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# Quest of Nigeria into Space for Sustainable Development

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**Subsequent to the launch of the first Nigerian satellite into space in September 2003, the National Space Research and Development Agency (NASRDA), Abuja, Nigeria, has demonstrated a peaceful use of outer space through the commercial, educational, humanitarian and governmental applications of its four satellites successfully launched so far. The nation has also maintained a sustainable national development since achieving this feat by joining other nations in space operations. The satellite operations are carried out indigenously by Nigerian Engineers and Scientist from the Mission Control Ground Station (MCGS), Abuja, Nigeria. Consequently, three remote sensing satellites; NigeriaSat-1, NigeriaSat-X and NigeriaSat-2 and one communications satellite; NIGCOMSAT-1R, have answered numerous questions on the status of space operations and the peaceful use of outer space. With the successful completion of its mission lifetime, NigeriaSat-1 was de-orbited after about nine years of useful and peaceful satellite operations. During its mission lifetime, it responded to both local and international disasters while in the Disaster Monitoring Constellation (DMC) including sustainable development campaigns initiated jointly or individually for satellites in the constellation such as Hurricane Katrina and the development of a national resource inventory showing land-use/land cover mapping at 1:50,000 etc. In continuation of this recorded achievements, NigeriaSat-X and NigeriaSat-2 which are advanced Earth Observation (EO) micro-satellites equipped with enhanced imaging performance for improved capability and applications have equally witnessed improved satellite operations from the Abuja MCGS. Also, NIGCOMSAT-1R has been applied in tele-medicine and tele-conferencing, data transfer, internet services, e-library etc. In the course of our satellite operations, useful lessons have been learnt in the management and operations of more than one satellite from a single ground-station for the remote sensing satellites. Therefore, in this paper, we review and share our operational experiences, achievements and future direction on our quest into space for sustainable development through the use of our remote sensing and communications satellites.**



## I. Introduction

Since the launch of the first man-made satellite into orbit in 1957, *Sputnik 1*, by the then Union of the Soviet Socialist Republic (USSR) now the Russian Federation, there has been discussions on the peaceful uses of outer space by the General Assembly (GA) of the United Nations[1]. This led to the formation of the United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) in 1959 with 24 permanent member states tasked primarily with the development and principles of laws governing activities in outer space. It has two subcommittees to perform the technical work of COPOUS; the Scientific and Technical Subcommittee (STSC) and the Legal Subcommittee (LSC), with the UN Office of Outer Space Affairs (OOSA) serving as COPUOS secretariat[1,2]. Currently, the membership of COPOUS has increased to 76 member states and about 32 organizations with permanent observer status[2]. Nigeria declared her intention to venture into space in 1976 at the ECA/OAU (Economic Commission for Africa/Organization of African Unity) meeting in Addis-Ababa (Ref. 3) and later

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became a member of COPUOS in 1977. She has since then actively participated in all meetings of the committee and its subsidiary bodies[4]. It is worthy to mention that a Nigerian, Dr. Adigun Ade Abiodun, served as the Chairman of COPOUS between June 2004 to June 2006 (Ref. 5), while another Nigerian, Mr. Tare Brisibe has served as Chairman in the Legal Subcommittee[6]. On 5th of May 1999, the National Space Research and Development Agency (NASRDA) was established with an overall agenda geared towards sustainable socio-economic national development including the development of space science and technology, new resources, understanding our environment, defence and national security[7,8]. This agenda necessitated the development of a National Space Policy which was approved in 2001 followed by the development of a 25-year Road Map that was approved in 2006 for a period between 2005 and 2030[8]. As stated in Ref. 9, the objectives of NASRDA can be summarized as:

- Development and deployment of high technologies in space systems for application in communication, earth observation, observatory and space transportation
- Application of the high technologies for infrastructural development, resource & environmental management including applications in hydrology, agriculture, water resources, education, healthcare delivery, security, etc.
- Facilitation of the development and domestication of space technology and its products towards enhancing job and wealth creation
- Development of infrastructure for geospatial data acquisition and management

In order to accomplish the aims and objectives on which NASRDA was established, three committees were set-up to implement the space technology programs in line with United Nation's Millennium Development Goals (MDGs), the New Partnership for Africa's Development (NEPAD) and the National Economic Empowerment and Development Strategies (NEEDS). These committees are:

1. The National Space Council chaired by The President, Commander-in-Chief of the Armed Forces, and has twelve (12) members including the Vice President and three (3) distinguished scientist (Ref. 10)
2. The Technical Advisory Committee (TAC) and
3. An International Cooperation Committee

NASRDA is made up of seven (7) operational or activity Centres as provided in the NASRDA Bill which was signed as an Act of Parliament in 27th August 2010 by the President. These activity Centres implement research and development programs and foster international as well as local collaborations in order to provide solutions for sustainable national socio-economic developments and also address the needs of Sustainable Development Goals (SDGs). The activity Centres and their locations across Nigeria are represented in Fig. 1.

