NUMERICAL CADASTRAL MAPPING WITH THE APY

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ABSTRACT

A brief history of Cadastral Surveys and the current situation of cadastral mapping in GHANA are given as background to the objectivity of the paper. The methodology leading to the digitization of a numerical map is given. The digital boundary information compiled is arranged to start an information system on the land, open and flexible enough to allow updating and expansion of data from different sources. Recommendations are made for developing countries.

1. INTRODUCTION

1.1. Historical Background of Cadastral Surveying

Cadastral surveying has a long history dating back to as early as 3000 BC with the Egyptians. Napoleon instituted it in France in 1853, for security and fiscal purposes. Now it also serves the purposes of Land Title and Deeds Registration.

As to photogrammetric applications one of the earliest attempts at systematic application of photogrammtry to cadastral surveying was undertaken in Italy in 1931 and by 1940, photogrammetry has become a standard method for the production of cadastral maps for rural areas in Switzerland, Dale (1976).

In a number of European countries the techniques have been extensively used in land re-allocation schemes whilst a number of cadastral surveys using photogrammetric methods have been carried out in Canada, New Zealand, Jamaica, Sri Lanka, Australia, Malawi, Kenya, Uganda, etc. Many countries are joining the race as a recent advert, calling for numerical cadastre in Senegal with proposals for possible photogrammetric applications, testifies (Ref. Nov. 1989 Issue of "Jeune Afrique"). The above-mentioned countries either operate the graphical or numerical cadastre and photogrammetry has been employed to advantage.

By definition, graphical cadastre is that survey of which the results -areas, coordinates, etc. are represented graphically on a map (compiled directly) and can be used in either a fiscal, a property or legal cadastre, P. Norman (1965). By numerical means - coordinates of points are recorded and any other desired data is compiled therefrom (P. Norman, 1965)

1.2. Review of Situation in Ghana

The system operative in Ghana until 1986, was the Registration of Deeds, under the Republic of Ghana Land Registry Act 122, 1962. A deed is a written instrument recording a transaction, usually the sale or transfer of property which is registered in the interest of private persons. Under this Act, no rigid proof of title was required, even a tracing from a general layout map at a scale of 1:2500, certified by a licensed surveyor was enough proof of the existence of a parcel due for registration. This Registration of deeds was found inherent with various weaknesses, giving rise to litigation over land, fraud from purchasers and mortgagees of land, problems associated with agricultural tenancies, etc.

To arrest this situation and instil some security in agriculture, housing and general transactions in land and also to give certainty and facilitate proof of title, the Government of Ghana passed a law, the Land Title Registration Law (P.N.D.C Law 152), 1986, introducing a system of compulsory land title registration throughout the country. The effective characteristic of land title registration is that land is placed on the folio of land register as a unit of property and transactions are recorded by reference to the land itself and not merely any transactions in it. This requires primarily, the boundaries or limits of the land at an appreciable accuracy.

A portion of the capital city, Accra, was declared as the first Land

Title Registration District for a pilot scheme. There are two parts to the programme -an administrative part and a technical part. There is a Land Title Registry to take care of the administrative part whilst the Survey Department, the national surveying organisation, is to handle the technical phase, the production of registry maps. To accelerate the work, several sections of the Registration District were contracted to private surveyors who use base maps produced at the scale of 1:2500, by the Photogrammetry Section of the Survey Department. The surround of the declared Registration District was controlled based on the national triangulation network and the internal sections are controlled therefrom, by running internal traverses. Anything from EDMs, tacheometers, to steel and linen tapes are employed for detailing. Whilst the property corners are supposed to be accurately fixed, the law stipulates general boundaries -hedges, drains, etc.

1.3. Objectives

With reference to the foregoing background if a cadastral system is based on a graphical approach to surveying and there is a boundary system which is visible from the air, then there is the high possibility of applying more photogrammetry and minimal ground survey methods. It is also possible to achieve higher speed and still be within tolerable error limits. This, partly, is what this paper attempts to establish in the ultimate.

In handling the boundary information compilation, the APY -a fairly new analytical photogrammetric equipment which is available at the Regional Centre for Training in Aerospace Surveys (RECTAS) was used. Not only the ground coordinates of each plot visible from the stereo-model were compiled but also information on land use allowance for the ownership, etc., the beginning of a geo-information system which offers enough flexibility to allow continuous updating of data connected to the land from different sources. Also the numerical compilation has the advantage of easy future revision. Moreover, the graphical representation of the data is facilitated at any scale.

The project also served to try out some capabilities of the APY, but it is not being used for the reason that it has no manual. However this did not stop our investigation that led to an elaborate working manual that we have finally produced.

1.4. Synopsis

Section 3, entitled "Methodology" deals with the data procured and its preparation for use on the APY, the orientation leading to the compilation of information on the plots and a brief mention of refinement of the results.

The compiled numerical information of roads and plot coordinates is found in section 3. A chapter that is conspicuously absent is that on analysis or comparison of the output with available data, possibly from the Cadastral section of Survey Department of Ghana. The latter was not immediately available due to technical problems. As such, the comparison could not be done within the time constraints of this work. It is hoped that this will be carried out with the Survey Department of Ghana and the results communicated to RECTAS at a later date.

