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Availability profile of Frontier Downstream Optic fibre Link and stability of terrestrial fibre infrastructures in Nigeria.

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Abstract

The scenery for optic fibre broadband utilization is on the increase owing to the exponential growth of internet traffic and the rising demand for high bandwidth consuming services and applications, all over the world. Telephone calls hitherto made through cellular networks has moved to the internet thus adding to network data rates with subsequent requirements for deployment of more optic fibre infrastructures across network edges to satisfy the extensive global appetite for broadband access and high-speed data. To this end, network traffic across the internet or within data centres and customer access networks must scale up in capacity and be optimally available, for end-to-end connectivity towards end-user Quality of Experience, QoE. In this paper, we propose that frontier downstream optic fibre links, FDOL, between Submarine cable landing stations and Carrier's Point-of Presence, PoP, be fortified for optimal availability as pointers to the stability of terrestrial optic fibre infrastructure in a Country.

Keywords: Frontier Downstream Optic fibre Link**,** Quality of Experience, Availability, Fibre broadband utilization, backhaul.

1. Introduction

Under the broadband ecosystem model, the basic elements of supply in the broadband ecosystem consist of four levels: international connectivity, domestic backbones, metropolitan connectivity and local connectivity [1]. In this study, we grouped these elements into the upstream and downstream segments where International connectivity is the upstream and the terrestrial elements of national backbone, metropolitan and local connection make up the downstream segment as illustrated in Figure 1.

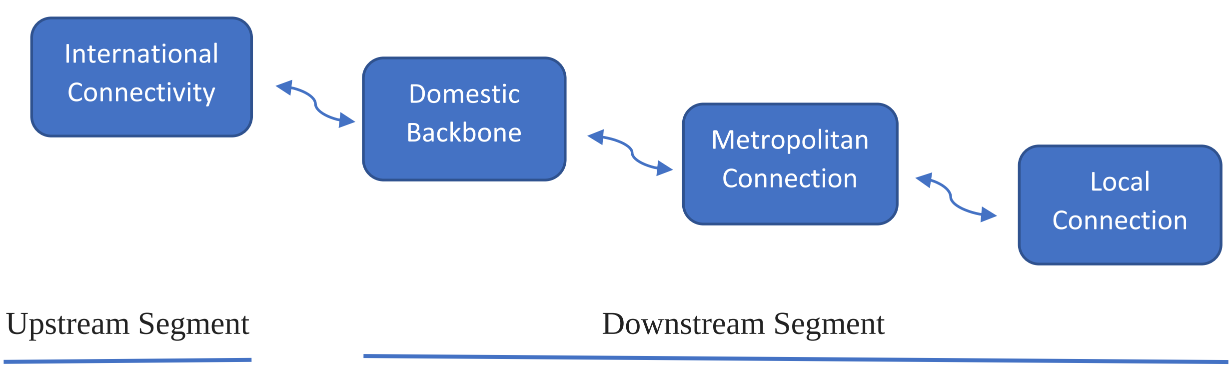

Figure 1: Upstream and Downstream segments of Broadband Supply Chain.

The International connectivity segment, by the model in Figure 1, is driven by submarine cable. The submarine cable terminates at Cable Landing Stations where submarine networks interconnect to terrestrial networks via a backhaul network into the Carrier's inland Point-of-Presence, PoP. Figure 2 illustrate submarine system interconnection to and from terrestrial networks.