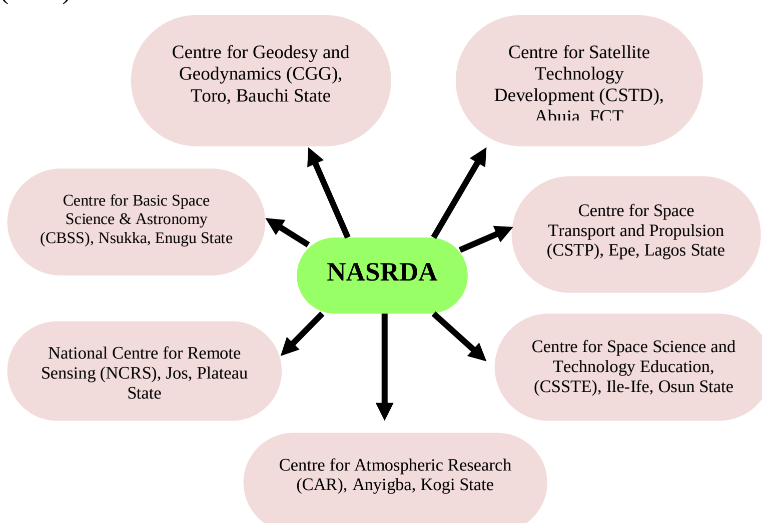



**Figure 1. NASRDA Activity Centers**

Therefore, through its seven activity Centers, the Nigerian Space Agency has a mandate to (Ref. 9);

a) Promote the co-ordination of space application programs for the purpose of optimizing resources
b) Develop national strategies for the exploitation of the outer space and make these part of the overall national development strategies
c) Develop space technologies of direct relevance to national development
d) Implement strategies for promoting private sector participation in the space industry, and
e) Strengthen capacity building and human resources development, which are required for the implementation of the national space program

Currently, NASRDA serves as the Regional Support Office (RSO) for the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER)[9], which was established as a program within the UN and implemented by the OOSA, to provide universal access to all countries and all relevant international and regional organizations all types of space-based information and services relevant to disaster management to support the full disaster management cycle[11].

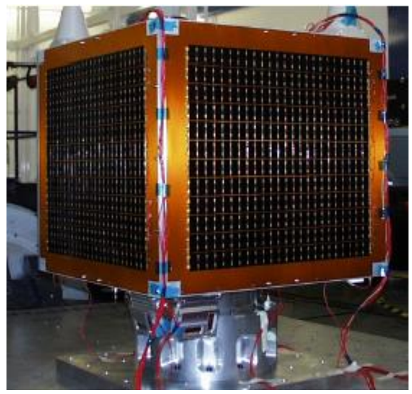
## II. Nigeria's Earth observation satellites and applications

### A. NigeriaSat-1

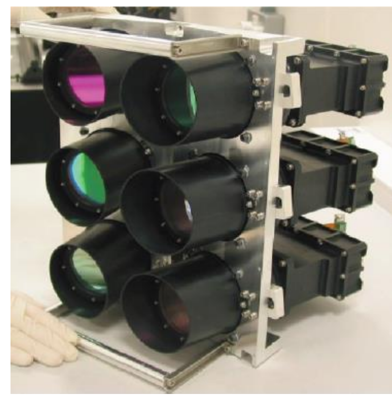
In line with NASRDA's space policy, the Nigerian Space Agency is committed in delivering efficient and effective human resources and capacity building, natural resources management, defence and national security, earth observation/environmental monitoring, space communication applications, education and training as well as international cooperation, through its SST programs[12]. On 27th September, 2003, Nigeria launched its first satellite, the NigeriaSat-1 shown in Fig. 2a (Ref. 13), from Plesetsk, Russia, into a Low Earth Orbit (LEO). This micro-satellite operated for about 9 years even though it was initially designed with a lifespan of 5 years, thereby outliving its mission design lifespan. Throughout its long years of operational lifespan, NigeriaSat-1's data was timely accessible, thereby stimulating indigenous research and development by many relevant institutions of government and private sector to enhance sustainable national development and support disaster management in the country and other parts of the world.