2.METHODOLOGY

2.1.Input Data and its Preparation

2.1.1. Input Data:

The materials obtained for the project were aerial photographs of the Cape Coast, a coastal town in Ghana, flown in March 1969 at a scale of 1:10000, sun-prints of large scale topographic maps of the same coverage at the scale of 1:2500 with grids in feet. There was also a repertoire (a list, description and coordinates) of the ground control points.

2 1.2. Preparation of Maps:

To make the maps suitable for use on the APY, the map coverage of the stereomodel must be as small as to go on the 40 by 40 cm digiting tablets. Thus, the 1:2500 topographic maps were reduced to 1:5000 using the linear pantograph on the Wild B8 Stereoplotter.

The control points were stereoscopically identified using a mirror stereoscope and their corresponding locations were marked on the maps.

Finally, the grids were converted to metric units and the reduced maps were inked to enhance their clarity during superpositioning of the model.

2.1.3. Preparation of Photographs:

The control points were marked with a fine pencil on one photograph only of each stereo-pair. The principal points were also marked on and behind each photograph.

2.2. Interaction with the APY

The APY prompts and instructs the operator at each step to go through the programs on its menu. Among the programs that automatically appear on

the screen when it is switched on - File Editing, Orientation, Compilation, List & Plot, Data exchange, Symbol Creation and Date and time -the first three, were relevant in that order.

2.2.1. File Editing:

On the instructions of the APY computer, files were opened for each photograph and the maps. The photo No., Date, Camera type, Lens No., Focal Distance, Photo scale and the Xg, Yg, Zg coordinates of the control points were called and entered. The XO, YO, ZO coordinates of the perspective centres were also called for but were not available. They would be calculated automatically in the orientation stage. Similar data on the map was also entered.

2.2.2. Orientation:

The main object of the orientation of photographs is to determine the coordinates of the perspective centres. These data are required to maintain the colinearity with ground- and photo- coordinates. The orientation mode is entered either by selecting the number 2 at the opening menu or by typing APYORIEN, at the system prompt.

First, the correction plates were zeroed on the instructions of the computer Then the map and photo, identification numbers were called for and entered Then the photographs were mounted on the stage, and centred under the pressure plates. Next, an approximate positioning of the photographs and map was instructed. This involved the setting of the photo. lens arms and rotation of photo bases (on the stage) to achieve stereoscopy; zooming of map and photo. lenses, shifting of the stage to match the control points on the map and the stereomodel

After this, 4 grid points on the map were visited and their coordinates were entered, one after the other. Next, a min. of 4 control points were visited and after parallaxes were removed between these points on the map and the corresponding model points, their heights were entered.In addition, two stage grid points had to be visited in each photograph for the stage/tablet scale ratio, and one point had to be visited twice to calibrate the optical plate rotations.

Thereafter, a check model was displayed with the Xg, Yg, Zg coordinates of the controls and their residual errors, Px, Py, Pz. The absolute orientation had been completed. By this time, the coordinates of the perspective centres were calculated automatically and stored in the photo files that were created in 2.2.1.

2.2.3. Compilation:

Compilation is the ultimate for which file editing and analytical orientation are preparatory steps.

To enter the APY Compilation mode the mode number 3 is selected at the opening menu. Otherwise, typing the sub-directory name APYCOMPI> and opening a file in that sub-directory takes one to the APY Compilation mode which displays options for Descriptives Line Split, Distance & inclination, Area, Delete, and Proceed.

The appropriate files -plot, road etc. were opened in the sub-directory, APYCOMPI> , to record all that transpired on the digitising tablet and the screen. In fact, as long as the compilation file was open, a continuous stream of ground coordinates was recorded automatically. Thus for a 4-cornered plot requiring four coordinates, for instance, about 50 coordinates could be recorded. The technique to enter at the neumonic cursor at relevant boundary points and PROCEED to terminate compilation for each file, was adopted to control the digitising.

During compilation, the map was obscured and digitisation was done from the model. Those residence plots, farmlands, etc. that were visible, were digitised. Also, roads were digitised on both sides. Texts were typed at the keyboard to describe various attributes.

2.3. Refinement of Coordinates

Due to the problem of continuous and automatic digitising it was necessary to process each file using the wordstar software, to sort out the right coordinates. The observation that when the ENTER button is pressed, the registration of coordinates at that instance is different was used to advantage in the refinement.

The coordinates of plots and roads in the next section have been refined by the above-described procedure.

