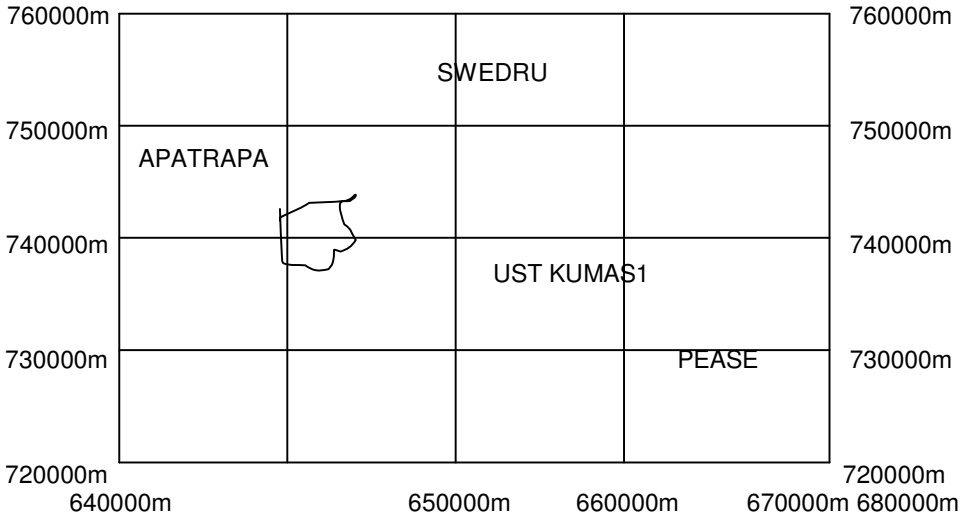

Figure 3.1.1 – ADPS target areas in UTM, Zone 30, WGS84 Coordinates

3.2 To develop a user-friendly image-index ready for integration into an effective information base for future peri-urban research and planning in the Kumasi city and peri-urban region.

4.0 Methodology and results to objective 3.1

4.1 The flight requirements for 20% forward and 15% side overlap imaging at1:25 000 scale at the focal plane, and for 23cm pixel resolution were calculated using the following system parameters:

4.1.1	Size of CCD	18.6mm x 27.9mm
4.1.2	Array of CCD	2036 pixels (along track) x 3060 pixels (across track)
4.1.3	Focal length of lens	28.8458mm
4.1.3	Image capture rate	9 seconds per frame
4.1.4	Native image size	6.4Mb
4.1.5	Extracted image size	18.6Mb

4.2 The flight requirements were:

4.2.1	Aircraft altitude	3000 feet agl
4.2.2	Maximum aircraft speed	40m/s [80 knots]

4.3 The system settings used were:

4.3.1	ISO setting	80
4.3.2	Exposure compensation	-1.7
4.3.3	Minimum shutter speed	1/250
4.3.4	Aperture	Automatic at f11 +/- 2 stops
4.3.5	Light metering	Full matrix

4.3.6 Focus Locked at infinity

4.4 Using the parameters defined in 4.1 fifty-six flight lines in a forward direction of 00 UTM Grid and a reverse direction of 1800 UTM Grid were planned for the trial surveys. Waypoints serving as rendezvous, line-start and line-end markers located at 1.5km outside of the zone of interest were entered into a Global Positioning System [GPS1 and routes constructed. Line start and end waypoints are positioned 1.Skm outside of the project area to avoid the hunting effect caused by navigating short flight lines or when arriving within 1000m of a destination waypoint. Under these conditions, automatic navigation mode is disabled.

4.6 Selective availability, the intentional degradation by the United States DOD [Department of Defense] of the GPS signal reduces the accuracy of the system to 100 meters. This is accounted for in the navigation by reducing by 100 meters the flight line spacing, after 15% lateral image overlaps have been applied to the across-track photocoverage.

4.7 The method adopted for air survey navigation permitted the drift of the aircraft to be corrected as rapidly as the GPS update rate of 1 second. This significantly reduced loss time incidences when targets are difficult to identify or under unfavorable atmospheric conditions.