Nigeriasat-1 was equipped with an imaging payload shown in Fig. 2b, designed and built in the class of Surrey Linear Imager Multi-spectral – 6 Channels (SLIM-6) by Surrey Satellite Technology Limited (SSTL) under the SSTL Class-100 (SSTL-100) series platform, and had a total satellite wet mass of about 100 kg.

The SLIM-6 design consists of two nadir pointing banks of three-band Multi-Spectral Imager (MSI) of Red, Green and Near-Infrared (RGNIR), operated in push-broom technology at a medium resolution of 32 m Ground Sample Distance (GSD) and offers a swath-width coverage of 600 km from a LEO altitude of 686 km[14,15]. The specification of the SLIM-6 design is given in Table 1.



(a)



(b)

**Figure 2. (a)NigeriaSat-1 satellite and (b) SLIM-6 MSI Payload onboard NigeriaSat-1 (Ref. 13).**

TABLE I
Slim-6 Specifications

| **Specification** | **Value** |
|---|---|
| Number of banks | 2 |
| Number of Spectral bands | 3 |
| Spectral bands | Red, Green, Near Infrared (RGNIR) |
| GSD @ 686 km altitude | 32 m |
| Swath-Width | 600 km |

The payload onboard NigeriaSat-1 is commonly referred to as a Medium Resolution Imager (MRI) payload. The NigeriaSat-1 satellite project at SSTL involved a Know-How Technology Transfer (KHTT) training of fifteen (15) Nigerian Engineers/Scientists in various satellite subsystems including the Ground-Station and also involved the design and building of a non-flight Training Model (TM).

Under the Disaster Monitoring Constellation, (DMC), coordinated by DMC International Imaging (DMCii), NigeriaSat-1, along with four other satellites in constellation from four countries namely; AlSat-1 (Algeria), UK-DMC & UK-DMC-2 (United Kingdom), Beijing-1 (China) and BilSat-1 (Turkey) with an addition from Deimos-1 (Spain) into the DMC, provided numerous satellite data for Earth Observations.

NigeriaSat-1 in its lifetime captured high quality satellite images using its SLIM-6 MSI payload and demonstrated efficient sustainable value. In demonstrating its image capture capability across the world and Africa in particular, NigeriaSat-1 has been employed in the areas of agriculture, monitoring desertification, land use, water resources, local and international disasters where real time data has been provided. It has been used to map the whole of Nigeria including the Niger Delta region of the country where cloud covers are present all year round. However, windows of opportunities present themselves in a matter of days for a period of about three weeks in the Harmattan season. These windows of opportunities provided the best sets of images to fully map the country.

The highlights of major projects based on NigeriaSat-1 data include[8,16]:

- Mapping of urban and rural landuse/landcover in Nigeria
- Mapping/Monitoring of gully erosion in parts of South Eastern Nigeria
- Mapping and analyzing flood hazard/risk along Kaduna River and Shiroro Dam in Kaduna/Niger States (Fig. 3)
- Monitoring of deforestation in Nigeria and its implication on biodiversity
- Mapping of settlement, major roads and water bodies in Nigeria
- Predictive model for early warning of desertification
- Spatio-temporal assessment of climate and human-induced impact on ecosystem degradation and water resources management