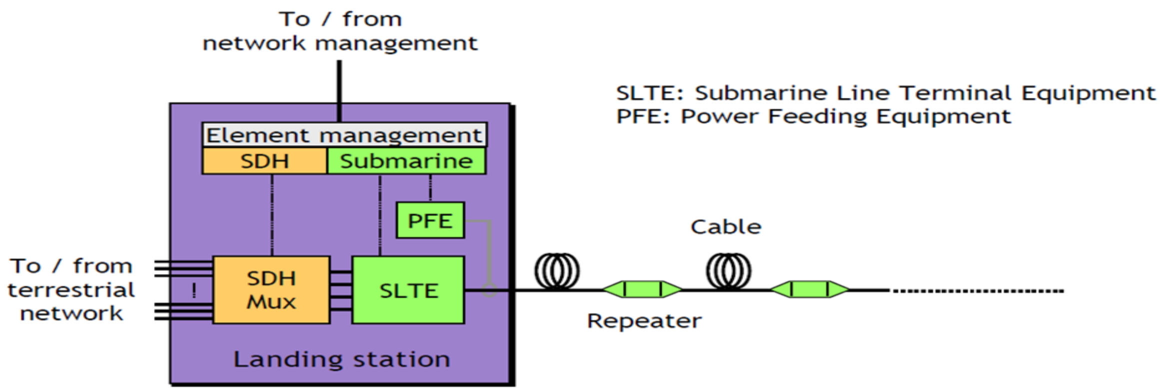

Figure 2: Terrestrial Backhaul to and from Cable Landing Station [2]

Backhaul networks are optical networks optimised for physical transportation of submarine capacity between the Cable Landing Station and the major POPs or Data centre for customers pick up. In an end-to-end connectivity for broadband access delivery between the upstream and downstream segments, as shown in Figure 3, the submarine section lies in between two portions of Terrestrial Backhaul designated A and B.

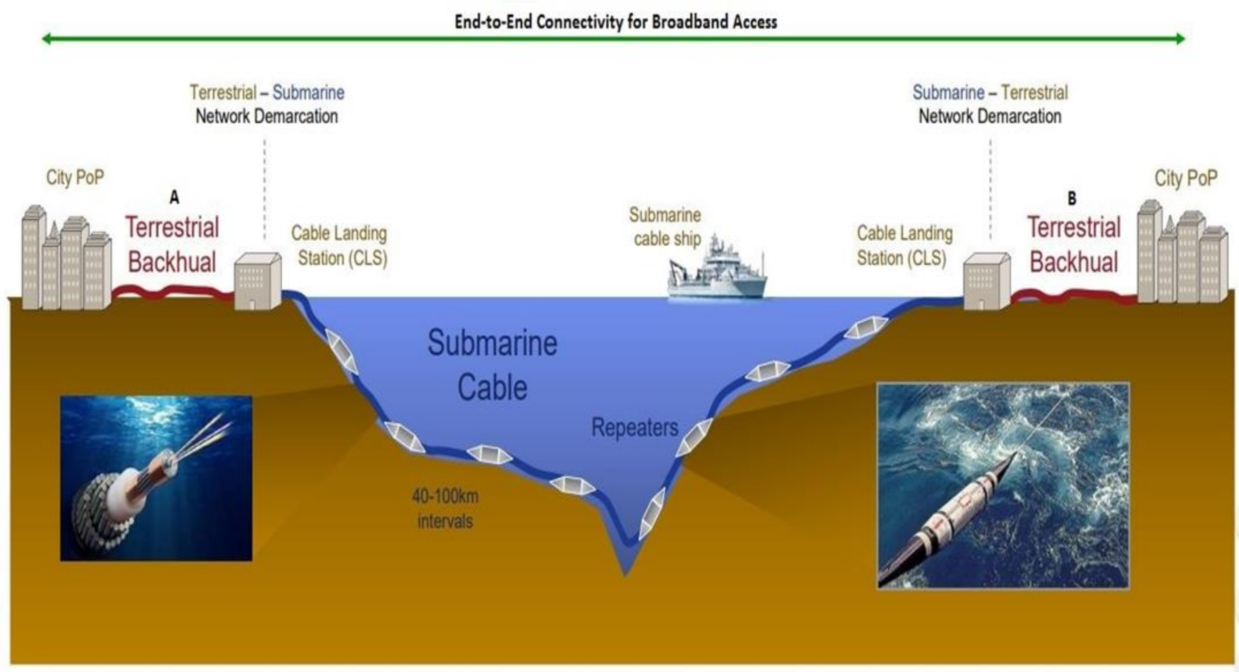

Figure 3: End-to-end Connectivity for Broadband Access delivery [3]

Wholesale Carriers or Communication Service Providers, CSPs, can thus pick up their purchased capacities directly from Cable Landing Stations and distribute it into their network by utilizing their own fibre infrastructures. From field experience, there are other terrestrial fibre links before and after the City PoP, that is, from terrestrial network into the Submarine section and vice-versa. In this paper, we define the terrestrial backhaul (portions A and B) fibre link from Submarine Cable Landing Station to the Carrier's PoP as Frontier Downstream Optic fibre Link, FDOL.

