The communications satellite industry as an element in Nigeria's attempt to modernise its economy and society

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Abstract

There is general consensus that Nigeria's inordinate reliance on oil has not had a positive impact on its social and economic development – indeed, that Nigeria has suffered from the 'resource curse'. In 2009 the National Planning Commission of Nigeria stressed the need for Nigeria to reduce its reliance on hydrocarbons, a crucial element in this goal is Information and Communications Technology. This paper examines the establishment of the communications satellite industry and the role it has played in modernising different sectors of the Nigerian economy and society.

Keywords: Nigeria, resource curse, ICT, communication satellites

Introduction: Nigeria and the resource curse

In December 2009, the National Planning Commission of Nigeria launched the *Nigeria Vision 20:2020* plan, with the aim of bringing Nigeria into the world's top 20 economies by 2020, a most ambitious target. As of October 2016, Nigeria was ranked 26th in terms of nominal dollars GDP and 23rd in terms of PPP dollars GDP but was forecast to drop to 29th and 25th in 2020 by these measures respectively (Statistics Times, 2017). In regard to transforming the economy, three specific actions were put forward for achieving this:

a. Aggressively pursuing a structural transformation from a mono-product economy to a diversified, industrialized economy;

b. Investing to transform the Nigerian people into catalysts for growth and national renewal, providing a lasting source of comparative advantage;

c. Investing to create an environment that enables the co-existence of growth and development on an enduring and sustainable basis (National Planning Commission, 2009, p. 11).

This paper focuses on the communications satellite industry as an element in this endeavour. The Nigerian authorities have long recognised the dangers of their over-reliance on hydrocarbons, especially oil exports, but have struggled to break from this "resource curse". This is the well-known seemingly paradoxical phenomenon, first given prominence by Richard Auty (1993), whereby countries rich in natural resources, in particular those endowed with

minerals, including oil, perform poorly in terms of economic growth and social welfare, in comparison with relatively resource-poor countries.

In an extensive survey of the resource curse literature, Jeffrey Frankel (2012, pp. 18-19) delineates six main explanations for this phenomenon. First, the prices of natural resources experience a secular decline on world markets – this is the Prebisch-Singer hypothesis. Reality has, however, not borne this out: terms of trade for primary commodities showed an upward trend from 1870 to World War 1, a downward trend in the interwar period, an upward trend in the 1970s, a downward trend in the 1980s and 1990s, and an upward trend in the first decade of the 2000s (*ibid.*, p. 24). Second, the volatility of world market prices of primary commodities that can generate macroeconomic instability via the real exchange and government spending. This is supported by evidence and is problematic to economies which are reliant on them owing to the uncertain impact on revenue streams – this has been especially true for oil and natural gas whose market prices are more volatile than for minerals and agricultural commodities (*ibid.*, p. 26); the reasons for this difference, however, are not relevant for the purposes of this paper.

The third explanation is that natural resource abundance may crowd out other sectors, particularly, manufacturing. Sachs and Warner (2001, p. 833) argue that export-led growth of many developing countries has largely been based on manufacturing and this sector offers spill overs and linkages that can drive overall economic growth. Fourth, holders of natural resource assets and attendant revenues – be they hereditary elites or governments – are less incentivised to develop institutions, especially the rule of law, that are conducive to economic development. Governments reliant on taxation from their citizens are more likely to face demands from them and respond accordingly, with a better development outcome. The fifth explanation stems from careless management of natural resources with insufficient regard to their rapid depletion

whilst failing to diversify the economy. Sixth, the tendency of resource rich countries to be more prone to armed conflict. Moss et al. (2015, ch. 3) provide evidence to show that since the early 1990s, oil-producing countries have been 50% more likely than non-oil-producing countries to experience civil war.

A seventh explanation is that of insufficient investment in education. Gylfason (2001, p. 847) found evidence to show an inverse relationship between the share of natural resources in GDP and public expenditure on education and concluded that natural capital crowds out human capital which, in turn, slows down economic development.

Unless governments are vigilant to the danger, and systematic in supporting other sectors where a comparative advantage exists, the resource indeed does become a de facto curse. Of particular concern that has been extensively highlighted in the literature is the attendant "Dutch disease", an eighth explanation, whereby the rising price of a natural resource such as oil leads to an appreciation of the domestic currency as a consequence of which exports of the non-oil sector lose competitiveness (Humphreys, Sachs, and Stiglitz, 2007, p. 5).

An inordinate reliance on natural resources, therefore, generates uncertainly in governmental budgets at every level – unless some, such as defence, are ring-fenced. Accordingly, investment decisions can fluctuate dramatically so that in the face of declining revenues from natural resource exports, projects are suddenly curtailed. This not only affects current departmental expenditures but also infrastructural capital spending with attendant negative multiplier effects. Brenda Shaffer (2012, p. 2) makes the important point that 'energy-exporting states invest in policies that produce short-term, often ineffective, results such as constructing new buildings and funding student scholarships instead of establishing comprehensive educational institutions and programs'. Unsurprisingly, the impact on overall development can be extremely severe.

The history of Nigeria indicates that with the exception of the incorrect first explanation, Nigeria has, to varying degrees, been afflicted by all the other explanations. Though it has accumulated vast rents from oil exports, these have had a debilitating effect on other sectors of the economy so that the economy has neglected diversification. Thus, between 1965 to the year 2000, Nigeria's combined revenues from oil – excluding payments to foreign oil companies – amounted to $350bn (1995 prices). In 1965, per capita oil revenues and GDP per capita were $33 and $245 respectively; whereas, in 2000, they were $325 and $245 respectively. Therefore, the stark reality is that in these three and half decades, oil revenues failed to contribute to the raising of living standards (Sala-i-Martin and Subramanian, 2012, p. 573).

