Satellite & Fibre Communications: A Solution for Africa?

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Engr Lasisi Lawal, Dr Young, Dr Birch – IET – Studio Theatre, Hawth, Crawley – 3rd June 2014
Summary

- Challenges & cost of the Internet in Nigeria
- Global Fibre Optic Backbone
- African Sub-sea Optical Fibre Backbone
- Satellite Option
- Satellite & Wireless Systems
- DWDM in Tanzania
Complexities in Africa

- Political instability
- Insurgencies
- Poverty
- Unreliable power generation systems
- Very little in the way of planning controls
- Taxes and rights of way
• Prevailing price of VSAT bandwidth before NIGCOMSAT-1 (2004 viability assessment)
• Average price paid for 64kbps was $8,340 per year
• 128/1024 kbps bandwidth costs about $2,000 monthly, this implies that estimated 2MB (E1) would cost $3,500 per month or $42,000 yearly
• Comparatively, equivalent capacity of 2Mbps (E1) full circuit on SAT-3 fibre optic cable from Lagos to Europe (Portugal). The only operating cable, was: $144,500 per year by NITEL. NITEL (Nigerian Telecommunications Ltd) is Nigerian Government owned telecommunication company managing the only landing cable in Nigerian Shores (Lagos).
20 hours of local dial-up internet per month in Nigeria is:

- 500% higher than in India
- 140% higher than in South Africa and Namibia
- About the same as Uganda
- International Internet Connectivity accounts for about 30% of ISP costs
- International Internet Connectivity has two parts:
  a. International leased circuits; over-priced (often grossly)
  b. Global Internet connectivity: rarely identified separately
- Reluctance by operators to disclose information suggests, it is key to competitiveness.
20 hours of local dial-up internet per month comparison

- India: less than $20 comprised of (ISP charges: $3.5; Telephone Call charges $10.2 and Telephone line rental $4.0)

- Nigeria: Over $100 comprised of (ISP charges: $33.0, telephone call charges $80 and Telephone line rental $4.0)

- OECD: less than $40 comprised of (ISP charges: $9.4, telephone call charges $15.1 and Telephone line rental $12.2)
International Bandwidth – Optical Fibre

![Graph showing international bandwidth usage and annual growth from 2008 to 2012.](Image)
Arctic Fibre is deploying state of the art technology utilizing 100 gigabit wavelengths to construct a system with a capacity of 24 terabits/s.

The construction of the system is beginning in May 2014 and is scheduled to be in service in January 2016.
More than adequate terabyte capacity at the shores of Africa

- **WEST COAST**: OVER 15TBPS AND 55 TBPS BY 2Q OF 2015
- **EAST COAST**: 10.160TBPS AND 15.460 TBPS BY 4Q OF 2014
- **MEDITERRANEAN**: 10.56TBPS

- WEST COAST: OVER 15TBPS AND 55 TBPS BY 2Q OF 2015
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Dense Wavelength Division Multiplexing (DWDM)

- Optical amplifiers amplify optical signals directly in the optical domain and are capable of simultaneously amplifying multiple signal wavelengths and this has facilitated Dense Wavelength Division Multiplexing (DWDM).

- Optical amplifiers are used as repeaters and at the end of each fibre span to boost the power of the DWDM signal channels to compensate for fibre attenuation in the span.
Submarine fibre optic cables

SLTE: Submarine Line Terminal Equipment
BU: Branching Unit
PEU: Passive Equalization Unit
Erbium-doped fibre amplifiers (EDFA) provide gain over a spectral range about 30 nm in width, from about 1530 nm to about 1560 nm.

This permits 40 DWDM signal channels with a separation of 100 GHz and

80 channels with a separation of 50 GHz,

corresponding to 400 or 800 Gb/s, respectively, 10Gb/s OC-192 or STM-64 channels.

In the future, with 40-Gb/s channels, capacities of 1.6 Tb/s (1600Gb/s) for 100-GHz spaced channels will be possible.
Course Wavelength Division Multiplexing (CWDM)

- CWDM systems are medium capacity wavelength division multiplexing systems used over distances up to 80 km (50 miles).

- They are defined by the International Telecommunications Union (ITU) recommendation (standard)

- G.694.2 (2003) as 18 wavelengths spaced 20 nm apart starting at 1271 nm and continuing to 1611 nm.
A cell site will often have three to four cellular providers, each one requiring a dedicated fibre for their backhaul capacity needs.