3. RESULTS - THE CADASTRAL MAP IN NUMERICAL FORM

APY Compilation
X2175

PLOT 1	COORDINATES:		
a. X	48,279.13 m	Y	244,035.71 m
b X	48,204.89 m	Y	243,961.50 m
c X	48,243.88 m	Y	243,926.72 m
d. X	48,285.61 m	Y	243,924.23 m
e. X	48,319.10 m	Y	243,950.65 m
f. X	48,368.86 m	Y	243,910.70 m

AREA:
USE: Undeveloped
OWNER:

APY Compilation
X2175

PLOT 2	COORDINATES		
a. X	48,366.90 m	Y	243,909.05 m
b. X	48,355.25 m	Y	243,895.58 m
c. X	48,302.61 m	Y	243,935.36 m
d. X	48,317.60 m	Y	243,950.31 m

AREA:
USE: Undeveloped
OWNER:

APY Compilation
X2175

PLOT 3	COORDINATES		
a. X	48,355.96 m	Y	243,892.53 m
b. X	48,342.13 m	Y	243,875.94 m
c. X	48,298.92 m	Y	243,898.33 m
d. X	48,309.58 m	Y	243,931.43 m

AREA:
USE: Undeveloped
OWNER:

APY Compilation
X2175

PLOT 4	COORDINATES		
a. X	48,298.59 m	Y	243,898.75 m
b. X	48,280.67 m	Y	243,859.61 m
c. X	48,294.23 m	Y	243,841.76 m
d. X	48,339.45 m	Y	243,874.99 m

USE: Residence
OWNER:

APY Compilation
X2175

PLOT 5	COORDINATES		
a. X	48,265.07 m	Y	243,848.00 m
b. X	48,280.11 m	Y	243,830.43 m
c. X	48,280.67 m	Y	243,859.61 m
d. X	48,294.23 m	Y	243,841.76 m

AREA:
USE:
OWNER:

APY Compilation
X2175

PLOT 6	COORDINATES		
a. X	48,258.42 m	Y	243,814.63 m
b. X	48,253.76 m	Y	243,825.16 m
c. X	48,254.21 m	Y	243,835.64 m
d. X	48,280.67 m	Y	243,859.61 m
e. X	48,294.23 m	Y	243,841.76 m

APY Compilation
X2175

PLOT 7	COORDINATES		
a. X	48,228.67 m	Y	243,958.56 m
b. X	48,224.44 m	Y	243,953.31 m
c. X	48,240.64 m	Y	243,942.10 m
d. X	48,243.72 m	Y	243,946.11 m

AREA:
USE: Residence
OWNER:

APY Compilation
X2175

PLOT 8	COORDINATES		
a. X	48,244.49 m	Y	243,946.39 m
b. X	48,246.41 m	Y	243,942.11 m
c. X	48,262.30 m	Y	243,919.68 m
d. X	48,265.47 m	Y	243,924.69 m

AREA:
USE: Abor
OWNER:

APY Compilation
X2175

PLOT 9	COORDINATES		
a. X	48,262.14 m	Y	243,927.97 m
b. X	48,285.98 m	Y	243,922.21 m
c. X	48,300.17 m	Y	243,911.87 m
d. X	48,304.18 m	Y	243,906.74 m
e. X	48,308.35 m	Y	243,899.45 m
f. X	48,302.51 m	Y	243,888.59 m
g. X	48,293.66 m	Y	243,871.51 m
i. X	48,278.45 m	Y	243,862.04 m
j. X	48,213.93 m	Y	243,873.72 m
k. X	48,247.55 m	Y	243,893.42 m
l. X	48,259.32 m	Y	243,912.63 m

AREA:
USE: Education - School Campus
OWNER: Government/Catholic Mission

APY Compilation
X2175

PLOT 10	COORDINATES		
a. X	48,239.58 m	Y	243,941.16 m
b. X	48,220.83 m	Y	243,926.59 m
c. X	48,240.55 m	Y	243,906.07 m
d. X	48,259.89 m	Y	243,922.39 m
e. X	48,261.29 m	Y	243,922.26 m

AREA:
USE: Residence
OWNER:

APY Compilation
X2175

PLOT 11:	COORDINATES		
a. X	48,216.66 m	Y	243,955.50 m
b. X	48,213.45 m	Y	243,947.95 m
c. X	48,218.77 m	Y	243,945.31 m
d. X	48,221.20 m	Y	243,951.66 m

AREA:
USE: Undeveloped
OWNER:

APY Compilation
X2175

PLOT 12	COORDINATES		
a. X	48,200.53 m	Y	243,946.84 m

b. X 48,189.93 m Y 243,933.69 m
c. X 48,207.56 m Y 243,943.07 m
d. X 48,209.63 m Y 243,943.27 m

AREA:
USE: Farmland
OWNER:

APY Compilation
X2175
COORDS, ROAD1 SIDE1

X 48,210.99 m Y 243,622.87 m
X 48,211.04 m Y 243,622.92 m
X 48,218.91 m Y 243,631.50 m
X 48,228.16 m Y 243,641.00 m
X 48,237.56 m Y 243,649.46 m
X 48,244.28 m Y 243,653.58 m
X 48,248.92 m Y 243,654.69 m
X 48,250.83 m Y 243,655.62 m
X 48,251.94 m Y 243,657.38 m
X 48,251.94 m Y 243,657.38 m
X 48,252.68 m Y 243,657.88 m
X 48,254.24 m Y 243,659.52 m
X 48,256.32 m Y 243,661.83 m
X 48,258.59 m Y 243,663.65 m
X 48,259.33 m Y 243,664.61 m
X 48,260.93 m Y 243,666.54 m
X 48,262.78 m Y 243,667.22 m
X 48,264.39 m Y 243,668.23 m
X 48,266.22 m Y 243,669.51 m
X 48,268.50 m Y 243,671.48 m
X 48,270.37 m Y 243,673.30 m
X 48,273.69 m Y 243,676.40 m
X 48,276.42 m Y 243,679.44 m
X 48,278.17 m Y 243,680.80 m
X 48,281.70 m Y 243,683.27 m
X 48,283.67 m Y 243,684.91 m
X 48,287.60 m Y 243,687.79 m
X 48,290.19 m Y 243,690.00 m
X 48,292.25 m Y 243,691.82 m
X 48,294.86 m Y 243,693.84 m
X 48,296.69 m Y 243,695.51 m
X 48,298.10 m Y 243,696.87 m
X 48,300.09 m Y 243,698.59 m
X 48,302.43 m Y 243,700.56 m
X 48,305.48 m Y 243,703.58 m
X 48,307.66 m Y 243,705.32 m
X 48,309.09 m Y 243,706.18 m
X 48,311.49 m Y 243,707.74 m
X 48,312.62 m Y 243,708.54 m
X 48,313.13 m Y 243,708.95 m
X 48,314.47 m Y 243,710.14 m
X 48,316.72 m Y 243,711.98 m
X 48,319.27 m Y 243,713.54 m
X 48,321.77 m Y 243,715.04 m
X 48,324.57 m Y 243,716.56 m
X 48,326.66 m Y 243,717.60 m
X 48,328.54 m Y 243,718.81 m
X 48,330.74 m Y 243,720.20 m
X 48,333.31 m Y 243,721.67 m
X 48,336.46 m Y 243,723.65 m
X 48,339.71 m Y 243,725.41 m
X 48,341.45 m Y 243,726.09 m
X 48,341.93 m Y 243,726.36 m
X 48,342.04 m Y 243,726.46 m
X 48,343.30 m Y 243,727.18 m
X 48,345.20 m Y 243,727.74 m
X 48,347.70 m Y 243,728.73 m
X 48,351.33 m Y 243,730.22 m
X 48,353.13 m Y 243,731.36 m
X 48,356.09 m Y 243,732.92 m
X 48,358.46 m Y 243,734.00 m
X 48,362.12 m Y 243,735.11 m
X 48,364.48 m Y 243,735.51 m
X 48,366.19 m Y 243,736.06 m
X 48,367.93 m Y 243,736.74 m
X 48,370.17 m Y 243,737.45 m
X 48,373.06 m Y 243,738.34 m
X 48,375.64 m Y 243,739.40 m
X 48,377.41 m Y 243,739.95 m
X 48,380.00 m Y 243,740.82 m
X 48,382.10 m Y 243,741.57 m
X 48,384.57 m Y 243,742.53 m
X 48,386.54 m Y 243,743.42 m
X 48,388.53 m Y 243,744.11 m
X 48,389.37 m Y 243,744.03 m
X 48,390.84 m Y 243,743.70 m
X 48,393.75 m Y 243,743.48 m
X 48,396.13 m Y 243,743.55 m
X 48,399.84 m Y 243,744.04 m
X 48,401.61 m Y 243,744.18 m
X 48,404.08 m Y 243,744.63 m
X 48,406.47 m Y 243,745.22 m
X 48,408.59 m Y 243,745.53 m
X 48,412.69 m Y 243,745.18 m
X 48,414.74 m Y 243,745.06 m
X 48,415.72 m Y 243,745.16 m
X 48,417.58 m Y 243,745.43 m
X 48,418.95 m Y 243,745.38 m
X 48,419.76 m Y 243,745.33 m
X 48,420.54 m Y 243,745.20 m
X 48,421.00 m Y 243,745.20 m
X 48,421.54 m Y 243,745.12 m
X 48,421.57 m Y 243,745.14 m
X 48,421.57 m Y 243,745.14 m
X 48,420.63 m Y 243,743.95 m

APY Compilation
X2175
COORDS, ROAD 1 SIDE 2

X 48,423.19 m Y 243,741.99 m
X 48,423.25 m Y 243,741.99 m
X 48,421.96 m Y 243,741.20 m
X 48,415.83 m Y 243,741.12 m
X 48,406.84 m Y 243,739.62 m
X 48,403.09 m Y 243,738.54 m
X 48,402.25 m Y 243,739.43 m
X 48,401.90 m Y 243,739.83 m
X 48,401.96 m Y 243,739.99 m
X 48,401.76 m Y 243,739.81 m
X 48,401.63 m Y 243,739.96 m
JN
X 48,401.66 m Y 243,739.98 m
JN
X 48,396.20 m Y 243,738.71 m
X 48,395.73 m Y 243,738.60 m
X 48,394.56 m Y 243,738.48 m
X 48,390.10 m Y 243,737.63 m
X 48,385.26 m Y 243,737.21 m
X 48,379.79 m Y 243,734.50 m
X 48,374.94 m Y 243,734.33 m
X 48,368.69 m Y 243,734.40 m
X 48,365.93 m Y 243,733.59 m
X 48,362.20 m Y 243,731.34 m
X 48,358.11 m Y 243,729.90 m

X 48,355.87 m Y 243,729.14 m
X 48,354.44 m Y 243,728.79 m
X 48,353.44 m Y 243,728.26 m
X 48,353.27 m Y 243,728.27 m
X 48,353.16 m Y 243,728.17 m
X 48,352.73 m Y 243,728.65 m