Furthermore, Sala-i-Martin and Subramanian (*ibid.,* p. 610) provide evidence to forcefully argue that waste and poor institutional quality stemming from oil have been primarily responsible for the country's poor long-run economic performance; indeed, they advocate the distribution of oil revenues directly to the people especially considering the failure to tackle poverty and income distribution. Though this redistributive proposal has not been accepted by any – present or past – Nigerian government, the severe economic and social problems highlighted have been well-understood by the government and form a core element in the *Nigeria Vision 20:2020* plan. In this paper, we examine the role of communication satellites as an element in Nigeria's attempt to modernise the economy.

The establishment of a communication satellites sector

Nigeria's poor level of development is shown by its ranking of 152 in the UN's Human Development Index (HDI) rankings for 2016, which is very much within the 'low human development' band (UNDP, 2017). With effective governance, the resource curse thesis suggests that Nigeria would have performed better without oil thereby enabling it to attain a higher HDI ranking in all its constituent elements, that is, Gross National Income per capita, life expectancy at birth, and mean and expected years of schooling.

Information and communication technology (ICT) is a crucial determinant of economic development that underpins the modern economy in myriad ways. It is of vital importance to developing countries with large expanses of countryside and rough terrain with scattered villages and hamlets. Communication satellites are particularly efficacious in providing speedy and economic means to service the communication needs of the vast array of isolated communities and, by so doing, uplifting their well-being and living standards[1]. Reliance on the conventional terrestrial infrastructure of copper, fibre, and microwave is not only difficult in remote areas but inordinately costly hence communication satellites are a superior option. Very small aperture satellite terminals (VSAT) have proved to be reliable and flexible incurring low development and operating costs (SUPARCO, p. 1). Universal access to ICTs are conducive to social and economic development by providing better educational opportunities, health services, stimulate private sector activity thereby greater employment opportunities. Importantly, whereas the more developed urban centres attain technologies as they arise on the market, the remote areas invariably do not. In summary, communication satellites can facilitate the reduction of this 'digital divide', that is, the disparity between urban and rural communities and assist in the creation of a more cohesive society and reduce migratory pressures from the countryside to towns and cities.

Nigeria ranks a lowly 137 in the ICT Development Index (IDI) for 2016[2]. Internet user penetration in Africa as of March 2017 stood at 48.8% (InternetWorldStats.com, 2017) but the

[1] Applications of communication satellites include internet access, broadband data communications, rural telephony, public switched telephone network infrastructure extension, news distribution, distance learning, telemedicine, disaster recovery, multicast services, land mobile communications, government closed user groups, intergovernmental and corporate applications, national and multinational networks, and aeronautical & maritime links (SUPARCO, p. 1).

[2] The ITU ICT Development Index (IDI) is a unique benchmark of the level of ICT development in countries across the world. The IDI combines eleven indicators on ICT access, use and skills, capturing key aspects of ICT development in one measure that allows for comparisons across countries and over time. The IDI 2016, which covers 175 economies worldwide and makes comparisons to IDI 2015, highlights both progress and persistent divides in the global information society (ITU, 2016, p. 3).

imbalance in access to ICT infrastructure is very pronounced in Africa. Existing infrastructure in the African hinterlands is grossly inadequate, thus there is a need to develop national, regional and sub-regional carriers of digital links with cross-border inter-connectivity. Although the continent has adequate capacity from submarine fibre optic cables along the shores of the African coast, it lacks an adequate infrastructure within African countries including cross-border connectivity (Lawal, Ahmed-Rufai & Chatwin, 2014).

Areas with good ICT facilities and applications have empowered individuals and businesses, especially SMEs, local and community groups and given women increasing participation in economic and human development activities including job creation. Various e-business applications and projects of government, public sector, banks and corporate bodies have stretched the capacity, capability and performance of existing ICT infrastructures; with some setbacks in efficiency of user experience, speed of transactions and operations.

Satellite communications provide advanced communications infrastructure to regions that do not have adequate terrestrial infrastructure, as is the case in large tracts of Nigeria. Satellite networks can be rolled out to hundreds or thousands of remote locations in a fraction of the time required for a comparable terrestrial network. A VSAT installation requires only a single vendor, so that multivendor coordination is not needed or required. An installation can usually be completed in a matter of hours, no matter where the site is located, meaning complete network deployment can be accomplished in a matter of weeks, rather than months or years. Satellite network installations and deployment are relatively quick and straightforward.

Governments, both in the developed and developing world are investing in Information and Communication Technologies through e-governance in order to attain greater transparency,

accountability, and improve service delivery. An array of government services come under the umbrella of e-governance: online access to official forms – including complaints, municipal services and registrations etc. to development planning, community awareness and emergency services. Nevertheless, rural communities lacking the required ICT infrastructure to support such programmes are often neglected and communication satellites fill the service gap allowing rural communities to access a variety of online government services (SUPARCO, p. 3).

Nigerian Communications Satellite (NIGCOMSAT) Limited was incorporated as a limited liability company in April 2006 and is responsible for the operation and management of Nigerian communication satellites starting with NIGCOMSAT-1 which was launched in May 2007 and de-orbited after 18 months. An insurance replacement satellite,
NIGCOMSAT-1R, which has the same features as NIGCOMSAT-1, albeit with a few modifications, was launched in December 2011, with optimized performance based on design inputs related to weather and climatic conditions of the African environment and lessons learned from operations and market experience of the de-orbited satellite. It has an expected service life of more than 15 years.