4.8 The trial survey captured digital imagery of Kumasi and environs in color infrared mode which were stored directly onto PCMCIA removable hard disks. The image data in their native TIF-EP [Tagged Image File-Electronic Photography] format were written overnight to a CD-R [Compact Disc-Recordable] using a Yamaha CD recorder. This provided a highly reliable and efficient technique. The archived images are accessible through the TWAIN driver and calibration routine supplied on the CD-R. Image location was obtained by synchronizing the camera clock with the GPS and logging the track of the flight lines during the survey. The image location is obtained by examining the time of image capture and locating the corresponding position data.

4.9 The coverage that resulted fromthis method proved to be highly reliable and resulted in "no navigation misses", Figure 4.9.1.

Figure 4.9.1 – dGPS point log of actual flight track, plotted to UTM Zone 30 WGS84

4.10 The aerial survey was conducted over 4 days and covered the planned area described in objective 3.1, resulting in a final topographic coverage of 290km2 and an image database of 7Gb made up of 1360 image frames at nominal pixel resolutions of 23cm.

4.11 For ground control and image database production purposes, a mobile dGPS survey of the Outer Kumasi Ring Road was conducted. This generated sufficient numbers of ground control points to enable a first order approximation of the parameters required for establishing the offsets between the Ghanaian National Grid and the Universal Transverse Mercator, Figure 4.11.1.

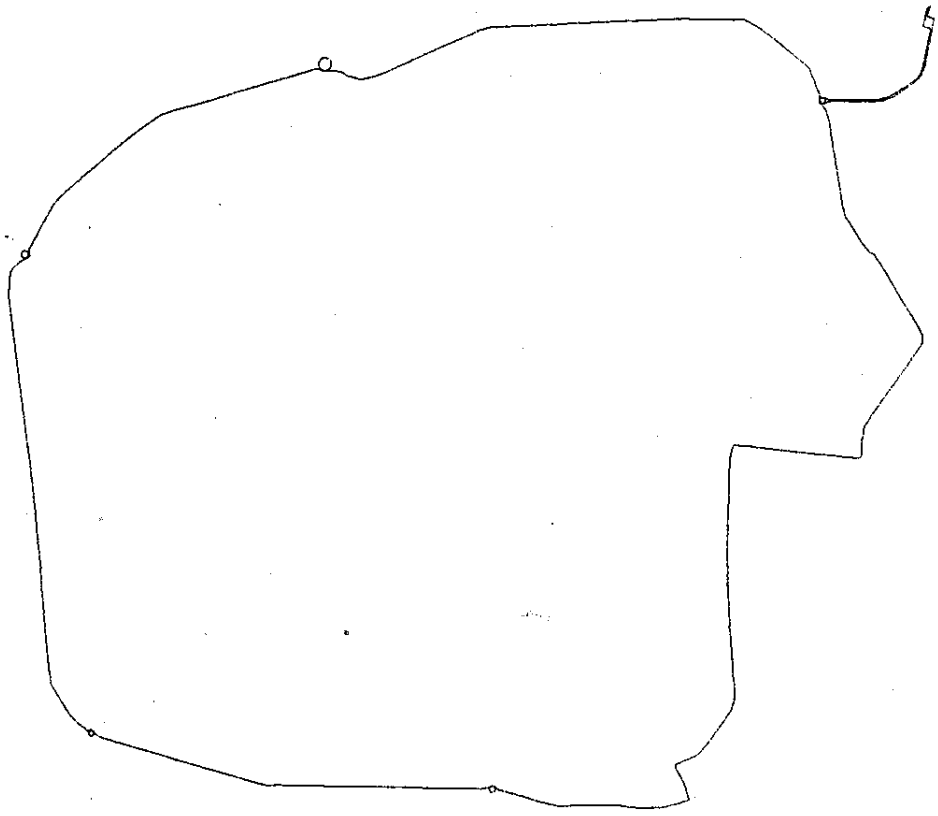

Figure Mobile dGPS survey of Outer Kumasi Ring Road for ground control of imagery and establishment of mapping datum offsets; road center line plotted to UTM Zone 30, WGS 84

4.12 Camera calibration was achieved by using a multi-station convergent network of 8 images. These were produced by

capturing photographs of a test pattern projected onto a calibration wall. These were up-loaded into the EOS System Photomodeler Pro Camera calibrator software for automatic camera calibration.

