

EXPLORING THE WONDERS OF SPACE TECHNOLOGY, ROCKETS, SATELLITES, AND SATELLITE LAUNCHING IN NIGERIA: A REVIEW.

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ABSTRACT

The fascination with space and the quest to explore the cosmos have driven human innovation for centuries. Over the years, space exploration has always been considered a reserve of the developed countries and world's superpowers. In recent years however, developing nations such as Nigeria, India, Chile and South Africa, have begun to change this view, by their participation in space technology and exploration. From the early days of rocket science to the current era of satellite technology, space exploration has become an integral part of modern life. The space technology program in Nigeria has been on a remarkable journey since its inception, with notable achievements in rocket and satellite technology. The National Space Research and Development Agency (NASRDA) is responsible for satellite operations and has been at the forefront of this journey, driving innovations and explorations. The goal of Nigerian space program is for socio-economic development, national security, development of indigenous satellite manufacturing and technology and the development of a national geospatial data infrastructure (NGDI). Nigeria through NASRDA has overseen satellite operations, including the launch of five satellites: NigeriaSat-1, NigeriaSat-2, NigeriaSat-X, NigComSat-1, and NigComSat-1R. This review will discuss rockets, satellites, and satellites launching, highlighting the key concepts, technologies, and applications that shape this exciting field. It will also discuss the Nigerian space programs, the challenges, contribution to national advancement and will recommend areas for improvement and sustainability.

KEYWORDS: NASRDA, Nigeria, Space-program, Satellites, Rockets, Sustainability.

Introduction:

Satellites are artificial objects that orbit around celestial bodies, such as the Earth, Moon, or Sun. These objects can be natural, like asteroids or comets, or man-made, like the thousands of satellites currently in orbit around the planet. Satellites play a vital role in modern communication, navigation, weather forecasting, security and scientific research (Nkordehet *al.*, 2017).

Types of Satellites

There are several types of satellites, each designed for specific purposes (Nkordehet *al.*, 2017; Agbolade, 2019):

1. Communication Satellites: These satellites facilitate global communication by transmitting data, voice, and video signals between different locations.

2. Navigation Satellites: Satellites like GPS (Global Positioning System) provide location information and timing signals, enabling accurate navigation and mapping.
3. Weather Satellites: These satellites monitor weather patterns, track storms, and provide critical data for forecasting and climate research.
4. Scientific Satellites: Satellites like the Hubble Space Telescope explore the universe, studying celestial objects, and expanding our understanding of the cosmos.

Parts of Satellites and their functions

- i. Satellite transponder: This does frequency conversion
- ii. Antenna subsystems: The antennas help receive and transmit the signals from the earth and towards earth respectively.
- iii. Solar cell and battery backup: It keep satellite running in space. Solar cell converts solar energy to the electrical energy for satellite operation. During sun light conditions, it is very useful. Sun light battery will take care of providing power to the satellite for its operation(Nkordehet *al.*, 2017; Agbolade, 2019).

Rockets

Rockets are the vehicles that carry satellites and other payloads into space. The process of launching a rocket is a complex and highly orchestrated event, involving multiple stages and precise calculations. The knowledge of rockets came in the seventeenth century with the works of scientists such as Galileo.

The foundation of rocket science is based on Isaac Newton's Three Laws of Motion (NASA, 2020):

First Law states that: Objects at rest remain at rest and objects in motion remain in motion in a straight line unless acted upon by an unbalanced force.

Second Law states that Force equals mass times acceleration (or $f = ma$).

Third Law states that for every action there is an equal and opposite reaction.

Types of Rockets

There are several types of rockets, each designed for specific missions (NASA, 2020):

1. Launch Vehicles: These rockets lift payloads into space, such as satellites, spacecraft, or crewed vehicles.
2. Spacecraft: These rockets are designed for interplanetary travel, carrying payloads to other planets or celestial bodies.

3. Sounding Rockets: These rockets study the upper atmosphere, collecting data on weather patterns, atmospheric conditions, and astronomical phenomena.

The Parts of a Rocket

The Rockets consists of

- i) the body, which is a hollow cylinder
- ii) the launch lug
- iii) the fins (which provide stability)
- iv) the engine holder
- v) the rocket engine
- vi) the nose cone
- vii) the recovery device (used to return the rocket to the ground after it has reached its highest point, tail nozzle.