The satellite has a quad-band payload capability providing Ku-band, C-band, Ka-band and a Navigation payload..
The Ku-band payload provides 14 operational channels, 2 fixed beams over Western and Eastern Africa. The C-band payload provides 4 active channels with coverage of Western Africa. The Ka-band payload provides 8 channels providing a communications and trunking capability using 3 fixed spot beams over Europe, South Africa and Nigeria. The Navigation payload provides 2 receive uplink signals on C-band covering Africa and Europe, and 2 transmit downlink signals on L-band: L1 and L5, giving global coverage.

The spacecraft system design ensures that each Radio Frequency (RF) channel meets the stipulated requirements, works reliably throughout its service life including eclipse conditions; it has a conservative allowance for degradation, wear-out and radiation damage. NIGCOMSAT has over 100 trained and professional engineers supporting it and a well-established ground control station at Abuja, Nigeria; it has a backup station at Kashi, China for the spacecraft tracking & control, operations and payload management.

The satellite's inherent strengths as a broadcast medium make its networks ideal for the distribution of bandwidth-intensive information — data, video or audio — to large numbers of remote locations. To achieve the same service, a terrestrial network requires the transmission of many separate and identical messages to all recipients, consuming valuable bandwidth and server resources. Satellite multicast technology eliminates duplicate transmissions and maximises the efficiency of existing servers and networks, freeing valuable bandwidth. There is no extra overhead at the hub or in the satellite. The only added cost for each recipient is the VSAT. This translates into significant cost savings. Direct-to-home services are relatively easy to deliver; a small dish is all that is required. There are about 33.9 million TV homes in Nigeria, with 8.98 million of them being served by satellites directly while the rest are served by terrestrial and cable networks. A satellite monitory study focussed on Nigeria conducted by SES, highlights that SES reaches 2.81 million TV homes across the country, of which 1.69 million are reached directly by SES satellites, and 1.12 million cable TV homes are fed indirectly by the SES fleet (Veronica, 2016).

NIGCOMSAT’s unified Direct-to-Home platform will provide broadcasters, content providers, content distributors as well as open up media business services in Africa for DTH

TV broadcasting entrepreneurs thus easing of implementation bottlenecks for digital switch over (DSO) especially for small and medium enterprises (SME) in the broadcast industry.
The NIGCOMSAT Direct-to-Home (DTH) system was designed to offer viewers hundreds of channels of Standard Definition (SD) television programming on both the free-to-air (FTA) and pay as you go service delivery model and thus an opportunity for a market share of the multi-billion-dollar broadcasting industry sector. The system is designed to support and transmit High Definition (HD) channels on demand (Lawal & Chatwin, 2013; Lawal, 2014).

The strategic plan is centred on using global space-based ICT infrastructure: NIGCOMSAT-1R, associated ground stations and supporting human resources is the vehicle driving the National ICT revolution in pursuit of affordable telecommunications and broadcast services for the nation and Africa; delivery of self-reliant services and the required skills for engineering and technology domestication. Additionally, NIGCOMSAT has partnerships with key strategic stakeholders in Nigeria and Africa's ICT infrastructure to support universal access goals of innovative, affordable, high speed broadband telecommunication services to enhance ICT usage, ICT skills and increase the ICT Development Index (IDI) of
Nigerian citizens. These efforts are geared towards increasing diversification with the long-term goal of gravitating towards a knowledge-based economy.

The company as a commercial satellite operator has the mandate to offer a wide range of information and communications services and applications in and outside Nigeria and within reach of its satellite's footprints. Such services and applications include telecommunications services in the form of corporate networks (virtual private networks), VSAT networks, urban rural telephony, mobile and paging services; inter-carrier services and satellite to satellite services; broadcasting - television (TV, HDTV), direct to home (DTH), multimedia, video

streaming and audio/sound (DARS); Internet and multimedia - video conference, virtual private networks (VPN), Voice-over Internet Protocol (VoIP); tele-presence - distance learning (tele-education), telemedicine/tele-health, e-transformation (such as e-Government, e-Commerce, e-Agriculture, e-Health etc.); tracking and monitoring aircraft, shipping lines and strategic national assets exploiting navigation transponders and customisation and domestication of foreign technologies. These include: satellite modems, antennas, feeds, switches, biometric systems, e-voting systems, RFID based systems, and silos. Finally, there are opportunities for telecommunications network infrastructure deployment and alliance with other network operators.

NIGCOMSAT remains the cornerstone for universal access and for ICT development, considered a crucial element in the social, political and economic re-engineering of Nigeria. The strategic plan for ICT development in Nigeria is centred on using the satellite as a vehicle to drive the National ICT revolution in pursuit of national security, self-reliance and the required skills for engineering and technology domestication for the socio-economic development of Nigeria. Implementation of the Nigerian Satellite Augmentation System (NSAS) exploiting the Navigation transponders of NIGCOMSAT-1R serves as Africa's contribution to Satellite-Based Augmentation System (SBAS) opportunities and market with benefits encompassing: wealth and job creation, enhanced security of assets and public safety, geographic information systems, environmental protection and agriculture - with a mix of controlled and free market opportunities.