4.13 The results from the camera calibration are as follows:

4.13.1	fl	28.846mm
4.13.2	Px (center origin)	-0.593mm
4.13.3	Py (center origin)	0.355mm
4.13.4	BL fiducial	-9.2961 -13.972
4.13.5	TL fiducial	-9.296, 13.972
4.13.6	TR fiducial	9.296, 13.972
4.13.7	BL fiducial	9.296, -13.972

5.0 Methodology and results to objective 3.2

5.1 The methodology used for the design of the image-index recognizes that ease of dissemination, user-friendliness, GIS integration, raster and vector capability, and low start-up and low long-term maintenance costs are desirable properties.

5.2 MapInfo was selected as the GIS software as it meets the criteria' described in 5.1. The software facilitates desktop use and embeddable component technology, and is expandable through the addition of the MapInfo MapXsite and MapInfo Spatial Ware components. This will provide server-based solutions and internet/ intranet deployment as the user-base increases.

5.3 Raster image support is identified as an important facility because it will enable scanned paper maps, satellite images and high resolution ADPS imagery to be integrated into the GIS, according to prescribed map projections and datum.

5.4 The ease of presenting the results of geographic analysis and compatibility with other desktop applications is an important facet which will further facilitate effective dissemination of the solutions.

5.5 The procedures adopted for the production of the image index is as follows:

5.5.1 From the image archive stored on CD-Rs, each image thumbnail is viewed and the location of the image and altitude of the aircraft above sea level derived by matching the image capture time with the dGPS UTM coordinate acquisition time, stored as

part of the dGPS point log of actual flight track, Figure 4.9.1.

5.5.2 A point is then plotted on the MapInfo UTM map base and the appropriate block and run information entered as a record.

5.5.3 The coordinates of the plot are then validated by checking the MapInfo reported coordinates against the derived UTM coordinate, item 5.5.1.

5.6 Theprocedures described in item 5.1 allow users to select the CD-Rs and flight lines appropriate to their needs.

5.7 The image index is attached as Appendix 1.

5.8 This is a time consuming procedure and a macro is under development. This will read the dGPS point logand camera time log and generate a results table giving image file name, aircraft altitude at point of image capture and the corresponding UTM coordinate.

6.0 Discussion

6.1 Remote sensing techniques have been used as a tool for planning purposes for nearly a century and in recent years it has gained additional importanceas a tool through the availability of contoured orthophotomaps derived from stereo digital photography.

6.2 Satellite remote sensing techniques has been used as a planning tool for nearly twenty-five years and is still undergoing rapid developments, but because of its low resolution, it is a technique that requires substantial improvement in terms of pixel resolution and data delivery times.

6.3 Theuse of digital imagery captured with the ADPS allows large geographic areas to be covered on a thematic basis and with considerable detail. This allows for immediate data processing, analysis and dissemination. Digital images have drawn the attention of planners and practitioners in forestry, water resource so wastedisposal, peri-urban farming, urban infrastructure development, transportation and demographics.

6.4 It is perceived that this awareness will enhance the methodologies used for cartographic production,population estimation, multi-criteria studies, impacts of infrastructure development and prescription mapping.

6.5 The integration of mult-spectral digital photography into site-specific and regional GISs will enable information derived from different sources and times to be cross-referenced, resulting in improved sensitivities to analyses. This close monitoring of space use resulting from urbanization using multi-date digital imagery will enable high-quality mapping of the natural and peri-urban environment.

7.0 Conclusions

7.1 The ADPS provides a useful and valuable data set which will significantly reduce the time and enhance the decisions made by planners and practitioners in forestry, water resources, waste disposal, peri-urban farming, transportation, demographics and infrastructure development.

7.2 Digital aerial photographs eliminate the difficulties associated with satellite remote sensing of cloud cover, untimely coverage, slow data delivery and low resolution.

7.3 The high resolution imagery from the ADPS enables fine-quality mapping of the environment and facilitates high-definition classification of the peri-urban environment.