A single cellular service provider can require 300 Mb/s to 1 Gb/s, eliminating the ability to use a copper facility.
The 9,300 square metre data centre near Frankfurt – requires a reliable power supply

- European data centres consumed 56TWh of electricity in 2007 and in the UK they are responsible for almost three per cent of electricity use.
EADS Astrium Ka-SAT, 6.1 Tonnes at launch, 15 year lifetime, 11 kW

The British military's Skynet 5 satellite system is based on this. The spacecraft is part of a £3.6bn system that will deliver secure, high-bandwidth communications for UK and allied forces.

Eutelsat’s Ka-SAT is the world’s most powerful satellite ever built, with a total capacity of more than 70 Gbps, 35 times the throughput of traditional Ku-band satellites.

KA-SAT will provide ubiquitous complete coverage of Europe and the Mediterranean Basin through its 82 spot beams in Ka-band.
ViaSat-1, which will be positioned at 115.1 degrees West longitude, is expected to provide more than 100 gigabits per second throughput in the Ka band, mostly for use in the West Coast of the U.S. and east of the Texas panhandle. The satellite has 72 spot beams, with 63 in the U.S. and nine over Canada.
The Intelsat Satellite Network
Nigerian Satellite Communication System

- NIGCOMSAT-1 was launched 13th May, 2007 GMT Nigerian time and was de-orbited on 10th November, 2008 due to in-orbit subsystem anomaly – After launch satellite internet prices almost halved, then increased by 50% when it was de-orbited.

- Nigcomsat-1R was launched on 20th December 2011.(GMT) Nigerian time but early hours of 21st December, 2011 Chinese Local Time. Internet connection charges decreased considerably.
Nigcomsat-1R Satellite up to 5 Gbps
Nigcomsat-1R Satellite – 9kW quad band

- C-Band Transponder – 4 active transponders - 36MHz
- Ku-Band Transponder – 14 active transponders – 31.5MHz
- Ka-Band Transponder and – 8 active transponders – 120MHz
- L-Band (Navigation) Transponder – 2 active transponders
- Seven (7) Service Antennas
- NigComSat-1R with service life of more than 15 years has a designed life of 22.5 years with more than 0.70 reliability value at the end of its service life.
Nigcomsat-1R Footprints and Coverage

ECOWAS C-BAND COVERAGE

ECOWAS I KU-BAND COVERAGE

ECOWAS II KU-BAND COVERAGE

ASIA KU-BAND COVERAGE

KA-BAND COVERAGE OVER NIGERIA

KA-BAND COVERAGE OVER SOUTH AFRICA

KA-BAND COVERAGE OVER EUROPE

GLOBAL NAVIGATIONAL COVERAGE IN L-BAND
Global Positioning System

- 24 spacecraft in 12 hour circular orbits, with 3 on-orbit spares. Six circular orbital planes, $R=26,560\text{km}$
- All users with clear view of sky see the minimum of 4, but usually see 6-8
- Augmentation generally not only improves accuracy but integrity, availability and continuity of GPS signals and GNSS signals generally.
• ICT is a development enabler and a prerequisite for a country’s transformation into a knowledge-based economy

• This requires ICT readiness, providing a networked ICT infrastructure with ubiquitous access to knowledge and data.

• Africa remains the least wired continent in the world.
• Broadband internet connectivity is grossly inadequate especially in the hinterlands.

• Last mile deployment of broadband through wire-lines requires huge investment, which is hardly affordable when deployed in rural areas.
## Table 1 – Research results of broadband impact on GDP growth

<table>
<thead>
<tr>
<th>Country</th>
<th>Authors – Institution</th>
<th>Data</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thompson and Garbacz (2008) – Ohio University</td>
<td>46 US States during the period 2001-2005</td>
<td>A 10% increase in broadband penetration is associated with 3.6% increase in efficiency</td>
</tr>
<tr>
<td>OECD</td>
<td>Czernich <em>et al.</em> (2009) – University of Munich</td>
<td>25 OECD countries between 1996 and 2007</td>
<td>A 10% increase in broadband penetration raises per-capita GDP growth by 0.9-1.5 percentage points</td>
</tr>
<tr>
<td></td>
<td>Koutroumpis (2009) – Imperial College</td>
<td>2002-2007 for 22 OECD countries</td>
<td>An increase in broadband penetration of 10% yields 0.25% increase in GDP growth</td>
</tr>
<tr>
<td>High Income Economies</td>
<td>Qiang <em>et al.</em> (2009) – World Bank</td>
<td>1980-2002 for 66 high income countries</td>
<td>10% increase in broadband penetration yielded an additional 1.21 percentage points of GDP growth</td>
</tr>
<tr>
<td>Low &amp; Middle income economies</td>
<td>Qiang <em>et al.</em> (2009) – World Bank</td>
<td>1980-2002 for the remaining 120 countries (low and middle income)</td>
<td>10% increase in broadband penetration yielded an additional 1.38 in GDP growth</td>
</tr>
</tbody>
</table>

