Spot Data - A TOOL FOR SUPPLEMENTING MAPPING EFFORTS IN THE DEVELOPING WORLD

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ABSTRACT

The progress in the total map coverage of the land masses of most developing nations is too slow and insufficient in respect of the exploitation of their natural resources.

The image map which evolved some few years back from satellite has become a useful alternative cartographic product capable of depicting land use and land cover conditions within a short period of time and at a lower cost compared to classical line maps.

The cost associated with image mapping is reasonably affordable, however, the problem of resolution and contrast often affects interpretation of planimetric details. The means of production also can easily be supported by an existing mapping system in a developing world.

Keywords: *image map, mapping, SPOT imagery, developing nations, economic.*

INTRODUCTION

Though there are users of cartographic products who may not have any stringent demand on accuracy, cartographers and photogrammetrists alike have a set of accuracy standards to go by. This may be found in the three kinds of information normally contained in a topographic map, namely:

i) Content - This has to do with the cultural and natural features of the map.

ii) Horizontal location - which deals with the reference graticule, grid and datum.

iii) Elevation - which are the spot heights, contour lines and profiles.

Map Content

This is determined by the photographic resolution and scale or the resolved distances on the ground. Here a criterion for accuracy is defined, using the photograph as a standard. Here, the least identifiable object on the map is taken as 0.25 mm: which must be imaged by 5 resolution element to be identifiable also on the photograph [8].

$$\begin{aligned} \text{i.e. } GR &= 0.2 \times 0.25 \times \text{Map Scale Number} \\ &= 5 \times 10^{-5}\ Sm \text{ (in metres)}. \end{aligned}$$

where GR = Ground Resolution
SM = Map Scale Number.

It is estimated that after the film has undergone various laboratory processes both lithographic and photographic, it could retain about 10 lp/mm, which is the resolving power of the unaided eye [8].

For imaging systems, these have to be enlarged to a point where the unaided eye can resolve.

Horizontal Location or Position

Where the accuracy standard specifies for example that the standard error of horizontal positions should not exceed 0.3mm at the map scale (U.S.), the standard error in relative position of a ground point (σp) is defined as

$$\sigma p = 3 \times 10^{-4}\ Sm \text{ (in metres)}.$$

Elevation

Here also when the accuracy standard requires that 90% (within 1.64σ) of the elevations must be accurate to one-half of a contour interval (e.g. of the U.S.), the required height accuracy (σh) of measuring an individual point is related thus:

$$\sigma h = 0.3 \times \text{contour interval (C.I.)}$$

DEFINITION OF PROJECT:

Test Area

The region chosen for this project is within the neighbourhood of Boffa, a town situated in the South-West of Guinea Conakry, Fig. 1a.

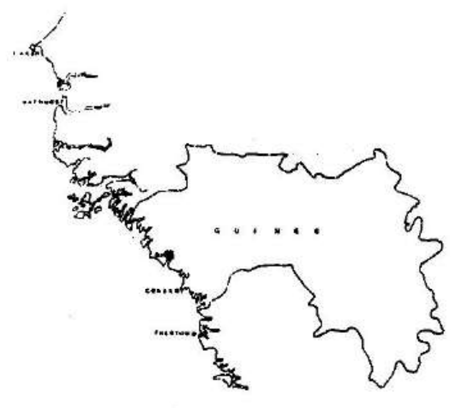

Fig. 1a. Location of the Study area

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Half of this region, about 72 km^2 is principally covered with mangrove. The other half is covered with Forest and Villages which are dispersed in the north and along the main road towards the capital Conakry, (Fig. 1b and Fig.3).

Fig. 1b: Image of the Test Area of Level 2b

METHODOLOGY

Available Source of Information

i) Level 1P* (SPOT data): image 1A (Appendix I) treated in such a way as to be adaptable to an analytical photogrammetric restitution instrument (scale of negative-approximately 1:400,000, enlarged 8x for a positive bromide print).

ii) Level 1A (SPOT data): Panchromatic mode and basically a 'raw' data on tape.

iii) An existing topographic map at 1:50,000 - date of publication: 1956.

Rectification and Radiometric Treatment of Imagery Serving as a 'Base'

The area of interest on the image is chosen and a histogram equalisation stretch applied. This is done such that the pixels have values lying between 0 and 255, rendering the image more expressive and interpretable. It is normally done by choosing areas without water and cloud cover. This area is rectified into an U.T.M. projection. A topographic map at scale 1:50,000 was used for this.

Seven control points uniformly distributed over the imagery were identified. These were features identified on both map and the image which were road intersections, road/river intersections and branch points of streams. All the control points and four other points (UTM Coordinates) read from the topographic map and situated at the four corners of the image were measured using a Benson digitiser with an accuracy of 0.02mm. Using the 4 points, an affine transformation is used to transform image coordinates into map (UTM) coordinates.. Then based on the calculated unknowns the rest of the points were transformed with a RMS of 26.59m (Table 1).