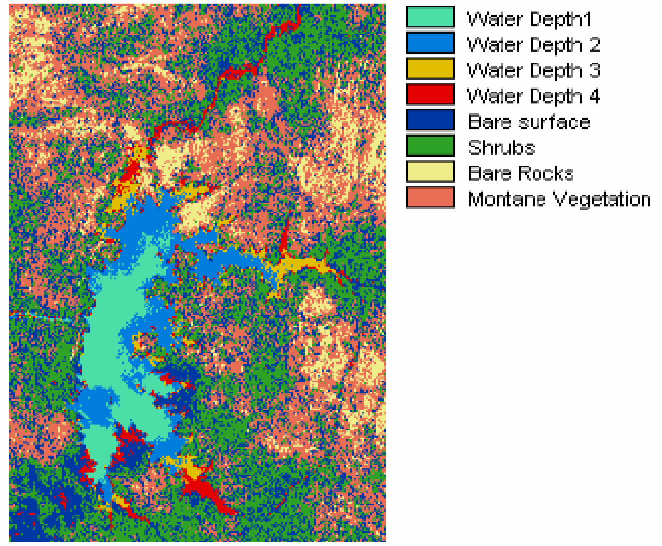
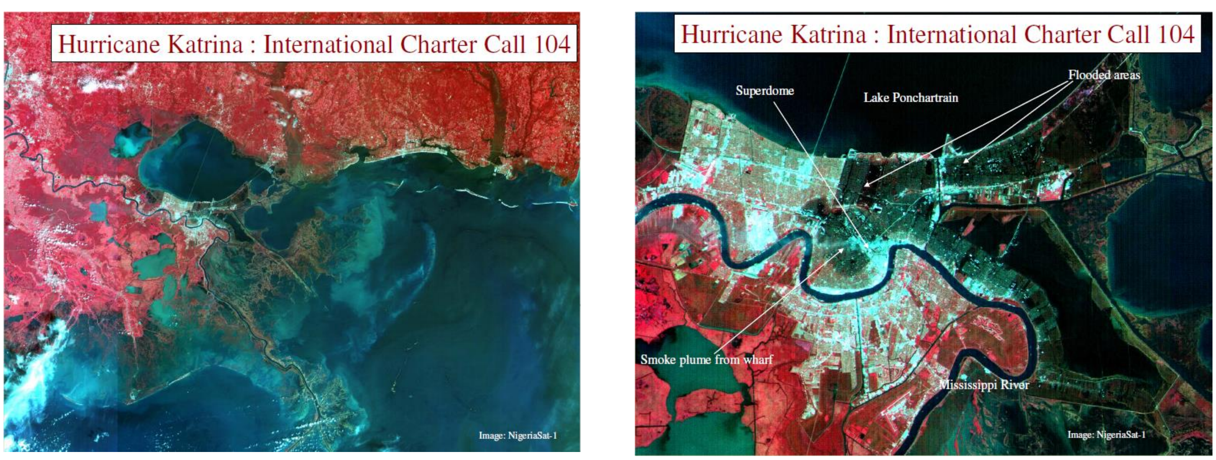



**Figure 3. NigeriaSat-1 image of Shiroro Dam showing land use and various**

In 2004, NigeriaSat-1 devoted its resources and supplied over twenty (20) images of the affected areas of the Southern Asian Tsunami to RESPOND – an European Space Agency (ESA) project set up to produce and deliver maps to aid agencies mapping the disaster. More significantly, NigeriaSat-1 was the first satellite from the DMC to capture images of the affected region of the Hurricane Katrina that




(a) (b)

**Figure 4. NigeriaSat-1 image of flooding in New Orleans, USA, due to Hurricane Katrina (a) full captured image (b) exploded view of affected region (Ref. 17)**

devastated New Orlean, USA in August 2005. As shown in Ref. 17, Fig. 4a shows the image captured by NigeriaSat-1 during Hurricane Katrina while Fig. 4b gives an exploded view of the affected region in New Orleans, USA.

Some of the other projects where NigeriaSat-1 along with other DMC satellites has participated through DMCii as shown in[17,18] include;

- Mapping of the whole of Australia
- Monitoring of California and Australia forest fires

- Mapping of the coastal areas of Vietnam
- Mapping of the Amazon forest in South America
- Mapping of the entire European Union countries

The campaign for mapping the Amazon basin kicked off in 2005 and continued annually[18].

In areas of agriculture, NigeriaSat-1 contributed in maximizing crop yield and quality for both locally (the world bank Fadama Project implementation) and internationally (particularly in areas of precision agriculture for France[17]), thereby minimizing production cost and environmental impact since fertilizers and crop protection chemicals were applied only where needed and at required quantities[19]. This near real time precision farming campaign involved all DMC satellites and took advantage of their wide swath-width coverage of 600 km and being in constellation. This precision agriculture campaign has also been carried out for other countries such as United Kingdom, Belgium, Netherlands, Canada, USA, Russia, Ukraine, Argentina, Japan, South Africa, Poland and Lithuania.

### B. NigeriaSat-2

In continuation of the success recorded in the launch of NigeriaSat-1 as detailed in section A, the Federal Government of Nigeria through NASRDA embarked on a Next Generation satellite project in November 2006 which culminated in the launch of NigeriaSat-2 and NigeriaSat-X on 17th August 2011 (although initially scheduled for launch in 2009) using a DNEPR-1 launch vehicle from Yasny/Dombarovsky launch site located in Orenburg Region, Russia. The NigeriaSat-2 satellite project involved the KHTT training of 26 Nigerian Engineers/Scientist alongside with a postgraduate program. NigeriaSat-X is the Training Model (TM) satellite robustly redesigned and built by the Nigerian KHTTs to flight standard during the NigeriaSat-2 satellite program at SSTL.

