BORDER MAPPING USING SATELLITE IMAGERY: THE NIGERIAN EXPERIENCE

BY

DR. S. O. IHEMADU,
SURVEY DEPARTMENT,
FEDERAL MINISTRY OF WORKS & HOUSING,
P.O.BOX 2980,
MARINA, LAGOS,
NIGERIA.

ABSTRACT

With the current population explosion in developing countries and the over-dependence of these countries on agriculture for subsistence, border mapping has assumed an added importance.

By its nature, border mapping demands fast production and presentation of the relevant data in a format that allows for unimpeded retrieval at any required scale, as well as easy up-dating and storage.

This paper describes the Nigerian experience in border mapping using satellite imagery and provides some conclusions and recommendations.

1. BACKGROUND AND OBJECTIVE

The need for border mapping, or its verification, often results from boundary disputes. The latter occur more frequently in developing countries, but still remain sporadic in nature. As these boundary disputes may often escalate and lead to bloodshed, the necessary steps required to resolve them, including border mapping, are generally most urgent and of utmost priority. With the current population explosion in developing countries and the over-dependence of these countries on agriculture for subsistence, border mapping has assumed an added importance and sensitivity.

Border mapping is normally executed for the purpose of initially obtaining a synoptic view of the boundary situation and subsequently acquiring a more detailed cartographic representation of the boundary situation. As the latter largely depends on human activities, it is highly dynamic in nature. Consequently, border mapping demands fast production and presentation of the relevant data in a format that allows for unimpeded retrieval at any required scale, as well as easy up-dating and storage.

In the case under study, the boundary area had earlier been mapped and the changes in mappable features were moderate. The border mapping therefore took the form of map revision.

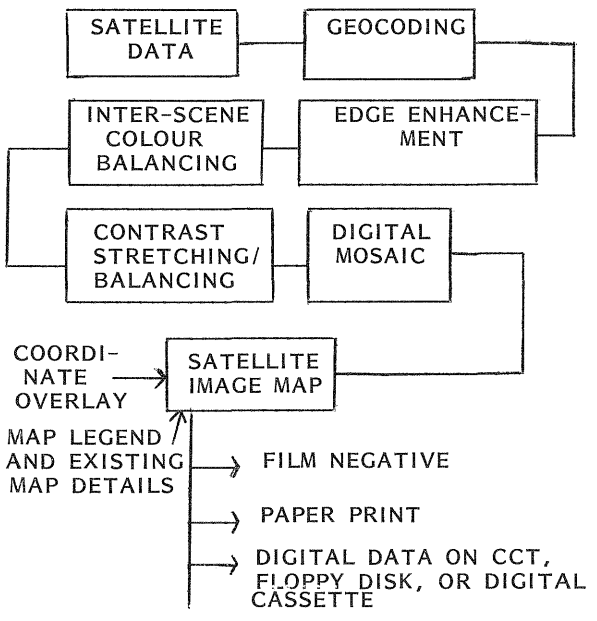
For a part of the country, efforts at acquiring aerial photography are almost always frustrated by perennial cloud cover. This calls for an effort to have an alternative approach for obtaining data for border mapping.

The objective of this study, therefore, was to assess the possibility and quality of carrying out the border mapping with satellite imagery.

As the study is continuing, only preliminary results and conclusions based on them have been presented.

2. METHODOLOGY

The methodology adopted may be illustrated as follows:



Under this methodology, the satellite images were geocoded and edge enhanced. The inter-scene colour and contrast were balanced. Thereafter, a digital mosaic was created. The map sheets were then extracted and co-ordinate overlay and map legends were added for photo products. In the case of map revision, following the extraction of the map sheets from the digital mosaic, coordinate overlay, details of existing maps and map legends were added for photo products. The final product could be film negative, or paper print, or digital data on a CCT, or floppy sidk, or digital cassette.