This must be expected since errors of 15-20m in position may occur in the topographic map coupled with measuring and identification error; hence the residual error. By applying a bicubic convolution and using a filter, both the texture and the radiometric detail appropriate for cartographic work are enhanced.

A half-tone negative film is obtained to serve as a 'base' (See Fig. 2).

Data Processing

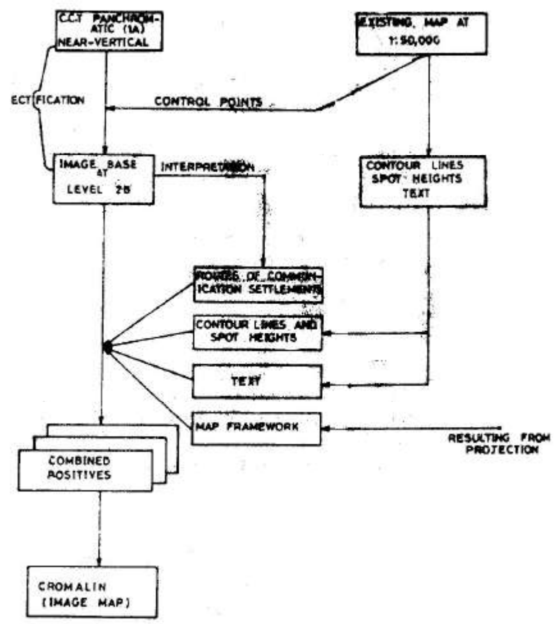

Fig. 2 Schematic drawing of the main processing steps

Interpretation of Imagery: A monoscopic interpretation was done. A tracing paper was laid over the 2B film negative and planimetric information directly traced over it.

Towns: The only town existing in the area of study was Boffa which clearly stood out without much problems.

Villages: These appeared as black on the negative but white on the bromide (positive) print. They could easily be made out except that similar white dotted areas existed. It was generally found that almost all the villages were partially covered by the forest.

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TABLE 1:

Geographic representations used:	GEOGRAPH-GE............CLGBUTM 28			
LonLatXYNumber 1 : -14.14	10.15	582136.823	1133046.646	
2 : -14.00	10.15	609518.058	1133121.060	
3 : -14.00	10.00	609602.881	1105478.405	
4 : -14.15	10.00	582200.433	1105405.730	

Geographic representations used: GEOGRAPH-GE...... LGBUTM 28

The degree of polynomial is : 1

Num.	Coord.	imag 1	Coord	imag.2	Coord.	imag 2	Corr	Residual
1.	606965.6	1127361.6	2452.8	469.9	2453.6	470.3	0.816	0.440
2.	587440.9	1130148.8	488.6	501.4	487.8	504.4	-0.858	2.991
3.	586060.5	1128400.0	391.6	697.6	392.6	698.2	0.946	0.537
4.	585530.8	1120208.3	524.0	1514.0	525.3	1512.3	1.266	-1.735
5.	605701.5	1110539.9	2708.1	2141.6	2708.9	2144.9	0.747	3.232
6.	594943.2	1118832.9	1476.3	1502.1	1473.6	1499.0	-2.602	-3.151
7.	607553.4	1124686.3	2571.4	726.5	2571.1	727.2	-0.314	-2.314

Residual (RMS) in X = 1.272 (Pixels)
Residual (RMS) in Y = 2.335 (Pixels)
Residual (RMS) in position = 2.659 (Pixels)

Routes: Major routes were easily found without any problem - except that the high reflection by these and the houses in the town made the tracing difficult. Secondary routes and tracks were such that they could only be found after studying the local situation; in relation to farm lands, nearby villages and available source of water.

Difficulties: The contrast as well as the resolution were not good enough and therefore made it difficult to sort out the secondary routes and tracks.

- Roads reaching villages were often partially covered by trees and were difficult to see where they joined when inside the village.
- The houses themselves in the imagery seemed to overshadow roads. This is characteristic of near-vertical imagery as opposed to the oblique.

Conclusions: The imagery whether used for protogrammetric compilation of planimetric information or purely monoscopic/stereoscopic visual interpretation will need a careful study and a particular knowledge of such an environment in order to make the right deductions. For the fact that the area had less planimetric details, the scale at 1:50,000 was acceptable.

Integration of the Different Linear and Point Information on the Map

Roads and houses were obtained directly from the interpretation of the imagery. Contours and spot heights were extracted from the existing topographic map at scale 1:50,000.

These were scribed on scribe coats for the various combined positive to be made.

For hydrography (Cyan) and vegetation (green), these two themes which are linear and zonal respectively were well portrayed by the 'image base' in such a way that it was no longer necessary to scribe them or treat them like the others. The following positives - red, black, bistre and the half tone image for the base were combined for a cromalin proof. (Fig.3).