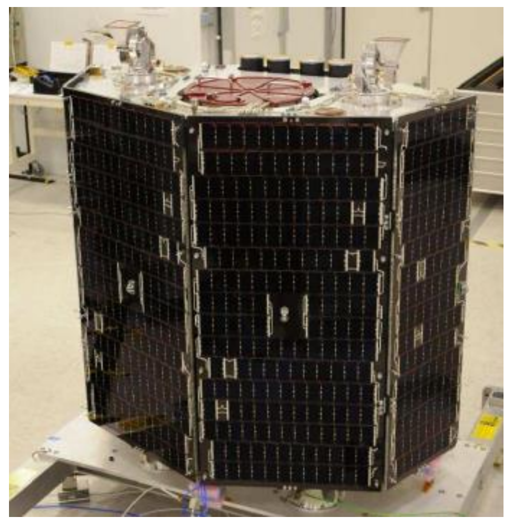


**Figure 5. NigeriaSat-2 spacecraft (Ref. 20).**

NigeriaSat-2, as shown in Fig. 5, is a next generation Earth Observation (EO) satellite by SSTL with a mass of about 300 kg (SSTL 300) and has its heritage from DMC+4 and TopSat missions[20].

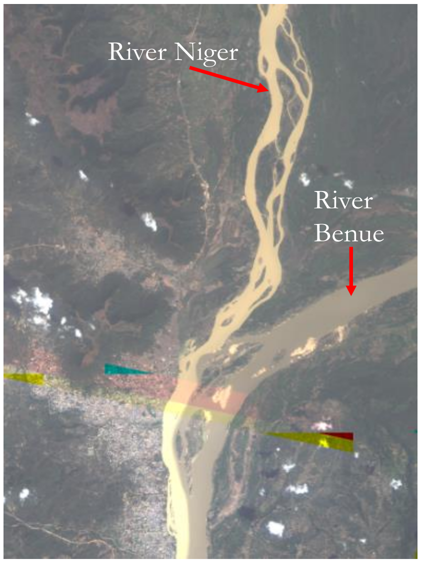
It has a Very High Resolution Imager (VHRI) with spatial resolution of 2.5 m in a panchromatic waveband and 5 m in four (4) multi-spectral wavebands of Red, Green, Blue and Near InfraRed (RGBNIR). It is equally equipped with a 32 m spatial resolution in four multi-spectral channels of RGBNIR in order to ensure continuity of NigeriaSat-1 imagery in variety of applications such as large-scale mapping and precision agriculture. Therefore the satellite is equipped with two payloads, the VHRI and the MRI. The VHRI has a swath-width of 20 km and thus defines its scene as a 20 km × 20 km image while the MRI with a swath-width of 300 km defines its scene as a 300 km × 20 km where the across-track is 300 km and the along-track is 20 km. The satellite has a design life of 7 years with advanced agile stereo imaging capability. This agility enables NigeriaSat-2 to deliver high data throughput, whilst still maintaining high levels of pointing accuracy[20].

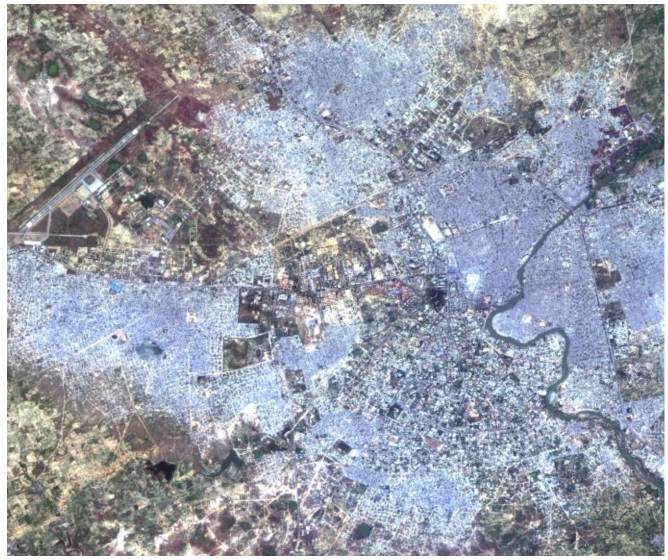
NigeriaSat-2 imagery also provides valuable high resolution geographically referenced images to local and international users for large-scale mapping and gives the ability to pinpoint individual buildings, roads or fields of interest from space. The very high resolution images are also used for urban planning especially in Nigeria’s rapidly expanding cities, water resources management, precision agricultural, land use changes, population estimation, health hazard monitoring and disaster mitigation and management, quarterly mapping of Nigeria in detail, enhancing food security through monthly crop monitoring.

