Space Technology and Geospatial Intelligence for National Security, Good Governance and Development in Africa: A Paradigm Shift

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Abstract
This paper examines and provides intrinsic information on prevailing Satellite-based Geospatial Intelligence (GEOINT) technologies and their applications in contemporary Nigeria geopolitical and socio-economic landscape as a necessity for national security, good governance and development. This became necessary in view of the intractable milieu resulting from social unrest and degrading economy orchestrated by the need for good governance and economic growth. Using a priori situational analysis of the activities of the National Space Research and Development Agency (NASRDA) in the provision of geospatial intelligence data and training to civil and security organizations, the paper reveals deep knowledge in Geospatial technology that are beneficial to personal safety, national security and development. It further reiterated the possibilities of harnessing satellite technologies for growth and prosperity. It then situates the need for everyone to embrace security tips with particular reference to the indomitable Class of 1994 Set of the Immaculate Conception College, Benin City Old Boys Association (ICCOBA) and Nigerians at large. The motto of ICCOBA is"Semper Et Ubique Fidelis" (Always and Everywhere Faithful), hence, members of the association, individuals, organizations/associations; whether private or public, including government agencies are encouraged to be security conscious and also be ready to learn from the knowledge based in GOEINT. Having a very rare opportunity to reunite after about thirty (30) years since graduation, it is recommended that ICCOBITEs and everyone should keep championing egalitarianism, professionalism, patriotism in service, rule of law and social justice as ingredients for national security, good governance and economic development in Africa.

Keywords: *ICCOBA, National Security, GEOINT, Geospatial Technology, NASRDA*

1. Introduction

Defining the concepts of Geospatial intelligence (GEOINT) and Geospatial Analysis, and then agreeing to acceptable definitions pertaining to principles, law and relevant theories have continued to be topics of topmost importance for debate in geospatial jurisprudence literature (Bello & Ufuah, 2018; Masback, 2010; Bacastow, 2010; Bridges, 20100). Nevertheless, a common denominator for the concept of GEOINT is that which includes deriving additional knowledge or information from carrying out further analysis on existing sources of geospatial data for effective and efficient decision making. Geospatial data sources include satellite imagery,

ground surveying, geographic field observations, and maps; whether produced from commercial satellites (such as SPOT, IKONOS, QuickBird, government satellites such as the NigeriaSat-1, NigeriaSat-2 and Nigerian Sat-x), aircraft (such as Unmanned Aerial Vehicles [UAV], drones, or reconnaissance aircraft), or by other means (such as maps and commercial databases, census information, GPS waypoints, utility schematic)s, or any discrete data that have locations on earth. In specific terms, GEOINT encompasses all aspects of imagery (including capabilities formerly referred to as Advanced Geospatial Intelligence (AGeoInt) and imagery-derived Measurement and Signature Intelligence (MASINT) and geospatial information and services (GIS); formerly referred to as mapping, charting, and geodesy (Bacastow & Bellafiore, 2009). GEOINT sources includes, among others, data ranging from the ultraviolet through the microwave portions of the electromagnetic spectrum in satellite remote sensing data acquisition as well as information derived from the analysis of literal imagery; geospatial data; georeferenced social media that are contributed voluntarily (Bello & Ojigi, 2013). GEOINT are also information technically derived from the processing, exploitation, literal, and non-literal analysis of spectral, spatial, temporal, radiometric (Bello and Rilwani, 2016), phase history, polarimetric data, fused products (products created out of two or more data sources), and the ancillary data needed for data processing and exploitation, and signature information (to include development, validation, simulation, data archival, and dissemination). These types of data can be collected on stationary and moving targets by electro-optical (to include IR, MWIR, SWIR TIR, Spectral, MSI, HSI, HD), SAR (to include MTI), related sensor programs (both active and passive) and non-technical means (to include geospatial information acquired by personnel in the field). The data obtained can be further used to generate maps and provide voluntarily, through collaborative web mapping platforms, location-based intelligence, Geo-tagging, image intelligence, decision planning and resource management (Bello and Ojigi, 2023). Geospatial intelligence specifically aids in the modeling and assessment of disasters such as floods (Nkeki, Bello & Agbaje, 2023), national security, conflict resolution and trans-border cooperation, assessment and monitoring (Bello, Nwagwu & Edobor, 2013), as well as smart city planning and modeling (Bello, Usman & Abubakar, 2022).