Source:
# Economic Impact of broadband - Jobs

## Table 2 – Broadband impact on job creation

<table>
<thead>
<tr>
<th>Country</th>
<th>Authors – Institution (*)</th>
<th>Objective</th>
<th>Results</th>
</tr>
</thead>
</table>
| United States    | Crandall et al. (2003) – Brookings Institution | Estimate the employment impact of broadband deployment aimed at increasing household adoption from 60% to 95%, requiring an investment of USD 63.6 billion | • Creation of 140,000 jobs per year over ten years  
• Total jobs: 1.2 million (including 546,000 for construction and 665,000 indirect) |
|                  | Atkinson et al. (2009) – ITIF | Estimate the impact of a USD 10 billion investment in broadband deployment                                                                                                                                   | • Total jobs: 180,000 jobs-year (including 64,000 direct and 116,000 indirect and induced)                  |
| Switzerland      | Katz et al. (2008b) – CITI | Estimate the impact of deploying a national broadband network requiring an investment of CHF 13 billion                                                                                                    | • Total jobs: 114,000 over four years (including 83,000 direct and 31,000 indirect)                         |
| United Kingdom   | Liebenau et al. (2009) – LSE | Estimate the impact of investing USD 7.5 billion to achieve the target of the “Digital Britain” Plan                                                                                                         | • Total jobs: 211,000 jobs-year (including 76,500 direct and 134,500 indirect and induced)                  |

(* Note:  
ITIF: Information Technology and Innovation Foundation  
CITI: Columbia Institute for Tele-Information  
LSE: London School of Economics)
• Africa is in dire need of national, sub-regional and regional carrier of carriers and digital links with cross-border inter-connectivity including intra-city and inter-city metro networks.

• The ICT readiness of any nation is a function of level of networked telecommunications infrastructure, which is a determinant for universal access goals and digital inclusion. The 3As are:

  • AVAILABILITY
  • AFFORDABILITY
  • ACCESSIBILITY
Thus, convergence in communications networks through integrated connectivity is required to bridge the digital hiatus

- Satellite,
- Fiber optics,
- Variants of Wireless Terrestrial Technologies (GSM, CDMA, WiFi, WiMaX, LTE etc)

African leaders and stakeholders have recognized the many challenges that confront their countries and are committed to addressing them through ICT
• African Governments and the Organized Private sector recognize that information and communication technologies (ICT) are central to the creation of the emerging global knowledge-based economies.

• The continent is presently served with several terabytes of submarine cable around its coastline, so there are big opportunities
More Than Adequate Terabyte Capacity at the Shores

- WEST COAST: OVER 15TBPS AND 55 TBPS BY 2Q OF 2015
- EAST COAST: 10.160TBPS AND 15.460 TBPS BY 4Q OF 2014
- MEDITERRANEAN: 10.56TBPS
ABSENCE OF INADEQUATE TERRESTRIAL LAST MILE INFRASTRUCTURE IS HINDERING BROADBAND PENETRATION AND UNIVERSAL ACCESS GOALS
Other Challenges

• Right of Way difficulties

• Appropriate corridor and channels for terrestrial last mile largely requires proper urban and regional planning

• Multiple taxation at national, state and local government council levels

• Theft and damage to optical fiber cables especially during road construction and urbanization
Other Challenges

- Anti-competitiveness among operators
- Non-implementation of infrastructural sharing
- Huge capital requirement for deployment of inter-city and Intra-city metro-ring optic fibre
- Affordability of service
Short and Medium Term Strategies

- To optimize access to information and guarantee universal access in the short and medium term to almost all African inhabitants

- Satellite Communications and wireless systems infrastructure should be given a priority within the ICT framework policy and broadband implementation to complement existing and inadequate terrestrial infrastructure.
Satellite and Wireless

- ComSats remain strategic national and continental telecommunication infrastructures especially during natural disasters and emergencies.

- As a means of catching up on the infrastructural gap, communications via satellite and terrestrial wireless systems has had significant success in facilitating information technology policies and infrastructures for most African nations especially Nigeria.
Modest Success Stories Based On Wireless Infrastructure

Growing percentage Contribution of Telecoms To Nigeria’s GDP (2001-2011)
Recent findings by the 2010 International Telecommunication Union (ITU) report show that mobile broadband subscriptions and penetration between 2000 and 2009 were increasing more rapidly than fixed broadband subscriptions.