Some of the projects undertaken from the launch of NigeriaSat-2 and NigeriaSat-X include (Ref. 12);

- Development of national resource inventory showing land-use/land cover mapping at 1:50,000
- Development of national environmental assessment map and national soil map
- Development of national flood vulnerability map for national disaster management
- Mapping of national surface water
- Mapping of Nigeria cities and national infrastructure
- Generation of Digital Terrain Model (DTM) at 3-4 m interval

Some of the local images from NigeriaSat-2 include the image of the confluence point in Lokoja, Kogi State (Fig. 6a) and Maiduguri, Borno State (Fig. 6b).



(a) (b)

**Figure 6. NigeriaSat-2 2.5m multi-spectral image of (a) the confluence point at Lokoja, Kogi State, Nigeria captured on 22/11/14 and (b) Maiduguri, Borno State as at 12/09/14.**

Equally, some of the NigeriaSat-2 satellite images of international locations include the Ferrari World, Abu Dhabi captured on 2nd July 2014 (Fig. 7a) and Windhoek, Namibia which was taken on 14th July 2013 (Fig. 7b).

(a) (b)

**Figure 7. Nigeriasat-2 5 m multi-spectral image of (a) the Ferrari World, Abu Dhabi captured on 02/07/2014 and (b) Windhoek, Namibia, captured on 14/07/2013.**

### C. NigeriaSat-X

As introduced in section B, during the NigeriaSat-2 satellite program, the Nigerian KHTT team designed, built and tested a flight standard experimental satellite, the NigeriaSat eXperimental otherwise known as NigeriaSat-X, which served as the TM of NigeriaSat-2 satellite to demonstrate the knowledge gained from both the academic and professional training during their stay at Surrey[21]. The aim of the NigeriaSat-X project was to provide the KHTTs with hands-on experience in mission design, requirement specification, project management, system engineering, test, manufacturing process including Assembly Integration and Testing (AIT) and Ground-Station operations. With the KHTT program geared towards advanced training in satellite engineering, the NigeriaSat-X also serves as a demonstration of Nigeria's readiness of building its own satellite in the near future as contained in the Agency's Roadmap. This next generation EO micro-satellite was launched alongside with NigeriaSat-2 on 17th August 2011.

NigeriaSat-X (shown in Fig. 8) is an advanced EO micro-satellite based on SSTL Enhanced Micro-Satellite Class 100 (SSTL-EMS100) which evolved from SSTL DMC and DMC-2 satellites.

It maintained the SLIM-6 structure for its payload design and has a design life time of 5 years. NigeriaSat-X is employed in areas of resource management, enhancement of food supply security, disaster monitoring e.g. flooding, erosion control, forest fires etc., providing support for the development of National Geographical Information System (GIS), high resolution mapping of Nigerian territory at every quarter and providing continuity to NigeriaSat-1 imagery at a higher resolution. The key features of NigeriaSat-X include;

- 22 m MRI (next generation imager) with enhanced image capability and improved optics
- Swath-width of 600 km @ 8 bit
- 2 × 2 GByte Solid State Data Recorders (SSDRs)
- High Rate Transmitter (HRTx) X-band downlink @ 20 Mbps
- Low Rate Transmitter (LRTx) S-band downlink @ 8 Mbps
- Wet mass of ~87 kg with spacecraft size of 0.6 m × 0.6 m × 0.6 m excluding antenna height and separation system

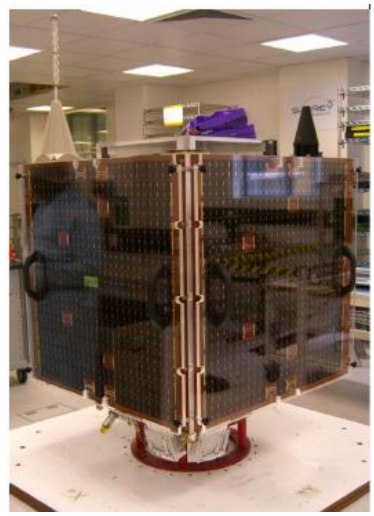


**Figure 8. NigeriaSat-X spacecraft.**

NigeriaSat-X captured its first image on the 21st of August 2011. The image as shown in Fig. 9 was a cloud free image of Auckland, New Zealand. This image demonstrates Nigeria's capability of designing and building its own satellite. Similar to NigeriaSat-2, the satellite is operated by Nigerian Scientist/Engineers at the Abuja Ground-Station in NASRDA.

**Figure 9. NigeriaSat-X image of Auckland, New Zealand.**

Following the brief description of the NigeriaSat-1, NigeriaSat-X, and NigeriaSat-2, it can be seen that NigeriaSat-X is an enhanced version of NigeriaSat-1. Table 2 below offers some comparative review of NigeriaSat-1 and NigeriaSat-2.

