Mapping of Regional Transportation Network with Medium Resolution Satellite Imagery

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SUMMARY

A good transportation network is essential for the economic and social development of any nation. Many socio-economic activities that enhance the life of a people depend on availability of good networks of roads, railways, waterways, etc. When these infrastructure fail or are threatened by forces of nature, many social activities that depend on them are also affected. Continuous mapping and monitoring of the state of these infrastructures help to identify areas of failure and thus lead to the development of proper control and maintenance measures. Satellite systems provide a synoptic view of large portions of the earth surface as an entity rather than in small bits. Therefore remotely sensed satellite images allow us to view and analyze different features of our environment on regional or global scale. With very high resolution satellite images now available, regional studies of various transportation networks are now possible. On 21st September, 2003, Nigeria launched into low orbit her first earth observation satellite – **NigeriaSat- 1.** NigeriaSat-1 has a medium ground resolution of 32m and generates images in three bands – Green, Red and Near Infrared. In this study, one of the first series of images from NigeriaSat-1 has been applied in identification and mapping of road networks in South- Eastern Nigeria. The study revealed that the image even at first level of production with minimal radiometric corrections facilitated the identification and mapping of inter-state expressways, major regional roads and minor but tarred road networks.

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1. INTRODUCTION

Social and economic development of a country depends on good transportation networks. Free and easy movement of goods and personnel are vital to industrial development of any nation. Tourism as an important sector of a national economy depends heavily on good transportation network and system. The state of transport infrastructure of any nation gives an indication as to the level of development of the nation.

In most developing countries of Africa, ground transportation networks consist mostly of roads, scattered railways and few waterways. However, road transportation remains the most prominent system of transport in these countries. In Nigeria, movement of industrial and farm products and personnel is accomplished mostly by road network. Very few rail lines exist in the country and are mostly unreliable. The state of our road networks is therefore important to planners and developers.

Satellite imagery provides a useful means of monitoring the state of our road networks and also provides the tool to constantly map these road networks and even plan for new ones. NigeriaSat-1 became operational in September, 2003 and has since been delivering medium resolution (32m) digital satellite imagery of different parts of the world. This study therefore has two main objectives;

- Identification and mapping of existing road networks in South- Eastern Nigeria, using NigeriaSat-1 image data.
- Comparison of the identified network with those extracted from a topographic map of scale 1 : 50,000

1.1 The Study Area

The Area selected for this study lies in the South-Eastern Nigeria, precisely between latitudes 5^0 56' N and 6^0 25' N and Longitudes 6^0 45' E and 7^0 08' E. The Area corresponds to a NigeriaSat-1 image window of 1625 x 1625 pixels, which is about 2704 Square kilometer of the ground.

The vegetation of the area consists of few scattered rainforests, wooded shrublands and farmlands. One major ecological problem affecting the area is soil erosion. The impacts of soil erosion on the landscape of the area is tremendous. Of the three types of soil erosion (sheet, rill and gully) found in the area, gully erosion is the most prominent. Expanding gully sites dot the landscape of the area and in many places wash away inter city and inter state highways or render them unusable.

The area is heavily populated with high concentration of population found in a number of commercial cities within the area.
Fig 1. shows the location of the study area.