RESULTS AND DISCUSSIONS

Investigation of Accuracy:

Metric Accuracy: The following results were obtained for the rectification.

RMS in X = 1.272 pixels
RMS in Y = 2.335 pixels
RMS in position = 2.659 pixels, ie. <u>26.6m</u>

The required accuracy is $\leq$ 20m with level 2B geometrically corrected images.

This inaccuracy of about 6m can be attributed to the fact that

i) points taken as branch points of rivers may not be precise.

ii) many points might have changed on the map which is 34 years old.

Fig. 3: Image map - (A cromalin proof) from SPOT imagery

iii) and also errors in measurements by the operator.

Semantic Accuracy:

The only document available for a check was also the only published map for the area, dated 1956. It was realised that apart from the correctness of the planimetry resulting from the interpretation process, many changes had also taken place in addition to what has been depicted on the topographic map. This was in respect of growth of towns, villages and routes of communication.

With these results both the planimetry and content, it could be concluded taking into consideration certain inaccuracies in measurement, that the data, is useful for the production of image maps at scales 1:50,000 and smaller for inventory and monitoring purposes but for line maps at scales 1:100,000 and smaller.

COST ANALYSIS

Cost of imagery is by far an advantage over serial photographs whose cost vary a lot (See Table 2).

The photo-interpretation phase did not pose much problem. However, the phase of field completion may involve much time and therefore cost because of uncertainties of identification due to resolution and contrast.

The cyan (hydrograpny) and green (vegetation) were not scribed or drawn and therefore their plates were eliminated. This provided relatively good time savings, reducing material expenditure and cost.

The overall cost therefore was relatively reduced when compared to traditional methods in a similar level of mapping. In respect of cost the process was compared to a revised map with traditional method of mapping.

NB: The choice of colour is left to the 'tastes' and convention of an established mapping institution. In the case of the river this may be scribed where contrast does not allow clarity. Colour imagery increases the rate of detection but increase cost.

TABLE 2: COST ESTIMATES

PROCESSING STEPS	K=COST OF A / COST OF B	REMARKS
Acquisition of image and pretreatment	K=10 to K=13	
Aero/Spatio		Cost affects only B
Restitution		
Photo-identification (interpretation)	K = 6	The cost for the image map depends to a greater extent on the quality of the image
Completion	K=½ to K=1/3	The cost depend on the quality of the image
Drawing		Cost on the image map does not include hydrographic (Blue) and vegetation (green) because they were not drawn or scribed.
Separation of colours	K = 1	
Reproduction (Impression) 1000 samples.	K = 1	
Total Cost	K = 2	

A = Tradition method for a revised topographic map
B = Image map from SPOT

CONCLUSION

In the light of the above, it can be seen that SPOT data when supplemented with other map information, and keeping sufficient internal map precision can achieve a good economy. The work was done in such a way as to be adaptable to an existing mapping structure in a developing country. While the cost of production is relatively cheap, it makes its introduction quite feasible. The infrastructure requirement and processes involved can therefore be expected to be cost-effective and operational.

The data and therefore the product can support or supplement world mapping efforts sufficiently enough for the inventory and exploitation of natural resources and in general to accelerate the rate of national development.

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APPENDIX I

SPOT PRODUCTS

The different levels for the preprocessing of a SPOT scene (nominal coverage: 60 km x 60 km) recorded in panchromatic or multispectral mode are:

Level 1A:

This is basically a 'raw' data, the only processing performed being equalisation of the response of the CCD* detectors. Level 1A data are intended for users requiring imagery that has undergone a minimum of preprocessing.

Level 1B:

This level involves radiometric and geometric system corrections (compensation of rotation of the earth, satellite perspective efforts, viewing angle and effects of satellite forward motion (desmearing). The location accuracy is 1500m (r.m.s.) for vertical viewing.

Level 2A:

This is a precision processed level. Radiometric correction is as for level 1B, but transformed into a desired cartographic projection (UTM, Lambert Conformal, Transverse mercator etc.) using uniquely the satellite data; orbit parameters and altitude. The location accuracy is 80m (r.m.s.).

Level 2B:

Geometrically corrected image with the help of ground control points.
The image is rectified according to a given cartographic projection or according to the projection of the map used. It is therefore possible to determine the localisation of each pixel in cartographic coordinates. The location accuracy is better than 20m (R.M.S.).

Level S:

This level of preprocessing involves scene rectification relative to landmarks to ensure registration with another scene used as a reference to within 0.5 pixels i.e. within 5 or 10 m depending on the image mode. Level S products are typically used for multidate studies.

Level 1P:

This is a level 1A image anamorphosed in order to eliminate variation of scale due to satellite perspective views in the direction of the lines in view of the photogrammetric restitution after histogram equalisation stretch and local contrast enhancement.

**CCD (Charge coupled Devices) is a microelectronic silicon chip, a solid state sensor that detects light*