COORDS, ROAD 1 SIDE 2 CONTD.
X 48,351.76 m Y 243,728.30 m
X 48,347.63 m Y 243,726.57 m
X 48,341.01 m Y 243,723.25 m
X 48,335.23 m Y 243,719.64 m
X 48,327.44 m Y 243,714.82 m
X 48,316.78 m Y 243,708.00 m
X 48,304.26 m Y 243,698.61 m
X 48,291.91 m Y 243,688.35 m
X 48,280.81 m Y 243,678.75 m
X 48,273.90 m Y 243,671.63 m
X 48,262.97 m Y 243,660.68 m
X 48,255.28 m Y 243,653.80 m
X 48,246.34 m Y 243,647.24 m
X 48,245.79 m Y 243,647.05 m
X 48,244.98 m Y 243,647.10 m
X 48,243.41 m Y 243,646.27 m
X 48,238.38 m Y 243,642.56 m
X 48,229.46 m Y 243,635.05 m
X 48,221.27 m Y 243,628.79 m
X 48,217.32 m Y 243,626.10 m

APY Compilation
X2175
COORDS, ROAD 2, SIDE 1
X 48,215.62 m Y 243,971.34 m
X 48,216.78 m Y 243,970.79 m
X 48,219.93 m Y 243,968.22 m
X 48,262.14 m Y 243,927.97 m
X 48,285.98 m Y 243,922.21 m
X 48,291.59 m Y 243,918.25 m
X 48,300.17 m Y 243,911.87 m
X 48,303.73 m Y 243,907.93 m
X 48,303.84 m Y 243,907.87 m
X 48,304.18 m Y 243,906.74 m
X 48,307.27 m Y 243,901.30 m
X 48,308.38 m Y 243,900.05 m
X 48,308.47 m Y 243,900.12 m
X 48,308.35 m Y 243,899.45 m

APY Compilation
X2175
COORDS, ROAD 2, SIDE 2
X 48,213.98 m Y 243,969.22 m
X 48,216 12 m Y 243,966.98 m
X 48,238.84 m Y 243,948.73 m
X 48,260.88 m Y 243,930.08 m
X 48,263 33 m Y 243,929.85 m

APY Compilation
X2175
COORDS, ROAD 3, SIDE 1
X 48,306.71 m Y 244,036.25 m
X 48,305.09 m Y 244,033.53 m
X 48,303.00 m Y 244,031.52 m
X 48,299.76 m Y 244,030.74 m
X 48,298.48 m Y 244,030.62 m
X 48,292.06 m Y 244,025.58 m
X 48,290.08 m Y 244,024.59 m
X 48,284.75 m Y 244,019.95 m
X 48,282.91 m Y 244,019.95 m
X 48,280.86 m Y 244,018.29 m
X 48,274.93 m Y 244,014.66 m
X 48,271.29 m Y 244,011.16 m
X 48,268.43 m Y 244,009.44 m
X 48,263.84 m Y 244,005.10 m
X 48,257.39 m Y 244,001.21 m
X 48,252.13 m Y 243,997.46 m
X 48,251.81 m Y 243,997.58 m
X 48,251.30 m Y 243,997.23 m
X 48,244.97 m Y 243,992.17 m
X 48,238.74 m Y 243,988.42 m
X 48,233.67 m Y 243,986.06 m
X 48,226.36 m Y 243,979.16 m
X 48,217.04 m Y 243,975.32 m
X 48,215.65 m Y 243,970.56 m

ROAD JUNCTION
X 48,215.50 m Y 243,971.19 m
ROAD JUNCTION
X 48,213.58 m Y 243,968.97 m

X 48,204.47 m Y 243,962.26 m
X 48,200.64 m Y 243,960.23 m
X 48,199.50 m Y 243,959.73 m
X 48,194.43 m Y 243,955.32 m
X 48,192.90 m Y 243,955.25 m
X 48,188.63 m Y 243,952.12 m
X 48,185.79 m Y 243,949.28 m
X 48,185.62 m Y 243,949.29 m
X 48,185.05 m Y 243,949.19 m
X 48,179.29 m Y 243,942 79 m
X 48,176.12 m Y 243,941.00 m
X 48,175.51 m Y 243,940.71 m
X 48,173.61 m Y 243,937.90 m
X 48,170.12 m Y 243,933.77 m
X 48,163.89 m Y 243,926.29 m
X 48,161.78 m Y 243,923.24 m
X 48,156.34 m Y 243,919.12 m
X 48,148.13 m Y 243,911.51 m
X 48,143.85 m Y 243,906.95 m

ROAD JUNCTION
X 48,141.19 m Y 243,905.34 m
X 48,138.73 m Y 243,904.03 m
X 48,135.99 m Y 243,902.62 m
X 48,132.02 m Y 243,899.50 m
X 48,125.52 m Y 243,897.25 m
X 48,126.24 m Y 243,893.80 m
X 48,127.77 m Y 243,893.52 m
X 48,125.49 m Y 243,890.68 m
X 48,124.53 m Y 243,889.98 m
X 48,120.01 m Y 243,887.40 m
X 48,115.99 m Y 243,885.31 m
X 48,109.98 m Y 243,884.31 m
X 48,107.32 m Y 243,880.05 m
X 48,105.76 m Y 243,876.98 m
X 48,100.23 m Y 243,873.13 m
X 48,097.71 m Y 243,870.39 m
X 48,093.22 m Y 243,868.19 m
X 48,085 83 m Y 243,861.72 m
X 48,075.19 m Y 243,855.23 m
X 48,074.93 m Y 243,852.24 m
X 48,074.32 m Y 243,847.45 m
X 48,074.43 m Y 243,846.53 m
X 48,074.72 m Y 243,841.72 m
X 48,074.80 m Y 243,841.79 m
From previous road junction to end the road was so narrow that is was better

to digitise the center of the road.