This is a particular trend in the developing nations (emerging economies) of Africa (ITU, 2010).
For Instance, Case Study of the Reality in Nigeria; Accounts For $\frac{1}{6}$th Of African Population

- Urban
- Suburban
- Rural

70% of the Nigerian citizens reside here!

Some degree of Coverage
Minimal Coverage to zero coverage
Hybrid Integrated Infrastructure as Solution
Typical Remote Site Configuration as Comsat Last Mile

Remote Terminal

- Antenna
- Satellite Modem
  - L-Band IFL

Remote LAN (Wired distribution)

- Ethernet Switch
- 10/100 Mbps Ethernet
- VoIP Phones
- PCs
- LAN

Remote Radios (Wireless distribution)

- WBSn
- WCPEn-2400-I

- PCs
Communication Satellites as a Bridge to the Infrastructural Gap and Niche in Rural Areas

- Satellite Communications have a competitive advantage as they complement the present sparsely distributed terrestrial links (fiber optic) and wireless link extensions contributing to accelerated economic growth.

- Secure communications for security agencies, socio-economic development, good governance encouraged through transparent processes.
Communication Satellites as a Bridge to the Infrastructural Gap and Niche in Rural Areas

- Promotion of financial and digital inclusion including universal access goals through the ubiquity of COMSATs

- A launch pad for participation in the global knowledge-based economy thus accelerating sustainable growth and development.

- Indigenous satellites serving such interests are NIGCOMSAT-1R, RASCOM-QAF 1R, NILESAT SERIES including international satellite operators such as Intelsat, Eutelsat etc
NIGCOMSAT Gateways and hubs are deployed at the coastal areas of the country to gain access to the huge communication potential of the various submarine landing cables with tens of terabytes capacity.

The strategic deployment and implementation of a teleport hub serves as an African convergence port, where the terrestrial fiber can connect and merge with the Communication Satellite Network.
NEWTEC SAT3PLAY BROADBAND GATEWAY SYSTEM
with differentiated classes of services
Services, Solutions & Applications

- Mobile
- Military
- Teleconferencing
- Internet
- Corporate VPN
- Disaster Recovery
- Distance Learning
- Energy SCADA
- Air Traffic Control

- Retail
- Security
- Surveillance
- Digital Signage
- Financial Services
- Lottery
- Telemedicine
- Multicasting
Nigcomsat-1R Services, Solutions & Applications
Broadband has the potential to enable entire new industries and to change how we educate our children, deliver health-care, enhance farming, ensure public safety, engage government, and access, organize and disseminate knowledge.
Financial Inclusion Strategies

For existing POS Terminals with Ethernet and WIFI communication options:

System Engineering Solution: 3G USB Dongle + 3G/4G Wireless Routers
Challenges of satellite broadband

- High cost of ComSat Resource (Transponders): Newer generation of satellite; HTS aggressively addresses cost.
- Back-up Communication Satellite to ensure and guarantee service continuity for service providers that operate a lone communication satellite.
- Two more satellites are planned
NICTTB is connected internationally to the SEACOM undersea cable and the Eastern African Sub-Marine cable System (EASSy),
• NICTBB network is delivering e-services such as:
  – e-Money, e-Commerce, e-Banking, e-Education and e-Government in both the public and private sectors and also in rural areas
• NICTBB operates as the wholesale business concentrating on large capacity interface of high-speed data streams i.e. Synchronous Transport Module-STM-1 (155 Mb/s), STM-4 (622 Mb/s), STM-16 (2.4 Gb/s), and STM-64 (10 Gb/s) to telecomm operators
• In Rural areas, the last mile of communications is still a cost issue
Tanzanian National ICT broadband backbone (NICTBB)

• NICTBB is implemented on three network technologies: Dense wavelength division multiplexing (DWDM), Synchronous digital hierarchy (SDH) and Internet protocol (IP)

• NICTBB has adapted the transmission of IP over SDH over DWDM, in which IP packets (i.e. Internet traffic) are encapsulated and then transmitted by a router with either fast Ethernet (FE) or giga Ethernet (GE) port directly over SDH then to the DWDM optical layer
• DWDM network incorporated into NICTBB supports 40 wavelengths per fibre and each wavelength can carry 10 Gb/s; thus enabling a single fibre to carry four hundred gigabits/s (400GB/s) of data