TABLE 2
Comparative study of Nigeriasat-1 and Nigeriasat-2

| **NigeriaSat-1** | **NigeriaSat-2** |
|---|---|
| Equipped with one MRI payload module | Equipped with two payload modules (MRI and VHRI) |
| No telescopic aperture | Fitted with a telescopic aperture |
| Provided multi-spectral images | Provides both multi-spectral and panchromatic images, and provides image continuity of NigeriaSat-1 |
| Had 3 multi- spectral bands of Green, Red and Near IR | Has 4 multi-spectral bands of Blue, Green, Red and Near IR spectral bands |
| Had a design life time of 5 years | Has a design life time of 7 years |
| Typical wet mass of 100kg (launch mass: 98 kg) | Typical wet mass of 300 kg (launch mass: 286 kg) |
| GSD of 32 m @ 686 km | GSD of 32 m, 5 m and 2.5 m @ 700 km |
| Used butane as propellant | Uses xenon fuel as propellant |
| Used gravity gradient stabilization | Uses 3-axis stabilization |
| Equipped with $2 \times 0.5$ GB SSDRs for data storage | Uses $3 \times 8$ GB HSDR (one master, one cold redundant master and one slave) |
| Equipped with OBC186 and OBC386 for on-board computing | Equipped with $2 \times$ OBC386 and OBC750 |
| Operated in linear array imaging mode | Operates in strip, stereo, scene and area imaging modes |

## III. Nigeria's Communications Satellite and applications

With the successful launch of Nigeria's first satellite, the NigeriaSat-1, being an Earth Observation satellite on 27th September 2003, there was a quest for a communications satellite due to its importance in Information and Communication Technology (ICT) which plays a very vital sustainable role in the socio-economic development of developing nations such as Nigeria. To this regard, the Federal Government of Nigeria approved the Nigeria Communications Satellite Project (NIGCOMSAT-1) as a national priority project on 12th November 2003 (about 46 days after NigeriaSat-1 launch). The NICOMSAT-1 project was handled by China Great Wall Industry Corporation (CGWIC) which is a subsidiary of China Aerospace Science and Technology Corporation (CASC). This project which included the training of about 55 Nigerian Engineers/Scientist, manifested in the launch of NIGCOMSAT-1 (Fig. 10) on 13th May 2007 into a geostationary orbit using Long March 3B launch vehicle from Xichang Satellite Launch Centre, China[8]. However, due to technical fault, this satellite failed on 11th November 2008. Considering its importance to national development, the satellite was replaced through the launch of NIGCOMSAT-1R on 19th December 2011 from Xichang Satellite Launch Centre, China.

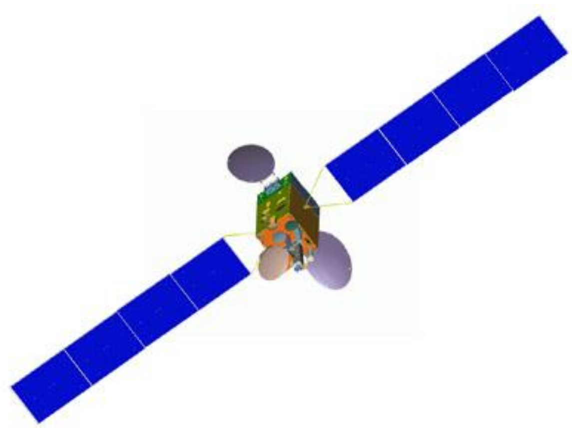


**Figure 10. Model of NIGCOMSAT-1.**

NIGCOMSAT-1R satellite has a wet mass of over 5 tonnes and is equipped with 40 transponders with 28 active transponders in the Ku, Ka, C, and L bands designed with life-span of 15 years (Ref. 16). The bands are as shown in Table 3.

The satellite coverage area of operation includes Africa, the Middle-east and Europe. Due to its economic value, a limited liability company was established, the Nigerian Communication Satellite Ltd, for the sole purpose of commercializing and managing the services/investments of the satellite[8,16].