3. EXECUTION OF STUDY

The input was SPOT data. The images were radiometrically corrected by applying calibration coefficients to each individual detector in the satellite sensor. The Satellite Image Maps (SIMs) were geometrically rectified to correspond to the UTM map projection and Clarks Reference Ellipsoid, normally adopted for mapping in Nigeria.

In a case of insufficient ground controls, control point correction of the SIMs was performed, using ground control points from maps of adjoining areas.

In order to achieve an enhanced interpretation accuracy, while retaining the geometric accuracy associated with the Panchromatic mode, the SPOT data source used was a combination of SPOT Pan and SPOT XS.

The SIMs were produced each with an image area of 50 cm x 50 cm over an area of 104,363 sq.km.

4. RESULTS OF STUDY AND ANALYSIS

The results so far obtained from this preliminary study clearly demonstrate the following advantages over the adoption of the conventional approach.

(a) The dependence of possibility of acquisition of data for the mapping on the availability of good weather was greatly reduced. This arises from the repetitiveness of the satellite coverage as against an exposure from a single flight of the Photographic Aircraft.

(b) The possibility of eliminating dependence of flight over a neighbouring territory to acquire mapping data upon the granting of permission by the appropriate Authorities through the purchase of available satellite imagery.

(c) The possibility of acquiring mapping data from an orbiting satellite, which can be as up-to-date as possible and with relative ease.

(d) The availability of the mapping data in digital form, which is relatively easier to up-date and compatible with modern techniques, such as GIS/LIS.

(e) The mapping method lends itself more easily to costing.

5. LIMITATIONS

(a) Low image contrast generally resulted in difficulties in edge matching, poor identification of details and, in a particular case, in the loss of an important feature.

(b) Differences in illumination between adjoining SPOT scenes because manifest in the combination of scenes to produce the image maps of some sheets.

(c) Differences in colour rendition between SPOT scenes resulted in two different colour hues (red and green) for a given feature, on adjacent image map sheets.

6. PROPOSALS FOR IMPROVED MAPPING

The following proposals, if implemented in future experimentation on border mapping, will yield improved definition and contrast and lead to enhanced accuracy of mapping

(a) The use of SPOT products, pre-processed to level "IAP", on Analytical Stereoplotter in the medium of photographic film, with auxiliary data recorded on CCT tapes, or MS-DOS diskettes, will ensure improved quality of interpretation, higher geometric accuracy and greater operator's comfort. Improvement in the quality of interpretation will result from

(i) use of a special digital filter, which considerably enhances the interpretation of linear objects through the amplification of frequencies close to half the sampling frequency, while attenuating the more "noisy" sampling frequency;

(ii) maintaining photographic specifications designed to meet aerial photography standards, such as:

$D_{min} \geq$ 0.2 above background fog and

$0.6 < \gamma < 1.2$ (or 1.5) in the case of very low contrast landscapes); and

(iii) slight mean scale increase to 1:350,000 from 1:400,000 for IA level.

Enhanced geometric accuracy will result from:

(i) special affine transform actions;

(ii) improved accuracy in relationship between the stereoplotter's floating mark and raw image through use of eight fiducial marks with unambiguous central marks

Viewing comfort of the Operator may be increased by the special application of anamorphic corrections in the image scanline direction to compensate for the viewing angle effect and for Earth's curvature.

7. CONCLUSIONS AND RECOMMENDATIONS

(a) Developing countries subsist virtually. entirely on agriculture, In addition, they are experiencing the highest population explosion. Border mapping, therefore, has assumed an intrinsic value for Developing Countries.

(b) In view of its prevailing circumstances, border mapping demands fast production and presentation of the mapping data in a format that allows unimpeded retrieval of any required scale, as well as easy up-dating and storage.

(c) Satellite mapping is best suited to meet the requirements of border mapping in terms of timeliness, format of presentation and up-dating possibilities.

(d) The proposals itemised in section 6 of this presentation are recommended. They will lead to a higher quality of border mapping.

(e) Developing Countries should see satellite mapping technique as a means of achieving border mapping.