• Following NICTTB being connected internationally to the SEACOM undersea cable and the Eastern African Sub-Marine cable System (EASSy), the International bandwidth cost reduced dramatically from $1,500 per Mbps to $180 per Mbps that is equivalent to an eighty eight percent [88%] reduction.
## NICTBB Pricing (US$), 2010

<table>
<thead>
<tr>
<th>Service</th>
<th>Annual (US$)</th>
<th>Price (2.048Mbps) (US$)</th>
<th>E1 Price</th>
<th>Monthly (2.048Mbps) (US$)</th>
<th>E1 Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>STM - 1</td>
<td>180,000.00</td>
<td>2857.14</td>
<td>238.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STM - 4</td>
<td>432,000.00</td>
<td>1714.29</td>
<td>142.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STM - 16</td>
<td>1,036,800.00</td>
<td>1028.57</td>
<td>85.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STM - 64</td>
<td>2,488,320.00</td>
<td>617.14</td>
<td>51.43</td>
<td></td>
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</tr>
</tbody>
</table>
Internet bandwidth monthly tariff rates for both commercial and residential
[Source: TTCL] Tanzania

<table>
<thead>
<tr>
<th>Internet tariffs for Retail Residential Market</th>
<th>Dec 2009</th>
<th>Dec 2010</th>
<th>Dec 2011</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadband 1GB</td>
<td>N/A</td>
<td>$18.57</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Broadband 2GB</td>
<td>$61.90</td>
<td>$37.14</td>
<td>$18.57</td>
<td>$18.57</td>
</tr>
<tr>
<td>Broadband 4GB</td>
<td>$123.80</td>
<td>$61.90</td>
<td>$37.14</td>
<td>$37.14</td>
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<thead>
<tr>
<th>Internet tariffs for Retail SME Market</th>
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</thead>
<tbody>
<tr>
<td>Broadband 20GB</td>
<td>$278.55</td>
<td>$222.84</td>
<td>$123.80</td>
<td>$123.80</td>
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<tr>
<td>Broadband 40GB</td>
<td>$619.00</td>
<td>$278.55</td>
<td>$222.84</td>
<td>$222.84</td>
</tr>
<tr>
<td>Broadband 80GB</td>
<td>N/A</td>
<td>N/A</td>
<td>$278.55</td>
<td>$278.55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internet tariffs for Retail Corporate Market</th>
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</thead>
<tbody>
<tr>
<td>Dedicated 512Kbps</td>
<td>$3466.40</td>
<td>$1374.18</td>
<td>$705.66</td>
<td>$705.66</td>
</tr>
<tr>
<td>Dedicated 1024Kbps (1Mbps)</td>
<td>$5694.81</td>
<td>$1943.66</td>
<td>$1163.72</td>
<td>$1163.72</td>
</tr>
<tr>
<td>Dedicated 2048 (2Mbps)</td>
<td>$7675.61</td>
<td>$2896.92</td>
<td>$2240.78</td>
<td>$2240.78</td>
</tr>
</tbody>
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<tr>
<th>MPLS VPN tariffs for Corporate Market</th>
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</thead>
<tbody>
<tr>
<td>MPS VPN 256Kbps</td>
<td>$800.00</td>
<td>$800.00</td>
<td>$800.00</td>
<td>$350.00</td>
</tr>
<tr>
<td>MPS VPN 512Kbps</td>
<td>$1,500.00</td>
<td>$1,050.00</td>
<td>$1,050.00</td>
<td>$480.00</td>
</tr>
<tr>
<td>MPS VPN 1024Kbps (1Mbps)</td>
<td>$2,500.00</td>
<td>$2,040.00</td>
<td>$2,040.00</td>
<td>$720.00</td>
</tr>
</tbody>
</table>
Conclusions

• The success of Africa’s information technology policy and infrastructure in the short and medium term remains wireless systems (space and terrestrially based).

• Satellite communications have a competitive advantage as they complement the present sparsely distributed terrestrial links.

• In broadcasting sector, satellite digital television complements terrestrial television and offers an alternative to digital terrestrial television.
Conclusions

• Communication satellites are strategic continental ICT infrastructure with far reaching impacts in enhancing telecommunications, broadcasting, the internet, multimedia services and emergency & disaster management. **Short lead time.**

• Intra-city and inter-city metro ring optic fibers built in and around Africa are ultimately desirable for sustainable broadband experience as a long term plan. **Long lead time.**
References

1. Pazi, Shaban, Chatwin, Chris, Young, Rupert, Birch, Phil and Wang, Wei (2009), *Performance of Tanzanian optical DWDM system*. European Journal of Scientific Research, 36 (4), pp. 606-626. ISSN 1450-216X


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