In many countries, the tremendous capacity of broadband services at Cable Landing points of the nation's submarine cable systems are not being felt in the hinterlands due to the unstable state of their terrestrial fibre infrastructures. In Nigeria, the argument has been that all cable landing points are concentrated in Lagos (a commercial city in South West of the country), from where other parts of the country are distributed. Therefore, there is limited growth in broadband access occasioned by the impairments in terrestrial fibre backbone to distribute the enormous capacity at submarine landing stations around the country.

It is against this backdrop that this research was undertaken to quantify and evaluate the availability profile of interconnecting optic fibre links across the elements of broadband supply chain, underpinning end user experience of broadband in the country.

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2. Link Availability Profile

The modern platforms of connectivity are premised on a mixture of network layers of various sizes, backhaul connections and different access technologies that would be accessed by a large number of smart and heterogeneous wireless devices. The aim of which is to achieve consistent and widespread broadband connections to open up links and communication with low latency and ultra-high bandwidth in conformity with Quality of Service, QoS, as well as and Quality of Experience, QoE, specifications. Link availability profile is therefore employed to determine the stability of optic-fibre links traversing the nodes along broadband supply chain relative to broadband ecosystem model. To this end, we consider a fibre link provisioning as a simple series system using reliability block diagram, RBD, in Figure 4. In this model, the availability of the system is formulated relative to the availability of the various components that make up the system.

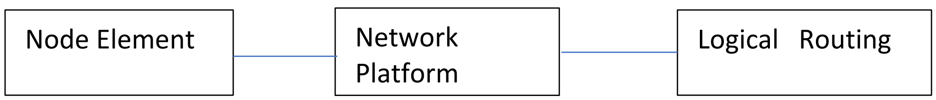

Figure 4: Fibre Link Provisioning

The rational connection relating the individual components are considered in estimating the system-level availability, and is represented graphically using RBD. Thus, we consider a fibre link provisioning system denoted by FLP that consists of a set of subsystems

$$F = \{F_i,\ i = 1, 2, 3\}, \qquad (1)$$

in which the success of the system is an amalgam of every subsystem F_i. Given the series configuration as shown in Figure 4, the availability of A_{FLP} is expressed such that

$$A_{FLP} = \prod_{i=1}^{3} A_i, \qquad (2)$$

where A_i is the availability of subsystem i [4].

Each subsystem F_i consists of a universal set of components $F_i = \{F_{i,j},\ i = 1, 2, 3,\ j = 1\ldots n_i\}$, where $F_{i,j}$ signifies the j^{th} component of the i^{th} subsystem, and n_i connotes the total number of components in the subsystem i. By assuming that the success of each subsystem depends on the success of every individual component $F_{i,j}$, the availability of subsystem F_i denoted by A_i is hence,

$$A_i = \prod_{j=1}^{n_i} A_{i,j}. \qquad (3)$$

Availability is thus expressed as [5]:

$$\text{Availability} = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}} \quad (4)$$

where, Uptime refer to efficacy to perform the task and Downtime refer to inability to perform the task. The values of Uptime and Downtime used in calculating availability is evaluated through actual field measurements from outage trouble tickets on the network as employed by this research. The other alternative is by service probes embedded in network monitoring system. Practical network performance monitoring thus calculates availability based on service downtime in addition to the total time by which the link was expected to be operational or in service. Therefore, equation (4) becomes,

$$\text{Availability} = \frac{\text{Total Time In Service} - \text{Downtime}}{\text{Total Time In Service}} \quad (5)$$

Total Time In Service is the sum of uptime over a reporting period that the links in consideration are expected to be operational; Downtime is the duration by which the link is unavailable. It is apportioned by the percentage of capacity or performances indices impacted during the outage. Information and Technology Infrastructure Library, ITIL, gives a modification of Equation (5) for evaluating Availability, A, such that [6]:

$$\text{Availability}\ (\%) = \frac{\text{Total Time In Service} - \text{Downtime}}{\text{Total Time In Service}}\ \text{X}\ 100\% \quad (6)$$

3. Materials and Method

A multi-service operator (MSO) with services in both upstream and downstream segment of broadband supply chain was chosen for investigation. For the upstream or International Connectivity segment, we use the West African Cable System, WACS, whose landing stations are as shown in Figure 5.