2. Statement of Challenges

No doubt, most governments of the day in Africa struggle to attain sustainable development through various planning programs and commitment to their plans. Supposedly, policies are aimed at achieving good governance. With all these plans in most African countries like Nigeria, spatial development is still slow especially in the face of geometric population growth and hunger (Bello, Irabor, Omole & Oboniye, 2016). Where data exists in most African countries, it cannot be relied upon because they are either obsolete or incomplete, or are still wrongly collected and collated. This partly explains why most African countries are bedeviled with duplication of poor socio-economic and bio-data required for strategic national security planning and development. It is disheartening that at every given opportunity, a citizen is required to provide similar data already provided and collected by different government organization or the likes. A good example is information for International Passport. Virtually similar or even same dataset is required for National ID Card, Driver's License, Permanent Voter's Card and even for Health Insurance Scheme. Unfortunately, over 75 percent of government data is geospatial in nature (location-based), and when you link this to base map, one can imagine the reliability or otherwise of the information for security and planning.

No wonder, in 2000, President Clinton's Address to Caltech on Science and Technology" at the California Institute of Technology (Clinton, 2000) is said to have affirmed thoughts on GEOINT such as… the future of technology and economic advancement and security will be in three broad technological areas, which are:

i.Biotechnology,
ii.Nanotechnology and
iii.Geospatial technology.

The aim of this paper, therefore, is to evaluate the concept and role of geospatial science and technology (geospatial intelligence) on national Security, good governance and development with focus on the roles of the National Space Research and Development Agency (NASRDA).

3. Geospatial Science and Technology (GST): Geospatial Intelligence in Focus

Geospatial Science (GIS) and Technology, now commonly known as Geomatics or Geoinformatics, refers to the science and technology used for geospatial data capture, measurement, analysis and visualization of features or phenomena that occur on the earth. A variant relying on the principle and methodology of GIS is the Cadastral Information System which centres on effective and efficient Land administration and management (Bello & Ortese, 2023). Put differently, Geospatial technology refers to equipment used to measure and analyze Earth's land and features. "Geo" is a *prefix* that comes from a Greek word meaning *"earth"*. "Spatial" means relating to *"Aerospace"*. Hence, and by extension, Geospatial intelligence deals with the application of satellite images and Remote Sensing technologies in solving spatial problems. As corroborated by Campbell (1987), Geospatial technology (GT) specifically includes remote sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS). Data from Geospatial technology can be analyzed to get information such as map, documentation and evidence for intelligent decision making (Figure.1).

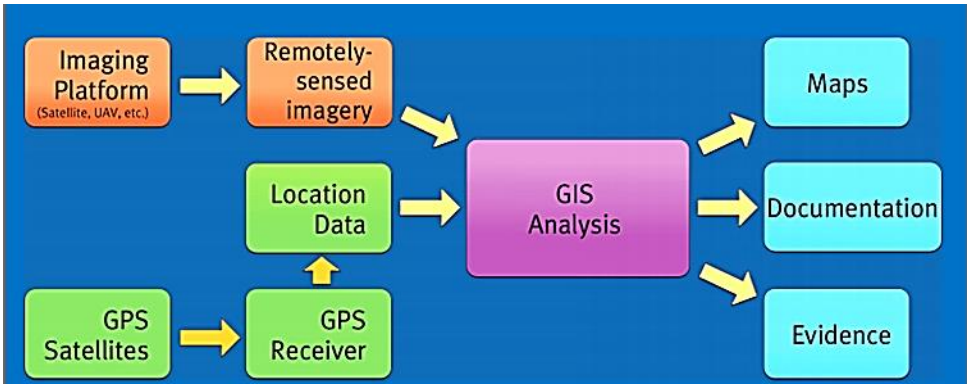

Figure 1: Geospatial Technology/Intelligence Application Work flow

The definitions and usage of the terms geospatial data, geospatial information, and geospatial knowledge are not consistent or unambiguous, thus further exacerbating the situation. While Geospatial data can (usually) be applied to the output of a collector or collection system before it is processed, i.e., data that was sensed, Geospatial Information is geospatial data that has been processed or had value added to it by a human or machine process. Consequently, Geospatial intelligence (Geo-knowledge) is a structuring of geospatial information, accompanied by an interpretation or analysis.