The Satellite-Based Augmentation System (SBAS) arose from the need to provide continuity, availability, integrity and accuracy of global positioning signals to eliminate errors and compensate for discrepancies associated with GPS signals and other navigation systems. An augmentation system can be Ground- Based (Ground-Based Augmentation System - GBAS)

or Satellite-Based (SBAS). Augmentation is important in applications that involve safety of life, i.e all phases of flight, which requires improved accuracy of the global positioning signals to eliminate errors and compensate for discrepancies through differential corrections associated with GPS signals and other navigation systems in terms of positioning, velocity and timing requirements of aviation, maritime and land-based transport systems.

The most effective augmentation system, especially for coverage capability, is the Satellite-Based Augmentation System (SBAS), which involves the use of Geostationary Communication Satellites to transmit signals over a wide geographic area creating and contributing to the Global Navigation Satellite System (GNSS).

Oscillators are found on all spacecraft vehicles as a primary element of their onboard clocking system, which is required for systems control, signal generators and transponders, whether in a communications satellite or a navigation payload. When using satellites for Navigation, time precision is the key determinant of accuracy in locating position, displacement and velocity. Improvement in accuracy for general transportation, especially in aviation, ushered in the Regional Augmentation System. The quest for performance focused on the ability to accurately transmit and keep time signals stable up to the picosecond level and more in receivers and clock reference of space systems especially in navigation satellites using high performance oscillators ranging from ultra-stable quartz crystals with ovenized control to high performance atomic circuits (Lawal, 2014).

The NigComSat-1R Navigation (L-band) payload is meant to provide a Navigation Overlay Service (NOS) similar to the European Geostationary Navigation Overlay Service (EGNOS) system. The system will augment the Global Navigation Satellite System (GNSS) over Europe and Africa. Recognizing the important advance of dual user frequencies over the single L1

frequency capabilities of previous GNSS, the planned modernization of the GPS constellation will produce an additional civil signal on the L5 frequency. The incoming GALILEO system will broadcast Safety-of-Life signals on both the L1 and L5 frequencies, the navigation payload of NigComSat-1R has been designed to support and operate in both the L1 and L5 frequencies.

Unlike the transponders of communication satellites, the receiver of navigation transponders (as is the case in the NIGCOMSAT-1R system design) uses a 10MHz ultra stable crystal oscillator to meet the performance requirements of frequency conversion stability and accuracy. The system functionality is identical and similar to European geostationary Navigation Overlay Service (EGNOS), where a number of ground reference stations monitor the GPS satellites' signals and provide their observations to one or more Master Control stations (MCS). An augmentation message is then generated by the MCS and two (2) signals, C1 and C5, are transmitted via uplink stations within the uplink coverage areas on the C-band. The navigation payload down converts the C-band signals to L-band, L1 and L5, and retransmits these signals globally to users. The NOS augments the GPS standard positioning service by providing three types of information to users: Ranging information, Differential GPS corrections and Integrity monitoring information.

The onboard navigation payload has various component redundancies. It is a dual-channel bent-pipe transponder that down-converts two C-band (C1 and C5) uplink signals from a ground earth station to two downlink signals in the two separate bands, L1 and L5. A 4.0 MHz-wide C1 band uplink channel relays the L1 downlink channel and allows the transmission of the L1 signal while a 20.0 MHz-wide C5 band uplink channel relays the L5 downlink channel and allows transmission of the L5 signal. The beam from the downlink L-band navigation antenna is global, ensuring that NigComSat-1R is capable of broadcasting to its coverage area,

GEO ranging signals and Satellite Based Augmentation System (SBAS) signals through the L1 and L5 frequencies. The In-Orbit Test (IOT) was used to validate the functional capability of the navigation payload and its readiness for function and purpose. Figure 1 and 2 shows the EIRP results of the re-launched Nigerian Communications Satellite (NIGCOMSAT-1R) in L1 and L5 signal bands respectively.

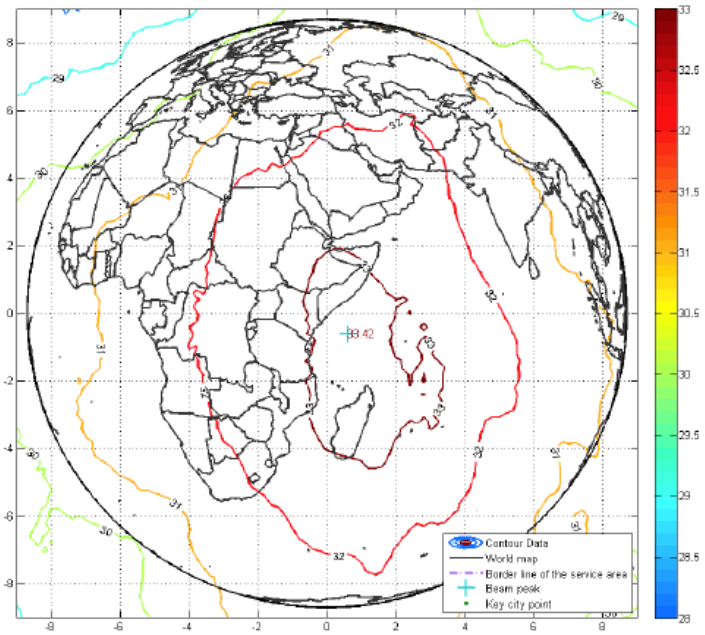

Figure 1: The Downlink coverage beam (L1-Band) of NIGCOMSAT-1R Geo-Navigation Satellite using Dual L-Band Helix Antenna