APY Compilation
X2175
COORDS, ROAD 3, SIDE 2

X 48,282.59 m Y 244,021.41 m
X 48,275.82 m Y 244,016.82 m
X 48,269.22 m Y 244,014.07 m
X 48,263.27 m Y 244,009.25 m
X 48,256.62 m Y 244,005.23 m
X 48,247.92 m Y 243,999.44 m
X 48,241 07 m Y 243,993.97 m
X 48,233.13 m Y 243,989.26 m
X 48,224 83 m Y 243,982 04 m
X 48,220.36 m Y 243,979.19 m
X 48,218.66 m Y 243,978.91 m
X 48,215.82 m Y 243,978.02 m
X 48,211 47 m Y 243,979.11 m
X 48,208.02 m Y 243,979.37 m
X 48,207.95 m Y 243,979.46 m

ROAD JUNCTION
X 48,207.42 m Y 243,975.97 m
ROAD JUNCTION
X 48,211.84 m Y 243,972 49 m
X 48,206.43 m Y 243,966.04 m
X 48,205 84 m Y 243,966.29 m
X 48,200 50 m Y 243,962.87 m
X 48,197.16 m Y 243,959.95 m
X 48,188 47 m Y 243,954.48 m
X 48,188.35 m Y 243,953 76 m
X 48,184.94 m Y 243,950.11 m
X 48,174.34 m Y 243,940.59 m
X 48,173.96 m Y 243,939.63 m
X 48,172.20 m Y 243,936.95 m
X 48,163 83 m Y 243,929.57 m
X 48,163 01 m Y 243,927.50 m
X 48,159.83 m Y 243,924.01 m
X 48,158.35 m Y 243,922.80 m

ROAD JN
X 48,156 48 m Y 243,921.50 m
ROAD JN
X 48,155.27 m Y 243,919.70 m

X 48,153 81 m Y 243,917 49 m
X 48,150 48 m Y 243,915 65 m
X 48,148 24 m Y 243,913.46 m
X 48,146 66 m Y 243,911.90 m
X 48,144 35 m Y 243,909.90 m
X 48,143 95 m Y 243,909 13 m
X 48,141 44 m Y 243,906.44 m

ROAD JN
X 48,139 81 m Y 243,905.51 m

Ref to File Road 3 for continuation.

APY Compilation
X2175
COORDS, ROAD 4, SIDE A

X 48,310.82 m Y 244,037.04 m Z 14.67m
X 48,332.18 m Y 244,013.53 m Z 14.67m
X 48,350.38 m Y 243,994.94 m Z 14.67m
X 48,370.71 m Y 243,971.85 m Z 14.67m
X 48,389.46 m Y 243,949.76 m Z 14.67m

ROAD JN
X 48,403.47 m Y 243,937.98 m Z 14.67m
ROAD JN
X 48,408.85 m Y 243,930.89 m Z 14.67m
X 48,422.25 m Y 243,917.60 m Z 14.67m
X 48,433.79 m Y 243,906.28 m Z 14.67m

APY Compilation
X2175
COORDS, ROAD 4, SIDE 2

X 48,324.54 m Y 244,021.83 m
X 48,339.94 m Y 244,004.79 m
X 48,357.14 m Y 243,985.97 m
X 48,379.45 m Y 243,965.81 m
X 48,400.45 m Y 243,947.30 m
X 48,418.28 m Y 243,934.78 m

APY Compilation
X2175
COORDS, ROAD 5, SIDE 1

X 48,401.69 m Y 243,936.65 m
X 48,397.52 m Y 243,943.02 m
X 48,394.22 m Y 243,931.18 m
X 48,393.48 m Y 243,929.20 m
X 48,392.97 m Y 243,928.85 m
X 48,389.20 m Y 243,925.55 m
X 48,386.33 m Y 243,922.69 m
X 48,384.26 m Y 243,920.70 m
X 48,377.95 m Y 243,914.28 m
X 48,375.70 m Y 243,911.00 m
X 48,374.49 m Y 243,910.23 m
X 48,371.55 m Y 243,906.13 m
X 48,372.16 m Y 243,902.73 m
X 48,376 03 m Y 243,897.23 m
X 48,381.17 m Y 243,891.27 m
X 48,387.43 m Y 243,884.35 m
X 48,388.92 m Y 243,881.23 m
X 48,384.53 m Y 243,876.96 m
X 48,379.80 m Y 243,871.99 m
X 48,375.93 m Y 243,867.48 m
X 48,370.13 m Y 243,863.25 m
X 48,366.23 m Y 243,861.88 m
X 48,364.65 m Y 243,859.81 m
X 48,355.24 m Y 243,861.82 m