In literature, there is a growing recognition that human geography (Murdock, Tomes & Tucker, 2014), socio-cultural intelligence, and other aspects of the human domain are a critical domain of GEOINT data due to the now pervasive geo-referencing of demographic, ethnographic, and political stability data. There is an emerging recognition that "this legal definition paints with a broad brushstroke an idea of the width and depth of GEOINT" (Masback, 2010), and "GEOINT must evolve even further to integrate forms of intelligence and information beyond the traditional sources of geospatial information and imagery, and must move from an emphasis on data and analysis to an emphasis on knowledge." (The National Academies Press, 2006)

4. Satellite Remote Sensing and Geospatial Intelligence: necessary tools

Remote sensing is the observation of an object, surface or phenomenon from a distance without actually being in contact with it using automated sensor. In principle, objects reflect or emit radiations in different wavelengths, and intensities depends on specific surface feature conditions (Bello & Rilwani, 2016). An aircraft, spacecraft, satellite, ship or other micro-sensors may be used for remote sensing or geospatial intelligence purposes because they are equipped with recording devises such as camera, antenatal, laser, radar, sonar, seismograph, gravimeter, etc. These devices are sensitive to electromagnetic energy/radiation (EME/R) such as light, heat and radio waves (from the target object). Sensed energy in the electromagnetic spectrum is carried out by studying energy interactions and providing information in the form of digital map (using imaging systems). With advancements in information technology, remote sensing is prominently being carried out using digital processes. However, non-digital methods can also be used depending on specific needs. Technically, the choice of a given satellite image for a given application is contingent on four resolutions such as temporal (time interval for repeat data capture), radiometric (signal levels in bit), spectral (band or channels used in data capture in the electromagnetic spectrum), and spatial (smallest area coverage; usually in terms of pixel size in length and breadth).

The launch of earth observation satellites by the Federal Government of Nigeria (FGN) through the instrumentality of the National Space Agency (National Space Research and Development Agency – NASRDA) in September 2003 (Nigeriasat-1, 32m Resolution.), August 17, 2011 (Nigeriasat-2; 5m multi-spectral, and 2.5m Panchromatic Resolution, and X; 22m Resolution), 13 May 2007 (NigComSat-1: with 4 bands - Ku, C, L, Ka) and NigComSat-R on December 19, 2011 at no cost to Nigeria government, have helped to shape the focus on national security, planning and economic development through the provision of relevant datasets.

The scientific advancement in the Nigeria's space industry has resulted in the use of Remote Sensing in a variety of disciplines such as military and civil intelligence as observed in mapping and monitoring movements of insurgents, bandits and smugglers, resources monitoring, among others (Abugu, Yamma, Bello & Agbanwu, 2022). Satellite images are not end to themselves, because they must be further digitally processed for informed decision-making as in the case of crime monitoring, management and intelligence gathering and sharing (Fig. 2) (Bello, Ikhuoria, Agbaje & Ogedegbe, 2013). Figures 3 and 4 respectively shows the different kinds of satellites in orbits that provides GEOINT as well as the focus of GEOINT in terms of Geospatial layer extraction, analysis and information presentation.