Uses of Rockets

- i. Rockets carry robotic probes to study other planets.
- ii. They carry artificial satellites such as weather and communication satellites.
- iii. They are used to carry astronauts to space.
- iv. They are used to carry portable laboratories to perform scientific research

The Rocket Launching Process

Launching a rocket involves several stages (Vogt, 1993; NASA, 2020):

1. Pre-Launch Preparations: The rocket is assembled, fueled, and prepared for launch. Gases burnt within the combustion chambers of the rocket engine are expelled downward through the exhaust or tail nozzle at a very high velocity, the rocket is given a thrust by an equal and opposite momentum, and it then moves upward.
2. Lift-Off: The rocket lifts off the launchpad, propelled by its engines.
3. Stage Separation: The rocket's stages separate, with each stage firing its engines to propel the payload higher.
4. Orbit or Interplanetary Trajectory: The payload reaches its desired orbit or trajectory, beginning its mission.

The Space Program in Nigeria

The National Space Research and Development Agency (**NASRDA**) is responsible for satellite operations in Nigeria with its main focus on satellite technology. The aim of the Nigerian space program is to develop a national geospatial data infrastructure (NGDI) which facilitates effective implementation of national developmental goals. The main objectives are:

- i. For socio-economic development
- ii. For national defense and security
- iii. For development of indigenous satellite manufacturing and technology

National Space Research and Development Agency (NASRDA), the agency in charge of satellites launched by Nigeria, is also charged with the mandate to consolidate all Space Science and Technology related activities in Nigeria. The Agency was established in May 5, 1999 has the Headquarters in Abuja, with six operational centres (Adetoro and Aro, 2007; Nkordehet *et al.*, 2017) as follows:

1. Centre for Satellite Technology Development (CSTD), Abuja
2. Centre for Space Science and Technology Education (CSSTE), Ile-Ife
3. Centre for Space transportation and Propulsion (CSTP), Epe
4. Centre for Basic Space Science (CBSS), Nsukka
5. Centre for Geodesy and Geodynamics (CGG), Toro
6. National Centre for Remote Sensing (NCRS), Jos

The National Space Research and Development Agency is in pursuit of the development and application of space science application and technology for the socio-economic benefits of the nation. (Adetoro and Aro, 2007; Halilu, 2010; Nkordehet *et al.*, 2017).

So far five satellites have been launched by the NASRDA;

1. NigeriaSAT-1 (27th September 2003)
2. NIGCOMSAT-1 (14th May 2007)
3. NIGERIASAT-X (17th August 2011)
4. NIGERIASAT-2 (17th August 2011)
5. NIGCOMSAT-1R (13th December 2011)

Satellite Launches in Nigeria: Early Beginnings

Nigeria's space history dates back to 1961 when the National Aeronautics and Space Administration (NASA) built a satellite earth station in Kano to monitor the Gemini and Apollo space missions. This early collaboration laid the foundation for Nigeria's future space endeavors. One of Nigeria's most significant achievements in space technology is the launch of its satellites. The NigeriaSat-1, launched in 2003, was the first satellite to send images of the US east coast after Hurricane Katrina. The satellite also provided valuable images for aid workers following the Asian Tsunami. In 2011, the NigeriaSat-2 and

NigeriaSat-X were launched, with the latter being built solely by Nigerian engineers. These satellites have been used for various applications, including disaster management, environmental monitoring, and education (Godstimeet *al.*, 2014).

Nigeria has also made significant progress in rocket technology. The Centre for Space Transport and Propulsion (CSTP) in Epe, Lagos State, has completed several successful experimental rocket launches. Although the country is still in the early stages of developing its rocket launching capabilities, these achievements demonstrate Nigeria's potential in this area (Adetoro and Aro, 2007; Nkordehet *al.*, 2017).

NIGERIAN SATELLITE PROGRAMME AND THE NATIONAL GEOSPATIAL DATA INFRASTRUCTURE (NGDI) PROGRAMME

Nigeria is one of the countries in Africa that have taken steps towards establishing a National Geospatial Data Infrastructure (NGDI). The NGDI system and data holdings will effectively address Nigeria's geospatial data needs which are essential to her socio-economic development. Accurate geospatial products accessible to key government agencies and regional governments within the country will be useful for infrastructural development, national security planning and environmental monitoring.