COORDS, ROAD 5, SIDE 2
X 48,371.57 m Y 243,861.46 m

ROAD JN
X 48,376.88 m Y 243,864.75 m

ROAD JN
X 48,381.99 m Y 243,869.34 m
X 48,385.63 m Y 243,873.08 m

ROAD JN
X 48,390.88 m Y 243,877.29 m

ROAD JN
X 48,394.42 m Y 243,879.98 m
X 48,390.13 m Y 243,885.22 m
X 48,377.46 m Y 243,900.34 m
X 48,375.72 m Y 243,903.90 m
X 48,375.80 m Y 243,906.69 m
X 48,379.27 m Y 243,910.38 m

ROAD JN
X 48,386.99 m Y 243,918.26 m
X 48,390.53 m Y 243,921.47 m
X 48,396.99 m Y 243,926.74 m
X 48,401.18 m Y 243,930.31 m

ROAD JN & END
X 48,405.73 m Y 243,932.62 m

APY Compilation
X2175
COORDS, ROAD 6, SIDE 1

X	48,380.74 m	Y	243,921.56 m
X	48,405.05 m	Y	243,896.28 m
X	48,405 35 m	Y	243,895.99 m
X	48,423.63 m	Y	243,877.61 m

COORDS, ROAD 6, SIDE 2

X	48,424 14 m	Y	243,878.94 m
X	48,400.13 m	Y	243,904.17 m
X	48,382.75 m	Y	243,924.42 m
X	48,382 40 m	Y	243,924 11 m

APY Compilation
X2175
COORDS, ROAD 7, SIDE 1

X	48,427.19 m	Y	243,825.51 m
X	48,436.56 m	Y	243,813.59 m
X	48,442.41 m	Y	243,806.67 m
X	48,450.89 m	Y	243,799.43 m

COORDS, ROAD 7, SIDE 2

X	48,428 98 m	Y	243,827.87 m
X	48,443.10 m	Y	243,812.96 m
X	48,437.56 m	Y	243,817.70 m
X	48,448.73 m	Y	243,807.38 m

APY Compilation
X2175
COORDS, ROAD 8, SIDE 1

X	48,382.47 m	Y	243.867.31 m
X	48,392.68 m	Y	243,853.99 m
X	48,409.20 m	Y	243,839.48 m
X	48,427.78 m	Y	243,826.80 m
X	48,433 64 m	Y	243,821.42 m
X	48,435.40 m	Y	243,820.07 m

COORDS, ROAD 8, SIDE 2

X	48,433.37 m	Y	243,816.83 m
X	48,423.08 m	Y	243,823.75 m
X	48,411.05 m	Y	243,833.25 m
X	48,402 01 m	Y	243,841.01 m
X	48,390.65 m	Y	243,851.27 m
X	48,385.91 m	Y	243,856.77 m
X	48,376.74 m	Y	243,864.73 m

5 LIMITATIONS, CONCLUSION, RECOMMENDATIONS

5.1. Limitations:

The reality of the situation cannot be fully appreciated without mention of the various limitations that were encountered. The input data, for instance, were constrained by what is available under a general scarcity of materials, or rather what can be safely released without interrupting production

Thus the photographs obtained from Surveys of Ghana, were on Cape Coast instead of Accra (where a pilot project of compulsory Land Title Registration is currently in progress). These photographs were flown long ago in March 1969. Many changes might have occurred in the topography and landuse since then to render any compiled data along such lines wrong.

The maps obtained were sun prints of same coverage as the photographs. They were at the scale 1:2500, much too large for use on the APY To be appropriate, they were reduced to at least 1:5000. The sun prints could not be photo-reduced without loss of detail. A linear pantograph was therefore employed. It must be mentioned that though conscious efforts were made to minimize errors, there were the inevitable ones that were carried throughout such programs as the analytical orientation, etc.

Beside these, the APY itself presented a few limitations. Firstly, there was no manual at our disposal and we assumed that it has step-wise computer guidance for the operator. In the absence of a prior exposition to the instrument, this turned out to be a most unfortunate assumption. Secondly, the floppy disks of the system's software were not available. Thus, in the event of the system's software getting corrupted as the case was, they cannot be restored. All the opening menu functions did not work. The various modes had to be entered by another route, viz: FILEDIT, APYORIEN, APYCOMPI, for file Editing, Orientation and Compilation respectively, instead of choosing 1, 2 or 3 at the opening menu. For the same reason, the areas of plots could not be calculated though the APY is very capable of doing that.

Moreover, whilst there are programmes for polygons on the APY, there are none for curves or conics. Line segments instead of curves for meandering roads for instance, do not augur well for accuracy. Even continuous mode of digitising in such a case is too operator-dependent to provide the best.

Finally, due to the small scale of the photographs (1:10000) resolution was poor and it was difficult to identify block boundaries, especially if they were not walled or hedged.

5.2. Conclusion:

With the afore-mentioned limitations it may be premature to draw any fast conclusions based on the findings of this work. Technically, it is highly feasible to generate digital data as in Section 4 but how accurate the output data or the APY is, cannot be known till ground truthing or a comparison with available data has been done. On the same grounds, parameters like speed and cost cannot be immediately assessed.