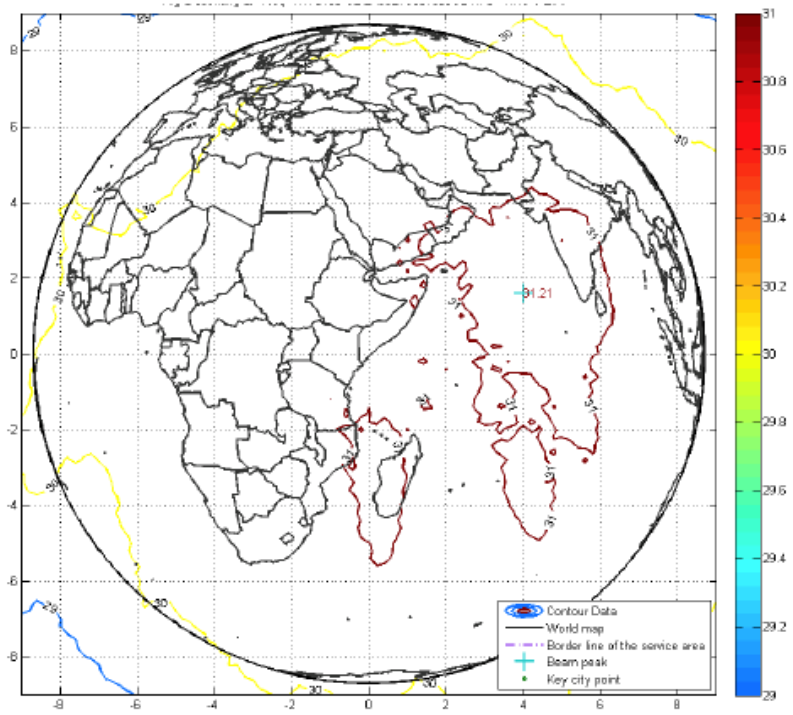

Figure 2: The Downlink coverage beam (L5-Band) of NIGCOMSAT-1R Geo-Navigation Satellite using Dual L-Band Helix Antenna.

National Security

Security is an issue of enormous importance for Nigeria today. Federal Government indicated recently a loss of 400,000 barrels of crude oil per day equating to over $1.7 billion monthly. Oil theft in the Niger-Delta region results in great financial loss and environmental impacts on the nation's well-being (Boris, 2015, p. 564). In 2014, Nigeria was ranked worse than Mexico, Iraq, Russia and Indonesia among the top five countries most plagued by oil theft (OilPrice.com, 2014). According to data from the NNPC, a total of 16,083 pipeline breaks were recorded between 2000 and 2010. 398 pipeline breaks (2.4%) were as a result of ruptures.

Pipeline vandals accounted for the remaining 15,685 breaks; 97.5% of the total number of cases. Vandalisation of pipeline systems nationwide has compromised the free flow of refined petroleum products, crude oil and gas, resulting in over $1.1 billion in product losses and pipeline repairs. Environmental damage and pollution has affected millions of people living in the Niger-Delta region due to pipeline vandalism. About 3 billion dollars is needed to clean-up the Niger Delta over a period of 30 years. There were 18 high-level kidnap-for-ransom attacks in 2010. There were also 58 piracy-related maritime security incidents in Nigerian offshore and coastal waters in 2010. Lagos, the commercial capital of Nigeria suffered a number of increasingly violent attacks on its shore and roads, where assailants opened fire on vessels on more than 10 occasions. In Lagos Command of the Nigeria Police, 246 persons were murdered, 542 vehicles were stolen in Lagos between December 2015 and November 2016 and 51 major kidnap cases were recorded in 2016 (Akoni & Olowoopejo, 2016).

The ongoing insurgency in north-eastern Nigeria has seen attacks on police posts and stations, the Force Headquarters, the UN building in Abuja, prisons, military barracks and market places, this activity has resulted in several deaths, injuries and loss of property.

The recurrent conflict between farmers and herdsmen in the North-Central region costs Nigeria at least $13.7 billion annually based on a study conducted by Mercy Corps, a global humanitarian organization that is funded by the UK government's Department for International Development. The middle belt states of Nigeria comprising of Benue, Kaduna, Nasarawa and Plateau States alone lost an average of 47% taxes in Internally Generated Revenues (IGR) due to these conflicts (MercyCorps, 2015).

These profound problems are attributed to poor surveillance, ineffective information gathering and security sharing mechanisms between the national security agencies. In order to solve these

problems between the security agencies, Nigeria requires a secure broadband and integrated communications public safety network for the security agencies and the emergency service organisations (that is, police, fire, road safety outfits, and medical services) with the ability to implement effective information symmetry between their operations. Such networks with huge data requirements require investment in broadband technologies built on an advanced IP network supporting IP/MPLS for real time video streaming, VoIP, e-mails, web browsing and applications support for operations. Optimising access to information with a guarantee of universal access to almost all parts of Nigeria, including very remote areas with little or no terrestrial network, requires the use of satellite communications and wireless systems infrastructure within the framework of the ICT policy implementation to complement existing and inadequate terrestrial infrastructure (Bowman, 2007).

The government of Nigeria has implemented a National Public Security Communications Network based on CDMA EVDO technology across the nation for public safety use, security organisations etc. It is composed of five sub-systems: Global Open Trunking Architecture (GoTa) Sub-system (a digital trunking communication system developed by ZTE, based on the Third Generation (3G) wireless communication technology (CDMA, 2000); video surveillance sub-system; e-police sub-system; video conference sub-system; and Coalition Emergency Response Sub-system (CERS). The network is being built with an integrated network infrastructure comprising of communication satellite, optical fibre, microwave links, and wireless network (Lawal & Chatwin, 2012).