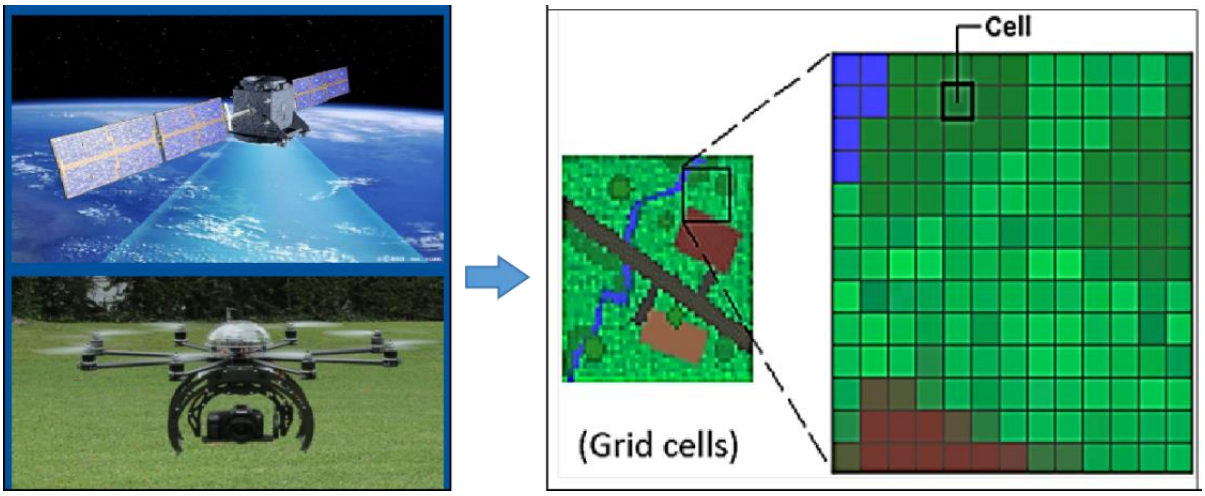

Figure 2: Geospatial Intelligence Remote Sensing Platforms and Image Rendition

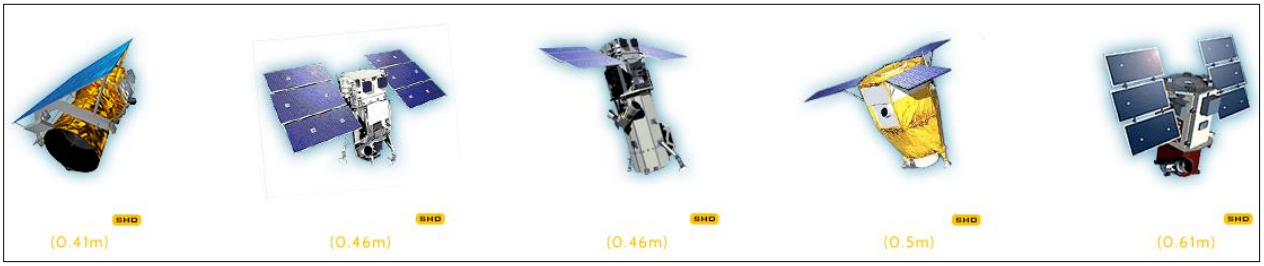

Figure 3. Some Geospatial intelligence Satellites in Orbit (2017 Satellite Imaging Corporation https://www.satimagingcorp.com/services/resources/geospatial-technology/)

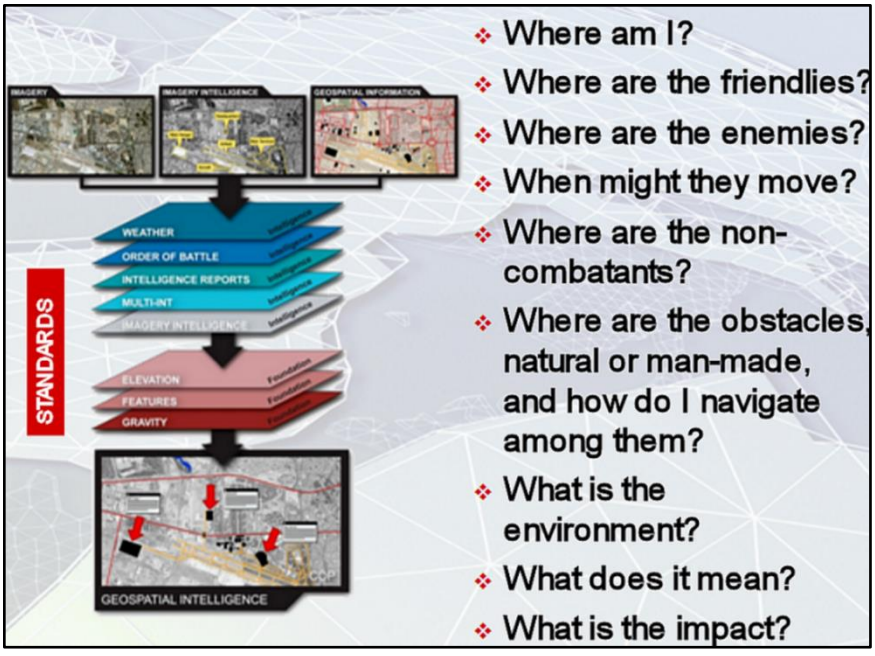

Figure 4. Information layers that Geospatial intelligence can provide answers to
Source: https://selliliar.live/product_details/20500307.html

5. Space Technology Applications In GEOINT: The role of NASRDA

The fuel driving the engine of growth and sustainable development of any nation is the nation's access to reliable and adequate geospatial information (GI). Geospatial data involves global positioning systems (GPS), geographical information system (GIS), and remote sensing (RS). Space or Geospatial technology can be regarded as a digital location-based information framework for geospatial data analysis. Space technology offers a radically different way in which we produce and use maps required to manage our communities and industries. Over 80% of socio-economic and environmental management decisions are based on quality and accurate information on natural resources and human activities on Earth and beyond (Akinyede & Agbaje, nd). Space Technology is considered a panacea for local intelligence management and crime mapping as corroborated in previous studies (Bello *et al.*, 2013; Bridges (2010). This is because of the use of multiple time-specific images for informed decision making through time series analysis of synoptic datasets.