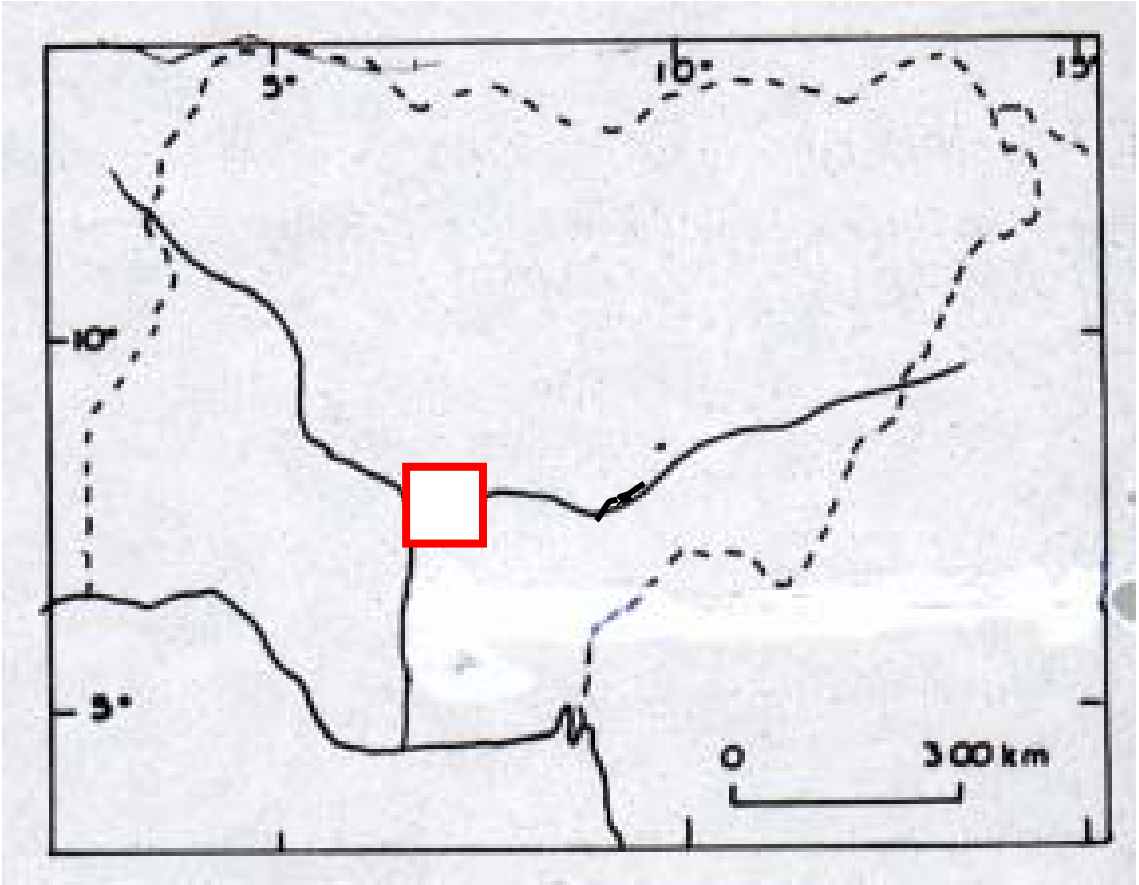

Fig. 1. Map of Nigeria showing the Study Area

1.2 The Satellite Image Data

The imagery of NigeriaSat-1 used for this study was acquired in January, 2004 and has a scene center coordinate of latitude 7^0 20' N and Longitude 7^0 40' E. The technical characteristics of the NigeriaSat-1 are summarized in table 1. 1

Table 1.1 Nigeria Sat – 1 Technical Data

S/No	IMAGE PARAMETERS	DETAILS
1.	Launch Date	27th September, 2003
2.	Swath Width	600 km
3.	Ground Coverage	600 x 570 km
4.	Image Recording	Multispectral Green: 0.52 – 0.62 Red : 0.63 - 0.69 NIF: 0.76 – 0.90
5.	Ground Sampling Resolution	32 m
6.	Typical Revisit	3 – 5 days

NigeriaSat-1 is a member of disaster monitoring constellation (DMC) which includes satellite systems from Algeria, Turkey, UK and China. The actual image window used for the study is shown on figure 2. The figure shows a composite of green, red and near infrared bands.

2. IMAGE PROCESSING AND MAPPING OF ROAD NETWORKS

The satellite image data was processed using standard digital image processing (DIP) techniques, the prominent of which are

- Radiometric Correction
- Image enhancement
- Extraction of Road Networks

2.1 Radiometric Correction

The image window is covered by cloud and haze in many places. Contrast manipulations were employed to reduce the haze while filtering operations were done to reduce cloud and sharpen the image

2.2 Image Enhancement

Directional high and low pass filtering were selectively applied to enhance the visual quality of the image. Fig 2. shows the enhanced image window.

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Fig. 2.1 Image of the Study Area (Green, Red and Near Infrared Composite)

2.3 Extraction of Road Networks

All the visible road networks were extracted through visual and digital interpretation of the enhanced image. Three categories of roads were extracted:

- Inter state Expressways
- Major Intercity Highways
- Major and minor tarred roads

Some of the road networks were not completely visible due to dense vegetation cover in some places. However, taking the resolution of the NigeriaSat-1 image into consideration, an average completeness of 81.25% was achieved in the extraction of the road networks. Table 2. 1 shows the percentage of completeness of the extracted road networks.

Table 2.1: Completeness of the Extracted Roads

S/No	Transportation Network	Identification from NigeriaSat-1	% of Completeness
1.	Inter State Express Ways	Clearly visible	100 %
2.	Major Intercity Highways	Visible	85
3.	Major tarred Toads	Visible on close zooming Covered by vegetation in some places	75
4.	Minor Tarred Roads	Partly Visible with zooming	65

3. COMPARISON WITH EXISTING MAPS

When the extracted road networks were compared with the existing topographic and road maps, the roads in the maps showed close match with the ones extracted from the image. However, very few roads in the image exist on the maps, particularly the topographic map. These maps were quite old and have not been revised . This study shows that at regional image mapping, it will be possible to carry out a review of the existing maps at scales of 1: 150,000 - 1: 250,000. Fig 2 shows the enhanced image with the road networks.