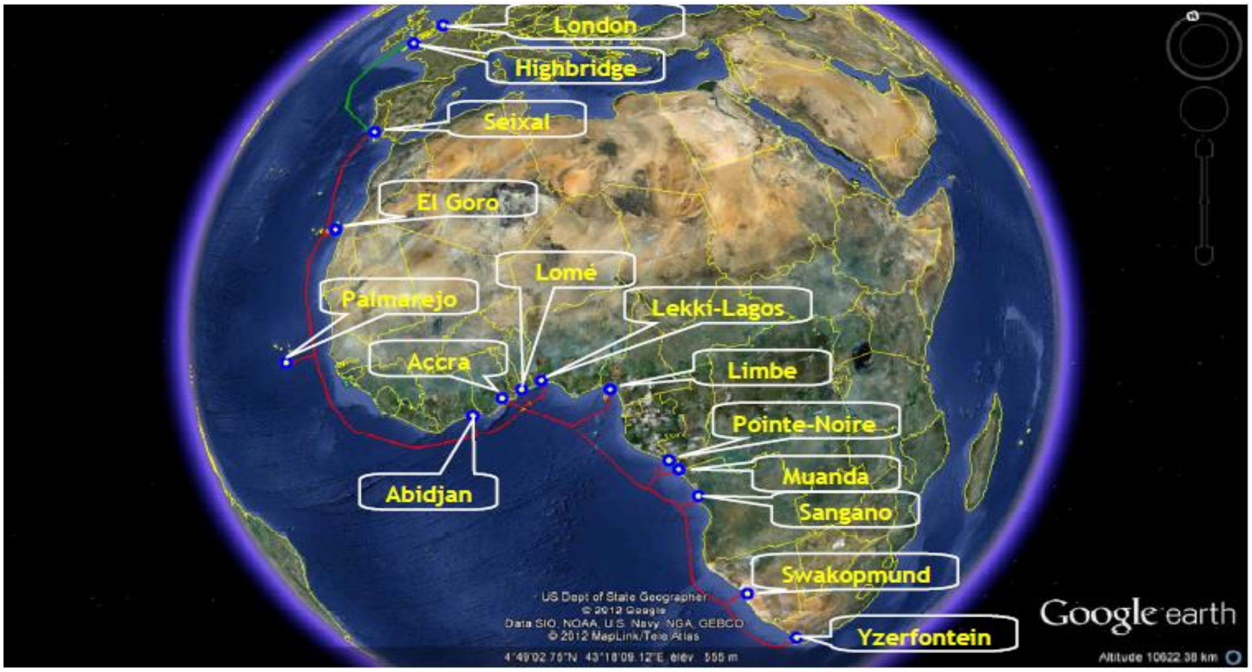

Figure 5: WACS Stations Geographic Location [7]

The downtime of frontier downstream optic fibre links, FDOL, from cable landing stations to the service provider's upland point-of-presence (POP), was investigated and quantified for three countries with WACS submarine cable landing stations. Availability Evaluation method was then employed (using equation 6) to calculate availability of the links. For Lekki-Lagos Landing station (CLS_OADM in Figure 6), the link between CLS_OADM and VGC_OADM, and the link between CLS_OADM and 21st Century was investigated.