The National Space Research and Development Agency (NASRDA) is a space research institution that is currently under the supervision of the Federal Ministry of Innovation, Science and Technology (FMIST) of Nigeria. The Agency was established on May 5, 1999 with the broad objective to pursue the development and application of space science and technology for the socio-economic benefits of the nation (https://www.un-spider.org/nigeria-national-space-research-and-development-agency-nasrda). NASRDA is also the host to one of UN-SPIDER's Regional Support Offices (RSO) in Africa. The RSO in Nigeria was established in 2008 with the mandate to promote and support the use of space technology within and outside of Nigeria for the management of the full disaster cycle including prevention and mitigation.

As earlier noted, the first Nigerian satellite, a microsatellite called NigeriaSat-1, was successfully launched into low earth orbit on 27th September 2003 (Akinyede & Agbaje, nd; Akinyede, 2003). In 2007, NASRDA's Nigeriasat-1 data through International Charter was used to respond to floods in Argentina/Paraguay, Uruguay, North Korea, Pakistan, China, Vietnam, North Korea, New York, West Africa; volcanic eruption in Nevado, Columbia, Yemen; oil spill in Lyme-Bay, UK; fires in California; locust threat in Algeria, Syria, etc. These images along with other Disaster Monitoring Constellation (DMC) images are made available free of charge for disaster management. In conjunction with other DMC satellites, Nigeriasat-1 has also been used for various mapping campaign e.g. the Amazon, Vietnam coastal areas, and European Union States. NigeriaSat-1 lasted until 2012, four years longer than expected.

Launched on the 17th of August 2011 into the sun-synchronous low earth orbit (LEO) using the DNEPR launch vehicle in Ukraine, NigeriaSat-2 is a Nigerian government imaging satellite and successor to NigeriaSat-1, produced by SSTL under a contract with NASRDA. The goal of launching the NigeriaSat-2 is to, among others, provide high-resolution imagery of the Earth's surface, with applications in supporting food security and agricultural data collection, mapping and security, as well as the provision of data continuity for the NigeriaSat-1 system. In addition, the aim of building Nigeriasat-X (NX) was to also improve the capacity of the Nigerian engineers and scientists as well as to serve as a compliment to Nigeriasat-1 whose design lifespan was nearly over at the time of launch in 2011. Similarly, Nigeriasat-X was built as a flight ready training model by 25 Nigerian engineers and scientists who participated in the Know-How Technology Program of Nigeriasat-2 that was built in conjunction with Surrey Satellite

Technology Limited (SSTL). NX was actually built alongside Nigeriasat-2 and features a 22-meter multi-spectral imaging system with a swath width of 600km and weighs 100kg. It had a design life span of 5 years and revisit time of 3 to 5 days temporal resolution.

Images from Nigeriasat-2 and NX have various applications in the area of agriculture like food security, which can be achieved through monthly crop monitoring, disaster management, security, and other natural resource management activities. In terms of specific applications, Geospatial Intelligence-based Satellite Remote sensing images acquired by passive and/or active sensors have been used for almost every conceivable types of security issues, national planning and resources development matters. It includes water-science research such as the study of floods, watershed, waves, currents, and oceanic circulation patterns (Nkeki, Bello & Agbaje, 2023; Bello & Shaba, 2021); the detection of marine organisms and detailed deep-sea and marine economy studies; the inventorying of lakes; and the mapping of wetlands, ocean floors, land-water boundaries, floodplains (Bello *et al.*, 2016); ice movement, snow cover, oil spills, shoreline changes (Bello & Rilwani, 2016), and many other features. Furthermore, remotely sensed data are key in flood prediction and prevention, irrigation and drainage studies (Taofik *et al.*, 2017), precision agriculture studies, water quality management, groundwater protection, and other water resource investigations (Bello, Ortese & Mohammed, 2024). In general, the applications of NigeriaSat-1, 2 and NX are multi-sectorial in nature. In addition to earlier argument, as part of the Disaster Monitoring Constellation (DMC), Nigeriasat-1 images have been used in various parts of the world for disaster management e.g. Asian Tsunami disaster (20 of 300 X 150 Km supplied); Hurricane Katrina, among others. Similarly, it has been used in Nigeria to also map flood hazards/risk along Kaduna River and Shiroro Dam in Kaduna/Niger States (Shaba, 2003).

Studies have shown that effective and efficient monitoring and mapping of insurgency activities within the Nigeria's territorial space (Abugu, Abugu, Yamma, Bello & Agbanwu, 2022) can be achieved better using the Nigeria's earth observation satellites as GEOINT input.