5.3. Recommendations:

That this project is important and merits continuation or further researches cannot be over-emphasized.

It is recommended therefore, that enthusiastic financial assistance be sought at high governmental levels to sponsor researches on this problem. If that is feasible, then a further recommendation is that photography with pre-marked parcel corners be employed to remove the problem of identification. Also, photos be flown at a larger scale (e.g. 1:5000) for better resolution. Apart from that, care must be taken to use recent photographs to ensure minimum changes in the topography and landuse between the exposure time and the start of the photogrammetric cadastral mapping experiment.

Meanwhile, to continue this work to its logical end, it is recommended that since the data for analysis and comparison can best be obtained from the Land Title Registration District 03 Accra, recent photographs on Accra be made available for the necessary comparison of parameters. It is also recommended that Survey Department of Ghana create the cooperative atmosphere conducive to the continuation of this work -the ground truthing phase, at Cape Coast.

This experiment has shown that developing countries can also have access to numerical cadastral mapping using relatively inexpensive instruments. Well-trained technicians from underdeveloped countries find it painful to learn that work they can competently undertake are let out to foreigners who often charge exhorbitant fees. This paper has demonstrated that numerical cadastral mapping can be carried out given the necessary facilities in a developing country.

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APPENDIX A

MAP FILES

X2175 - MODEL 0007-0006
X2175-2- MODEL 0006-0005

APY File Editing

Map File: X2175.

Identifier	X2175
Map name	CAPE-COAST
Map scale	1:5000
Initial date	15/03/1977
Last revision	01/01/1980 06/01/31
SPOT Image	No.

0 to terminate

APY File Editing

Map File: X2175-2

Identifier	X2175-2
Map Name	CAPE COAST
Map scale	1:6250
Initial date	15/03/1977
Last revision	01/01/1980 01/55/36
SPOT Image	No

APPENDIX B

PHOTO FILES

APY File editing

Photo No	0007
Date	14/03/1969
Camera type	UAg
Lens No.	369
Focal distance (in mm)	152.05
Photo scale	1:10000
SPOT Image	No

XOg=48,295 69 YOg=243,790.54
ZOg= 602.80.
sin.Omega=0.2785; sin Phi=-.0375

1	Xg=48,701.59	Yg=243,301.76	Zg=15.80
2	Xg=48,756.87	Yg=244,242.20	Zg= 7.63
3	Xg=48,250.14	Yg=243,797.32	Zg=32.97
4	Xg=47,756 92	Yg=243,512.76	Zg=11.15
5	Xg=47,704.75	Yg=244,469.72	Zg= 5.62
6	Xg=48,246.82	Yg=241.047.20	Zg=27.69
7	Xg= 0.00	Yg= 0 00	Zg= 0 00
8	Xg= 0.00	Yg= 0.00	Zg= 0.00
9	Xg= 0.00	Yg= 0 00	Zg= 0 00
10	Xg= 0 00	Yg= 0.00	Zg= 0.00

APY File editing

Photo No	0006
Date	14/03/1969
Camera type	UAg
Lens No.	369
Focal distance (in mm)	152 05
Photo scale	1:10000
Spot Image	No

XOg=48,184.59 YOg=244,026.24
ZOg=556.36
Sin.Omega=0.0464 sin.Phi=0.0506

1	Xg=48,701.59	Yg=243,301.76	Zg=15.80
2	Xg=48,756.87	Yg=244,242.20	Zg= 7.63
3	Xg=48,961.59	Yg=245.152.04	Zg=12.56
4	Xg=48,250.14	Yg=243,797.32	Zg=32.97
5	Xg=48,471.16	Yg=242.820.44	Zg=28.66
6	Xg=47.756.92	Yg=243,512.76	Zg=11.15
7	Xg=47,704.75	Yg=244,469.72	Zg= 5.62
8	Xg=47,810.34	Yg=245,136.94	Zg=10.65
9	Xg= 0.00	Yg= 0.00	Zg= 0.00
10	Xg= 0.00	Yg= 0.00	Zg= 0.00

APY File Editing

Photo No.	0005
Date	14/03/1969
Camera type	UAg
Lens No.	369
Focal distance (in mm)	152.05
Photo scale	1:10000
SPOT Image	No.

XOg= 0.00 YOg= 0.00 ZOg= 0.00
Sin. Omega= 0.0000 Sin.Phi=0.000

1	Xg=48,756.87	Yg=244,242.20	Zg= 7.63
2.	Xg=48,704.75	Yg=244,469.72	Zg= 5.62
3	Xg=48,471.16	Yg=242,820.44	Zg=28.66
4	Xg=47,810.34	Yg=245,136.94	Zg=10.65
5	Xg=48,961.59	Yg=245,152.04	Zg=12.56
6	Xg=48,875.47	Yg=245,583.60	Zg= 2.35
7	Xg=49,038.70	Yg=246,035.24	Zg= 7.31
8	Xg=47,961.23	Yg=246,095.28	Zg= 3.50
9	Xg= 0.00	Yg= 0.00	Zg= 0.00
10	Xg= 0.00	Yg= 0.00	Zg= 0.00