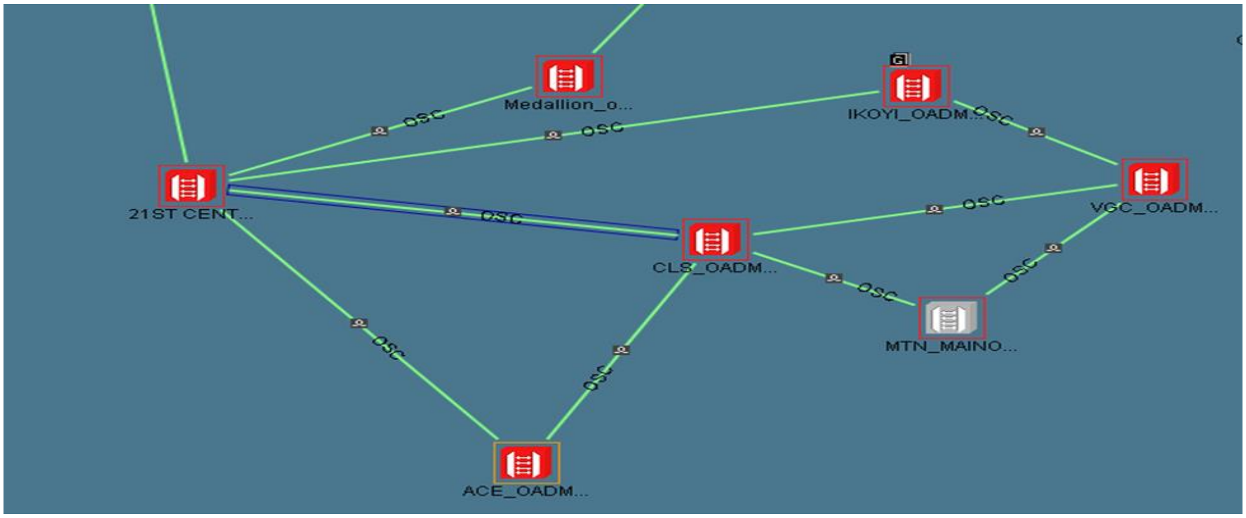

Figure 6: Frontier downstream fibre links from WACS cable landing in Nigeria.

For Accra Landing Station (CLS_AM in Figure 7), the terrestrial fibre link between CLS_AM and ACE_Landn, and the link between CLS_AM to IA_AM N022, was analysed.

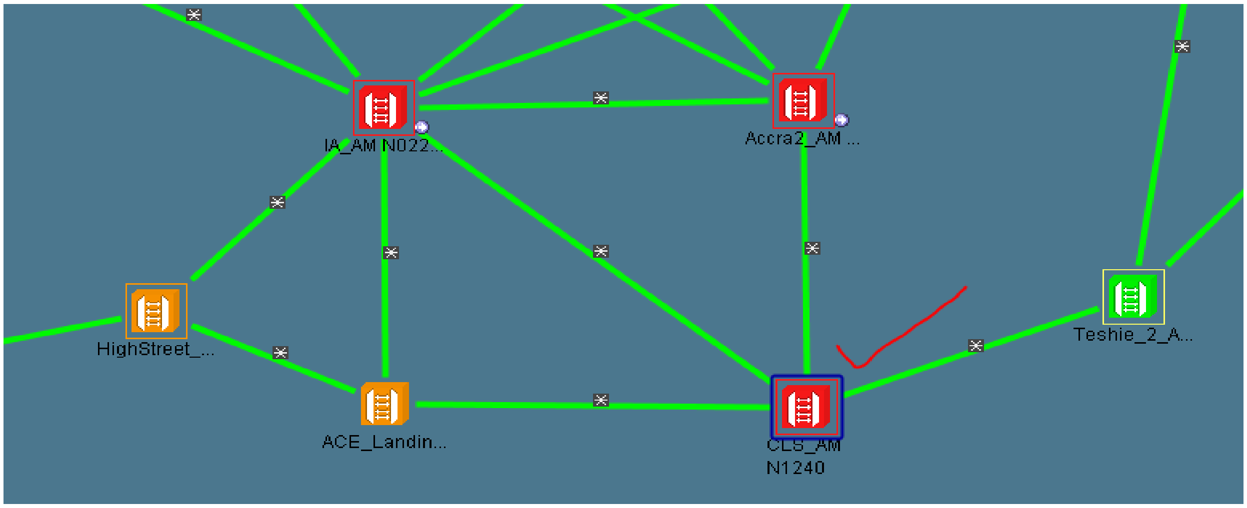

Figure 7: Frontier downstream fibre links from WACS cable landing in Ghana.

Furthermore, the fibre link between submarine cable landing station in Highbridge (LTE Highbridge) and Global Switch through Stratford in one path and through Goswell Road in alternative path to London (LTE London), as shown in Figure 8, constitutes the frontier downstream link in London, evaluated with respect to WACS submarine cable system.