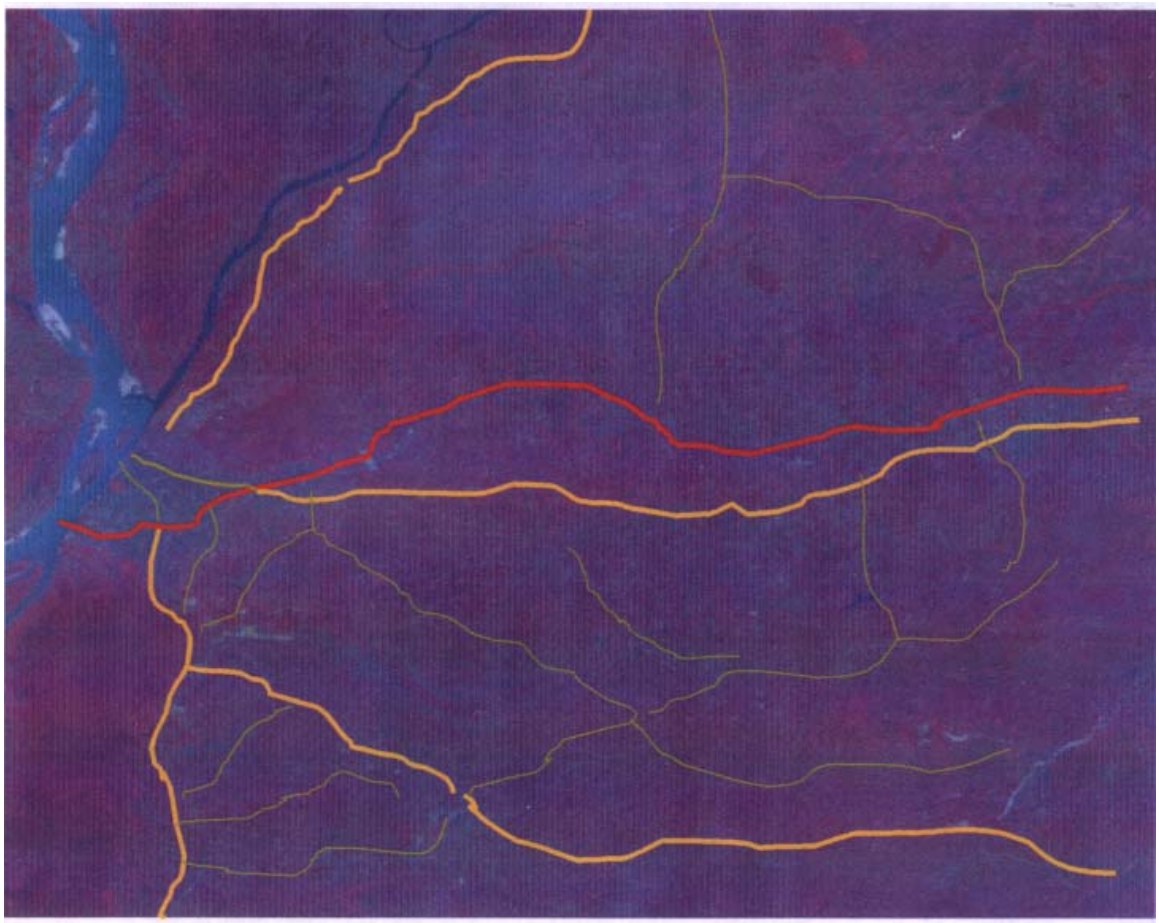

Fig. 2. 2 Enhanced Image of the Area with the Road Networks

The study highlights one of the major problems of satellite image users in Nigeria. That is lack of up-to date maps-topographic and thematic maps. However relevant Agencies in Nigeria are now working towards solving this problem

4. CONCLUSION

At a medium resolution of 32m , NigeriaSat-1 image data can support the identification and mapping of regional road networks at scales of 1: 150,000 –1: 250,000. At these scales of mapping all inter state express ways, inter city highways, major tarred roads can be mapped. Smaller roads will require field completion to be adequately represented. This means that the images can support planimetric map revision at medium scales. Where there are very good

geometric models and well distributed ground control points, it may be possible to achieve a planimetric accuracy that will allow regional mapping at 1: 100,000.

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