The National Geospatial Data Infrastructure [NGDI] coordinated by NASRDA, will also facilitate (Akinyedea and Agbaje, 2003; Agbaje, 2008):

- i. Sustainable growth in the real sector of the economy
- ii. Physical Infrastructure: Power, Energy & Transportation
- iii. Agriculture
- iv. Human Capital Development: Education & Health
- v. Security, Law & Order
- vi. Combating Corruption
- vii. Niger Delta Development

SOME RESEARCH OUTPUTS FROM NASRDA SPACE TECHNOLOGY PROGRAM

- i. **The NASRDA Navigator Pro43: EXCLUSIVE SATELLITE.** The NASRDA Pro43 offers a unique new navigation experience in Nigeria. It is a high-resolution touch screen SAT-NAV, used for views and display of current locations. It provides simple, understandable, complete and clear voice instructions, which makes navigation easy. It pronounces street names during navigation, to make driving easy.
- ii. **The NASRDA MEGANETOMETER-** for Monitoring of Space Weather; Earth Movement.
- iii. **The NASRDA EPSM Station** - Environmental pollution and Soil Monitoring (EPSM) Station.

- iv. **The NASRDA surveillance system** - Portable stand-alone wireless surveillance system.
- v. **The NASRDA GPS System** - High Precision GPS System (Chizea, 2017; NASRDA, 2024)

SOME SPACE APPLICATION OUTCOMES FROM NASRDA SPACE TECHNOLOGY PROGRAM

- i. Gully erosion mapping in Anambra, Imo, Abia and Enugu States.
- ii. Flood hazard mapping in Kainji lakes.
- iii. Response to flooding in Lokoja
- iv. Natural resource/vegetation inventory in the FCT/Abuja region for sustainable development.
- v. Nigersat-2 High Resolution Satellite Imagery used for Dysemetric Population Estimation of Abuja Municipal Area Council.
- vi. Assessment of Environmental Sensitivity to Desertification in Northern Nigeria/ Katsina State (Chizea, 2017)
- vii. NASRDA-Telemedicine Remote Project- The telemedicine project is geared towards the provision of professional and affordable healthcare delivery for patients in rural and urban settlements via expert systems and aerospace facilities (NASRDA, 2024).

Applications and Future Directions

Satellites and rockets technology have numerous applications in modern life and have the capacity to improve socio-economic development in Nigeria. In addition, it represents the beginnings and repositioning of Nigeria and Africa in the current Space Age, technological and scientific advancement (Nkordeh, 2017):

- i. **Global Communication:** Satellites enable global communication, connecting people and businesses worldwide.
- ii. **Navigation and Mapping:** Satellites provide accurate location information, enabling navigation and mapping applications.
- iii. **Weather Forecasting:** Satellites monitor weather patterns, providing critical data for forecasting and climate research.
- iv. **Space Exploration:** Rockets and spacecraft explore the universe, expanding our understanding of the cosmos.
- v. **For defense and security**

Challenges and Future Directions

Despite these achievements, Nigeria's space program faces significant challenges, including funding constraints, limited infrastructure, lack of indigenous expertise, and political instability,. These hinder the long-term sustainability of space programs. The country's space budget is grossly inadequate with respect to the total budgetary allocation for the Ministry of Science and Technology and NASRDA in 2021 (Agbolade, 2019).

Conclusion

Satellites, rockets, and rocket launching represent the cutting edge of space technology, driving innovation and exploration. The nation's investment and interest into space technology while impressive and laudable requires more work. Therefore, amidst the socio-economic and political crises, it is essential to recognize the importance of sustainability of the space technology programs. As the nation continues to push its boundaries into space technology, more remarkable achievements and applications will be registered in the years to come. There is no doubt that the future of space technology holds much promise and excitement for Nigeria.

Recommendation

Nigeria's journey into rocket and satellite technology is a testament to their resilience and potential for innovation. While there are challenges to be addressed, the nation's space program has made significant progress and is poised for further growth and development.

To overcome these challenges, Nigeria needs to adopt a more sustainable and inclusive approach to space development. This includes but not limited to:

- i. increasing funding for space research and development
- ii. promoting private sector participation
- iii. developing strategic partnerships with international space agencies
- iv. bringing the existence of the Nigerian Space Research and Development Agency and the satellites services they provide to the general public through public outreach programs and the social media (Nkordehet *al.*, 2017).
- v. capacity building among undergraduate and postgraduate students through mentoring and technology transfer (Agbolade, 2019).

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