ICT and Development

There is a strong association between economic and ICT development, with least developed countries at a particular disadvantage. The average IDI value for developed countries is 7.40 which is 3.33 points higher than that for developing countries - 4.07, although developing countries improved their IDI value more than developed countries. There is also a strong association between least connected countries, countries that are in the bottom quartile of the IDI 2016 distribution, and least developed countries. Indeed, the bottom 27 countries are all least developed countries, and the gap in IDI values between these countries and higher-performing developing countries continues to widen (ITU, 2016, p. 3).

The recognition that ICTs can be a development enabler, if applied and used appropriately, has general consensus, especially for developing nations like Nigeria that are moving towards information or knowledge-based societies, which is central to the ICT Development index's conceptual framework. The ICT development process, and a country's transformation towards an information-based society, can be described using the following three-stage model:

Stage 1: ICT readiness (reflecting the level of networked infrastructure and access to ICTs);
Stage 2: ICT intensity (reflecting the level of use of ICTs in the society);
Stage 3: ICT impact (reflecting the result/outcome of efficient and effective ICT use)

Connectivity through communication satellites has a pivotal role to play in bridging the knowledge gap that exists in Nigeria and the entire African continent; it offers a plethora of new opportunities. Un-served and under-served regions can enjoy the benefits of reliable communication technologies made possible by communications satellites thereby providing access to reliable telecommunications services to places with difficult terrain. NIGCOMSAT also promotes the establishment of Mobile ICT Clubs which deliver ICT awareness, capacity-

building and other services in order to foster economic growth in rural and poor areas in particular, especially for youth, women and persons with disabilities by means of training programmes in ICT skills, including basic computer literacy, specialised software applications, and maintenance of hardware and software (NPC, 2015).

Education and Learning

Satellites are also efficacious in enhancing education via distance learning by which rural communities gain access to skilled educators delivering a variety of educational programmes. VSAT-based distance learning tools utilising digitised learning materials can provide higher education courses via a network of tele-education centres connected to universities and specialist institutions located in the major cities (SUPARCO, *op. cit.,* p. 3).

With support from the National Board of Technical Education (NBTE), the supervisory body for polytechnics and vocational studies in Nigeria, over 78 Polytechnics were connected to NIGCOMSAT-1R Ku-band network with broadband connectivity. The necessary infrastructure is being set up and equipped with networked PCs, printers, software libraries and an Internet connection via satellite with mobility options. The mobile option (vehicles) move to different locations around the country in an optimally planned manner. The *School Connect Programme* is NIGCOMSAT's project aimed at connecting 111 secondary schools (3 in each state and the Federal Capital Territory in Nigeria) with broadband Internet access in the first phase. All schools are equipped with networked PCs, printers, e-Library and e-Learning applications. Furthermore, broadband connectivity is available to all universities and learning institutions in the country.

The *E-Cafe Programme* deploys mobile broadband internet vehicles at all the 37 National Youth Service Camps in the country during the camp season (quarterly each year). Nine vehicles are equipped with broadband internet access, networked PCs and printers. The vehicles are moved to other locations where there is demand for internet services when the camp is briefly closed before admission of the next batch of students.

The *Internet 4 All Programme* provides an IP cloud covering the country using global communication infrastructure (communication satellites and complementary ground infrastructures). This facilitates the availability of transmission infrastructure and connectivity everywhere in the country by an access network that provides both data and voice services. This helps integrate the villages in Nigeria and indeed Africa into a single virtual village hub as well as an emergency network required for disaster management during disasters such as flood, earthquake, fire outbreak etc. The programmes are aimed at laying the building blocks of e-transformation in the country including e-government, e-agriculture, e-health, e-education, and e-library.

Information and knowledge are critical components of poverty alleviation strategies. Advanced and emerging economies increasingly rely on information and knowledge as key drivers for productivity and economic growth. The growing quest for knowledge and its diffusion through information and communication technology has led to the emergence of informed societies with an increased demand for a well-informed and knowledgeable workforce (Ramachandran, 2003). NigComSat-1R provides access to large amounts of information useful to the poor as services, which can be provided to effectively reach economically under-privileged people with information that is relevant and useful to them. The deprived can take advantage of increased

income, better healthcare, improved education and training, access to job opportunities, enterprise development opportunities, and increased agricultural development.

Communication satellites enable a teacher to stay in a centralised location to teach students in any part of Nigeria and students are able to interact with the teachers in real time; furthermore, teachers are able to teach students remotely and Nigerian students can also take lectures and join a virtual classroom in any part of the globe. NIGCOMSAT has in the past partnered with the Federal Ministry of Science and Technology, National Space Research and Development Agency (NASRDA) and National Information Technology Development Agency (NITDA) to provide an easy-learning card offering access to portals and a repository of online training courses and certifications using a registered use name and password. With the combined efforts of the Ministry of Education and private sectors, the delivery of a robust e-learning policy and framework for implementation will be sustained. This brings opportunities for new business developments and youth empowerment via business outsourcing as is common in several East Asian countries.