6. Geospatial Intelligence and the ICCOBA's *Semper et Ubique Fidelis Motto*

It is important to stress the role of geospatial intelligence, national security, safety and good governance and economic development in any forum, organization or association with a view to informing and instilling the essence of national pride, growth and development (Murdock *et al*., 2014; Bridges, 2010; The National Academies Press, 2006). This is because, economic growth and governance are championed by well-informed and decisive individuals or groups that have the mindset to improve the overall well-being of their environment. One of the avenue to disseminate such information and knowledge could be in high schools, tertiary schools or during the Old Boys/Girls reunion. One of the high school or college of repute in Benin City, Nigeria is the Immaculate Conception College (ICC) which was established in 1944. Built by Catholic mission in 1944, the high school is a Catholic secondary institution, guided by the Christian principles of holistic inter personal training and a preparatory ground for further education.

ICC, Benin has been running since 1944 in Nigeria; and hence, has witnessed three phases in the management history of the College. The first phase of management was when the Catholic Mission first established the College. The second phase corresponds with the period when Government seized and took over all private and mission schools, and turned them into public schools. During this era, a lot happened and the level of security awareness and the knowledge

sharing on the essence of having a well secured and developing environment was not that high. The third phase is the return of ICC by the Government of Edo State to the Catholic Mission, the original owner of the College. During its First Phase, the then Catholic Bishop of Benin City, His Lordship, Bishop Patrick Joseph Kelly established ICC in 1944 with Rev. Andrew O'Rouke SMA as the First Principal of the College. The College started with only 30 students (at the present site of St. Paul Minor Seminary) until 1954 when it was approved as a Secondary School. Till date, the school has continued to wax strong in learning and character, thus molding the upcoming leaders in various fields of human endeavours. The school has graduated a countless number of professionals in different fields of science, engineering, arts and humanities, for which intelligence, security and development are part of the areas of expertise.

At the 30th year pearl anniversary of the Immaculate Conception College Old Boys Association (ICCOBA) of the Class of 1994 set, which held between 12th and 14th of January, 2024 at Edo Heritage Hotel, 2nd Ugbor road, GRA, Benin City, Nigeria, it became clear and necessary to enlighten members of the importance of supporting good governance, security and any initiative that is geared towards instilling patriotism and national development. This re-emphasizes the theme of the Anniversary: *"Resilience Through The Ages"* (Figure 5).

Sequel to the above, regardless of the various ICCOBA sets, or schools attended or association one belongs to, it is important to always be enlightened on the roles of GEOINT in safety planning, security and economic development. With careful use of Collaborative Web Mapping (CWM) platforms such as Google Map (https://maps.google.com/), Wikimapia (https://wikimapia.org/), OpenStreetMap (https://www.openstreetmap.org/), etc. (Bello & Ojigi, 2013), which have different layers such as maps, satellite, Digital Elevation Model, etc., one is able to plan routing and then navigate dangerous areas, locate relevant facilities or landmarks such as hotels, hospitals, police stations, and also calculate time and distance it might take to arrive at a given destination. Thus, the rationale behind examining ICCOBA in this paper as a proof of concept is because of the enviable roles it has played in providing security awareness, welfare for one another, and uniting all those that graduated from the High School over the years and are now resident in different continents, countries, states, Local Government Areas as chapters or sets.

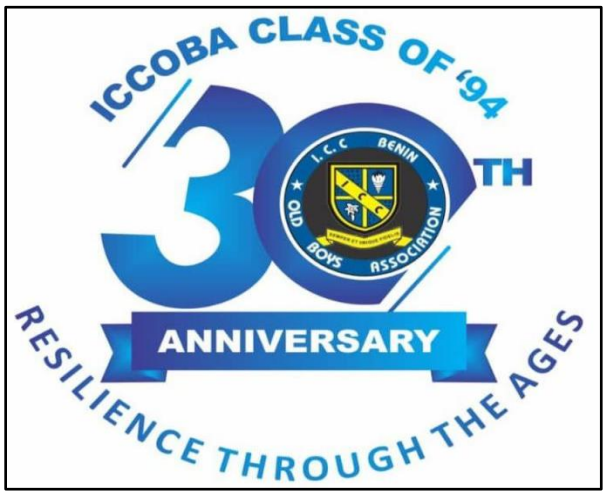

Figure 5. Logo of the 1994 Set of ICCOBA

It is the motto of ICCOBA to be "*Semper et Ubique Fidelis"* (always and everwhere faithful) in all that they do. This includes promoting national cohesion and security, rule of law, good character, respect for the elders (senors) and one another, economic and political growth and development wherever they find themselves. Therefore, in order to get a better understanding of the spatial nature and spread of insecurity and developmental challenges, the adoption of geospatial intelligence has become inevitable, and NASRDA is highly commended for their roles in Space science and Engineering in Africa and beyond.