TABLE 3
Application of bands used on Nigcomsat-1R (Ref. 8)

| | Ku-band | Ka-band | C-band | L-band |
|---|---|---|---|---|
| Telephony | ✓ | ✓ | | |
| Video | ✓ | ✓ | | |
| Data Transfer | ✓ | ✓ | | |
| Tele-medicine | ✓ | | | |
| Tele-conferencing | ✓ | | | |
| Tele-education | ✓ | | | |
| Television Signals | | | ✓ | |
| Internet data transmission | | | ✓ | |
| Security | | | | ✓ |
| Surveillance | | | | ✓ |



## IV. Earth observation satellite operations

NigeriaSat-1 Mission Control Ground-Station (MCGS) was located at a temporary site at Asokoro, Abuja, Nigeria. This MCGS was divided into two major units; the Satellite Control Unit (SCU) and the Mission Operations Unit (MOU). While the SCU is made up of two key areas namely; the Mission Control Systems (MCS) and the Mission Planning System (MPS), the MOU on the other hand houses the Mission Data Centre (MDC). The SCU is responsible for monitoring and maintaining the satellite and its sub-systems as well as performing propulsion planning, telemetry data handling, general house-keeping task and commanding the mission. It is also responsible for the routine operations and maintenance of the Ground-Station facilities. Details of these units are discussed in[3].

Similar to the NigeriaSat-1 MCGS, the NigeriaSat-2 Ground-Station is simply known as the Mission Control Centre (MCC). It monitors and maintains both NigeriaSat-2 and NigeriaSat-X satellites and is made up of the Spacecraft Control Centre (SCC) and the Mission Operations Centre (MOC). The SCC performs similar functions as the Satellite Control Unit of NigeriaSat-1. The MOC however, is a highly integrated suite of computerized systems that facilitate the planning and management of satellite imaging acquisitions and the processing of downloaded image data into data products. It comprises of the following components:

- User Interface for Mission Operations called the Atlas Interface
- Mission Planning System including Satellite Planners which interfaces with the SCC
- Image Handling System including Keystone Image Catalogue
- Image Processing Systems including Smart-i and Keystone
- Image Archive
- Delivery point system

## V. Sustainable gains through capacity building

The second United Nations Conference on Exploration and Peaceful Uses of Outer Space (UNISPACE II) which took place in 1982 in Vienna, Austria, recommended that the UNOOSA, through its program on Space Applications, should focus its attention, inter alia, on the building of indigenous capacities for the development and utilization of Space Science and Technology[22]. In pursuant to this, NASRDA has focused significant attention on capacity building since inception. This is evident in all NASRDA's satellite programs starting from the first satellite program that kicked off at SSTL in November 2001 where 15 engineers and scientist were trained in all areas of satellite technology in a KHTT program. This trend has continued over the years with some improvement in the training packages such as the inclusion of postgraduate academic courses in satellite engineering to its Nigeriasat-2 KHTT programme. In consolidating its achievements further, NASRDA has recorded a tremendous feat in training of over 123 staff up to Masters level and over 77 staff up to PhD level.

As stated in Ref. 8, the NIGCOMSAT-1 project was instituted mainly to provide critical and innovative collaboration for capacity building and the development of satellite technology for a quantum transformation in the telecommunication, broadcasting and broadband sector in Africa as well as providing strategic business information access to rural and remote regions of Africa for rapid economic growth. Currently, these targets are vigorously pursued for efficient service delivery and rapid economic growth. As stated in section III, the NIGCOMSAT-1 project included the training of Engineers and Scientists, its replacement satellite project, the NIGCOMSAT-1R also included capacity building where 30 Engineers and Scientists where further trained on satellite operations and maintenance in order to consolidate the gains recorded in sustainable national development.

Apart from the training of its personnel, NASRDA also embarks on;

- the training of related government agencies on the use of space-based technologies for intelligence gathering towards national security
- creation of awareness of space science and technology for students of primary, secondary and tertiary institutions
- collaboration with local and international universities and
- collaboration with international space agencies

## VI. Conclusions

In light of the above, it can be better argued that although developing nations should focus on traditional agricultural practices to provide food for its citizens, space technology has proven to support agriculture thereby enabling higher yield of crops and agricultural produce for food security of both developing and developed nations. It is also the driving force behind the economic growth of most developing and developed countries of the world.

Through the satellite data derived from NigeriaSat-1, users have appreciated the affordable access to real-time and archived space-derived medium resolution geo-information. With the launch of NigeriaSat-2 and NigeriaSat-X, where individual houses can be pinpoint from space, mapping and planning of rural and urban areas have become possible and affordable. Global development in all areas including precision agriculture and response to international Charters on disasters have also been made possible through a constellation.

In reaping its economic benefits, Nigeria has always applied a peaceful approach in exploration of outer space in order to sustain her economic development.


## Acknowledgments

We are very grateful to Mr. Baslem Okehie for his contributions on the operations of the NigeriaSat-2 Mission Control Centre.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