NigComSat-1R also enhances agricultural productivity and wealth creation at the grass roots level: through awareness, capacity building and interfacing to facilitate effective information flow and strengthen the farmer-resource linkage, through the establishment of a communication network to create a robust information network to ensure farmers have access to agricultural information as well as commodity market information that enables them to increase their productivity and returns. Currently, precision agriculture exploiting the Global Navigation Satellite System (GNSS) and Satellite-Based Navigation System (SBAS) technologies are to be demonstrated with the Nigeria Satellite Navigation System (NSAS) as a proof-of-concept for enhanced agricultural practice and productivity.

Tele-medicine and Healthcare

In regard to healthcare, an unavoidable fact is the desire of medical professionals to live and work in urban centres where there are modern facilities, including access to teaching centres and the advancement of knowledge and training, a consequence of which is much lower numbers of doctors and nurses per capita in rural areas and, concomitantly, lower health indicators. Communication satellites can provide tele-medicine services that improve access and quality of health care including earlier diagnosis and treatment and also enable medical professionals to maintain contact with hospitals in the urban centres thereby providing an incentive for doctors to remain in rural areas. Medical specialists in teaching hospitals can provide their expertise to several hospitals and clinics across a region or the country as a whole.

For example, a major hospital such as the Abuja National Hospital is linked to distant centres for the provision of clinical services, medical education, research and diagnosis, thereby enabling teams of medical experts to undertake cross-consultation and obtain second opinions on any case handled between themselves, without moving from their locality. NIGCOMSAT achieved success in this field by partnering with the Ministry of Health to link up six teaching hospitals in six geo-political regions of the country using the Ku band of NIGCOMSAT-1R using a Hughes Hub. Based on lessons learnt from the pilot project, which includes but is not limited by recurrent bandwidth requirements for connectivity, maintenance and servicing of devices and equipment, there is a clear need to partner with both private and public sectors to guarantee the sustainability of mobile tele-medicine centres and e-health facilities. By creating a beneficial business environment the government can attract inward investment from partnering organisations. The mobile tele-medicine centres are equipped with video

conferencing facilities and tele-medicine basic equipment and a set of personal computers, printing and scanning equipment.

In collaboration with the Federal Ministry of Health, a web portal can be accessed by each tele-medicine centre and, for example, content is published on HIV/AIDS prevention and control, for National Quality Management Programme on adult and paediatric care and treatment, Prevention of Mother-To-Child Transmission (PMTCT), counselling and testing and early warning indicators; malaria prevention and control information (use of insecticides, anti-mosquito nets, etc.); information on prevention, control and managing fire disasters, floods, etc.; and general community health programmes (how to create and maintain clean environments) as well as Ebola virus disease outbreak control. The portal provides content published in English and the major languages within the region of the country. This enables dissemination of health information in the community, save lives, and reduces expenditure of foreign reserves on antiretroviral and malaria drugs.

Banking, financial Services, e-payment systems and e-governance

In a concerted effort to check corruption and enhance accountability and ensure transparency in governance and avoid delays in government transactions, the government of Nigeria directed all ministries, departments and agencies to adopt e-payment mechanisms for disbursing salaries to employees and also for making third party payments.

E-payment is simply an electronic method of transferring funds rather than the usual inconvenient way of carrying large sums of money that may lead to misappropriation. It is a system that seeks to eliminate many of the problems associated with physical cash distribution.

Under the current scheme, the government has made it mandatory for employees, suppliers/vendors, pensioners, utility organisations (water, electricity, telephone), insurance organisations, subscription organisations (clubs, associations, etc.) to indicate their bank account number and other relevant e-payment details so that payment can be transferred via electronic means instead of payment through cheques or cash. However, implementation of the e-payment systems by some organisations in the country is marred by payment delays with cumbersome processes and procedures largely attributed to improper implementation and inadequate ICT readiness for the e-payment programme. NIGCOMSAT Ltd followed with special interest the Central Bank of Nigeria's policies to reduce the high usage of cash, moderate the cost of cash management and encourage the use of electronic payment channels with a view to reducing the dominance of cash in the economy and its attendant implications for the cost of cash management to the banking industry, security and money laundering - *inter alia.*

The pilot cash policy started in Lagos State on January 1st, 2012 (tagged "Cashless Lagos"), which provided an insight into how a combined hybrid solution of the regional Communications Satellite (NIGCOMSAT-1R) and the National Public Security and Emergency Network could be used as a model to mitigate against the failures experienced in the Lagos trial project, drive financial and digital inclusion and thereafter roll out the policy to other regions across the country on a nationwide scale for a win-win scenario. The policy no doubt reduced the cost of banking services; improved the effectiveness of monetary policy in managing inflation and driving economic growth, increased tax collection, checked corruption, enhanced accountability, ensured transparency in governance, avoided delays in government transactions and has driven development and modernization of the payment system in line with

Nigeria's financial inclusion strategy as well as investment in ICT infrastructure and technology.

However, the success of this policy depends largely on easy, affordable and the ubiquitous availability of broadband Internet access in the country. Presently, 75% of broadband connectivity exists only in urban areas and it is expensive. Last mile deployment of broadband through wire-line requires significant investment and, moreover, deployment in rural areas is time consuming and uneconomic. As a "Proof-of-Concept (POC), locations experiencing connectivity challenges and transaction difficulties using the inadequate last mile infrastructure of commercial mobile operators for live-demonstrations by guaranteeing at least a consistent 4kbps to enable POS terminals to conduct an end-to-end query with the backend E-payment servers of the clearing house and the Nigeria Inter-Bank Settlement System (NIBSS). A bottom-top approach yielded success and the combined executive of CBN and NIBSS provided NIGCOMSAT Ltd with a further 20 locations across six geopolitical regions of the country slated for the six-state pilot project with recorded success (Lawal, 2014).