Also, the use of smart phones with Google Application Programming Interfaces (APIs) and freely available social media applications (Apps) are highly encouraged as the world goes digital in the 21st Century Information Age. These days, it is common place to get missing if one has limited or no knowledge of a given location as a result of unplanned urban space (Edobor and Bello, 2017; Bello, Nwagwu & Edobor, 2013). It is, therefore, argued that Google Map, OpenStreetMap, HERE and Wikimapia with location intelligence interfaces be used for navigation and planning by individuals in their routine activities so as to reduce the incidences of criminal attacks and other societal milieus. The time to key into Geospatial Intelligence is now, and all should be very conscious of their movements viz-a-viz having good knowledge of yet-to-be visited areas through the use of Social media platforms like Google Maps (Figure 6), Google Earth, OpenStreetMap ((Figure 7), Wikimapia (Figure 8), and the likes as earlier examined by Bello & Ojigi (2013).

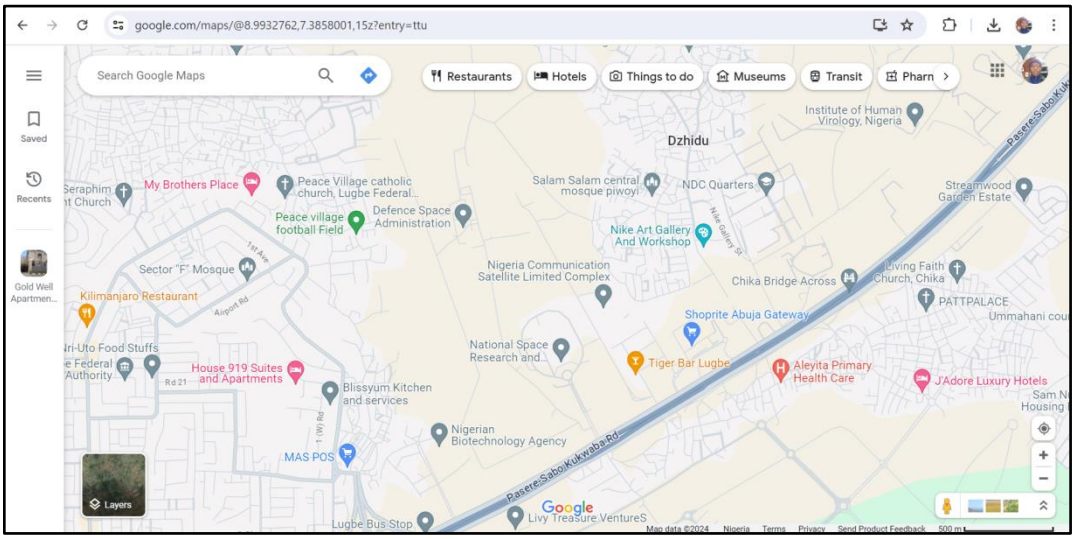

Figure 6. Google map interface showing GEOINT mashup layers for navigation and planning