NIGCOMSAT-1R's complementary role with terrestrial network infrastructure in the banking and financial service sectors with dedicated links to their branches across the country is designed to improve e-payment performance and efficiency. The service has a secure future in Nigeria given that it provides a robust and resilient capacity for the banking industry enabling more efficient banking transactions, including online banking services. It enables the linking up of various government offices under a wide area network such that they can communicate with each other and be able to share information seamlessly and even have the capacity to implement video conferencing thus improving the efficiency of governance as well as promoting transparency and accountability. Corporate intranet/extranet and Virtual Private

Networks for the government are also established. These encourage investors to invest in the enterprise ICT solutions market sector allowing small-scale companies in Nigeria, without physical ownership of satellite hubs and gateways, to participate in the satellite value chain and extract value by leveraging NIGCOMSAT's assets through Virtual Network Operators (VNO). This presents a new investment opportunity that can stimulate market growth, development and employment opportunities while enhancing penetration of services to a wider population (Lawal & Chatwin, 2015).

NIGCOMSAT has developed a range of integrated software packages comprising of electronic voting registration and a voting system, Radio Frequency Identification-based electronic attendance system, tracking and fleet management system, link budget calculator, PCB (printed circuit board) Development Boards and e-message display system amongst others. Another important new product is the Development Control Information System (DevCIS) for the Development Control Department in Abuja. DevCIS is an integrated solution that will assist the department in automating its functions and activities to facilitate urban planning and development control processes through a common platform that is timely and resource sensitive. The system is flexible, easy to use, easy to maintain and provides a simple operational environment in an effective and efficient manner (Lawal, Chatwin, Ahmed-Rufai & Liu, 2013). The same automation is already being planned through pilot demonstrations for oil and gas sector applications, such as: oil field management, pipeline monitoring, oil and gas transportation exploiting hybrid of VSAT technology with LoRa [Long Range]. LoRa wireless technology is a long range, low power radio frequency platform and is the prevailing technology of choice for building the Internet of Things (IoT) networks worldwide The wireless RF technology is being integrated into cars, homes, estates, street lights, offices,

manufacturing systems, supply chains, home appliances, wearable devices and every desirable thing that requires connectivity.

Smart IoT systems and applications have improved the way we interact and are addressing some of planet earth's biggest challenges, such as: early warning of natural disasters, climate change, pollution control - thus making our planet smart.

Similar demonstrations will be extended to street lights, home appliances, utilities, sewage systems, terrestrial telecommunications ducts for evolution, validation and acceptance of smart cities and smart home concepts.

The concept of e-governance has seen the introduction of several initiatives aimed at accelerating development through several technological platforms. This is aimed towards connecting communities, vital agencies, institutions of Government and educational institutions at all levels - through ICT. Such initiatives include: the Nigerian telemedicine initiative, Public service network initiative, Internet exchange point initiatives, State and Local Government ICT initiative. Most government owned agencies now have webpages either fully developed or at various stages of development, thus creating an online presence for citizens and businesses. This has created public awareness of the vision, mission and mandate of several Ministries Departments and Agencies (MDAs). Other cost effective components of e-governance implementation include: e-passport and Resident Permit for Nigerian Immigration Services, The Nigerian Customs computerization processes, Computerization of Land and Certificate of Occupancy in the Federal Capital Territory Administration (FCTA), The Integrated Payroll and Personal Information (IPPIS) of virtually all Federal Government employees, online checking of West Africa Examination Council (WAEC), National Examination Council (NECO) and Joint Admission and Matriculation Board (JAMB) results as well as National Youth Service Corps (NYSC) postings in real time. These fragments of e-government initiatives are giant strides paving the way for the much needed electronic

government (e-government) master plan in its entirety to enhance productivity as well as efficiency and accountability in government processes in Nigeria. Communications Satellites play a strategic role as critical ICT backbone infrastructure to drive Nigeria's national ICT revolution in providing cost effective solutions and affordable access to meet telecommunications and broadcast needs of the entire nation, especially in rural and swampy areas as well as providing interconnection of MDAs, citizens etc beyond cities and urban areas.

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Concluding Remarks

NIGCOMSAT-1R has become the cornerstone for universal access goals and an important provider of development resources. Effective use of satellite resources can facilitate improved security, national emergency management, natural disaster management, defence and internal security with improved telecommunications infrastructure access and it can be enhanced by deploying more advanced satellites. The NIGCOMSAT satellite VNO model presents new investment opportunities that can stimulate economic development, and job creation whilst enhancing provision of services to the wider population.

This acts as an incentive to inward foreign investment. In summary, NIGCOMSAT provides competitively-priced satellite services for Nigeria and the African continent of a broad range of ICT services, including broadband access, data traffic, inter-switching between financial institutions for easier online payment, voice-traffic, and IP telephony; and government activities such as e-government, e-commerce, e-agriculture. In so doing it augments the goals of the New Partnership for Africa's Development (NEPAD) policy frameworks and initiatives, the Millennium Development Goals (MDG's) now transitioned to Sustainable Development Goals (SDG's), and *Vision 20:2020*. In a vital, albeit modest manner, the recourse to

communications satellites can contribute to Nigeria's development and assist it in a shift away from reliance on hydrocarbons.

This paper draws on Lawal Lasisi Salami's doctoral thesis *Economically Sustainable Public Security and Emergency Network exploiting a Broadband Communications Satellite,* University of Sussex, 2014

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