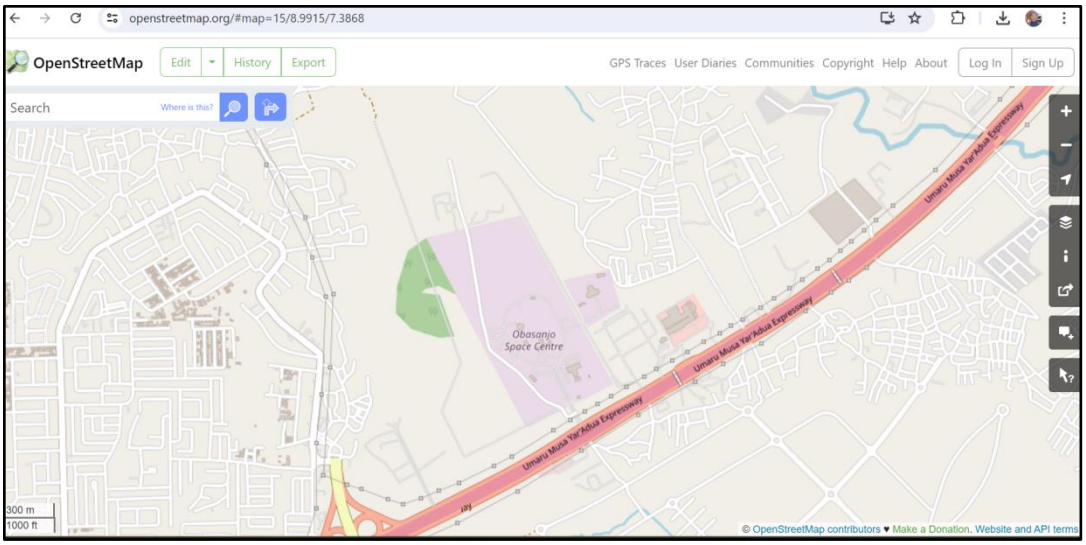

Figure 7. OpenStreeMap interface showing GEOINT mashup layers for navigation and planning

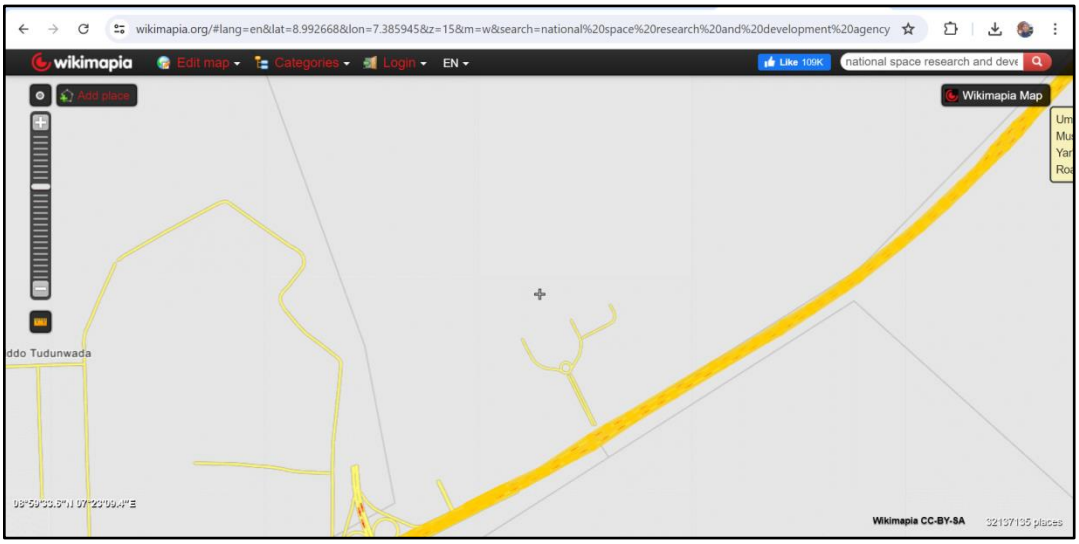

Figure 8. Wikimapia interface showing GEOINT mashup layers for navigation and planning

7. Conclusion and Recommendations

It has been argued that Geospatial Intelligence (GEOINT) is an intelligence discipline comprising the exploitation and analysis of geospatial data and information to describe, assess, and visually depict physical features (both natural and constructed) and geographically reference activities on the Earth. A nation that prides itself as a sovereign state must be seen proficiently and effectively investing in space science and technology because of the multifarious benefits it will derive from the initiative in terms of national security, growth and sustainable development. The launch of Nigeria satellites by NASRDA (NigeriSat-1, 2, X, NigComSat-1, and R, and EduSat) are testament to the fact that Nigeria's quest in space is a right step in the right direction. Enthusiasts must be seen taping into the technology more practically in order to improve personal safety, national security and good governance system.

The need to embrace and champion safety and development locally and internationally is inevitable in a changing world characterized by wars, insurgencies, trafficking in persons, terrorism, kidnapping and all forms of organized crimes. It is recommended that everyone be involved in security matters because it affects all. In particular, the indomitable Class of 1994 Set of the Immaculate Conception College, Benin City Old Boys Association (ICCOBA) are encouraged to be more aware of the debilitating challenges posed by insecurity and thus be ready to promote safety initiatives and a progressive society devoid of all forms of crimes. This, of course, will be contingent on reliable and evidence-based GEOINT. In other words, reliable decision making is contingent on evidence-based synoptic time-series image datasets as well as georeferenced digital fundamental and thematic dataset. Thus, having a very rare opportunity to reunite after about thirty (30) years since graduation from high school in 1994, efforts should be made to be more professional in executing national, regional and global tasks with decorum and patriotism. In addition, ICCOBITEs should keep championing egalitarianism, rule of law, spatial and social justices as necessary ingredients for achieving national integration, cohesion, security and economic development through the adoption and use of GEOINT.

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