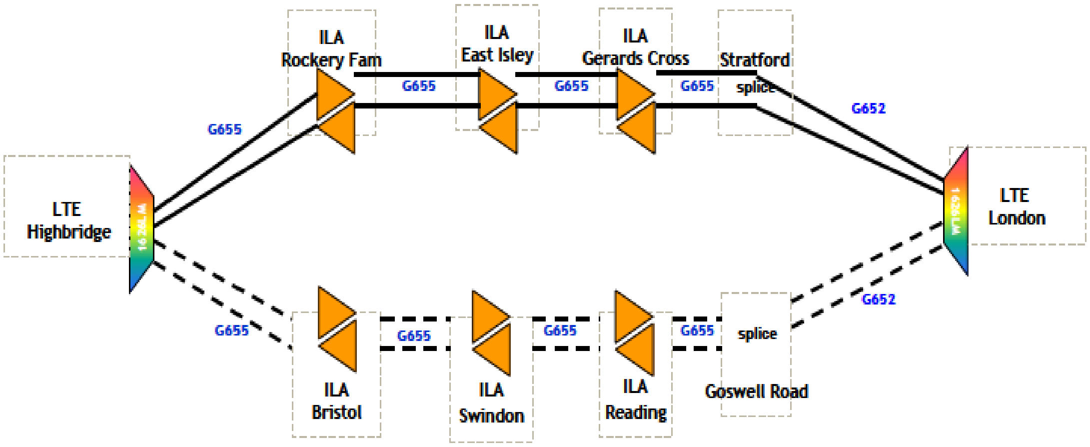

Figure 8: Frontier downstream links from WACS cable landing in Highbridge [1]

These links at the extremities of cable landing stations were investigated for impact analysis. The data obtained in the course of investigation was characterized and availability profiles of the links compared.

4. Results and Discussion

The results obtained from quantitative/statistical analysis of data for years 2017 and 2018 is presented in Tables 1 and 2 and illustrated in Figures 9 and 10 respectively. It is empirical that though frontier downstream links branches off from a common source being the WACS submarine cable to interconnect various domestic backbones in each of the countries accessed, availability profile is least in the Nigerian segment with a mean value of 96.80% for the last two years.

Table 1: Comparison of Frontier Downstream Link Availability, 2017

Month	Frontier Downstream Link Availability from Lekki-Lagos		Frontier Downstream Link Availability from Accra.		Frontier Downstream Link Availability from Highbridge	
	CLS_OADM to VGC_OADM	CLS_OADM to 21st Century	CLS_AM to ACE Landing	CLS_AM to IA_AM N022	LTE Highbridge to Stratford	LTE Highbridge to Goswell Rd.
Jan	97.61%	91.47%	100.00%	100.00%	99.98%	100.00%
Feb	100.00%	94.21%	100.00%	100.00%	100.00%	100.00%
March	95.52%	100.00%	100.00%	100.00%	100.00%	100.00%
April	100.00%	90.27%	100.00%	100.00%	100.00%	100.00%
May	100.00%	100.00%	100.00%	100.00%	99.96%	99.96%
June	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
July	96.66%	83.92%	100.00%	100.00%	100.00%	100.00%
August	89.20%	85.74%	100.00%	99.93%	99.99%	100.00%
Sept	98.55%	94.73%	90.14%	100.00%	100.00%	99.86%
Oct	97.38%	99.98%	100.00%	100.00%	100.00%	100.00%
Nov	98.25%	99.95%	100.00%	98.99%	99.99%	99.99%
Dec	92.63%	95.22%	100.00%	100.00%	100.00%	100.00%
Mean	97.15%	94.62%	99.18%	99.91%	99.99%	99.98%

Table 2: Comparison of Frontier Downstream Link Availability, 2018

Month	Frontier Downstream Link Availability from Lekki- Lagos.		Frontier Downstream Link Availability from Accra.		Frontier Downstream Link Availability from Highbridge.	
	CLS_OADM to VGC_OADM	CLS_OADM to 21st Century	CLS_AM to ACE Landing	CLS_AM to IA_AM N022	LTE Highbridge to Stratford	LTE Highbridge to Goswell Rd.
Jan	89.94%	96.06%	100.00%	100.00%	100.00%	84.32%
Feb	99.89%	99.99%	100.00%	100.00%	100.00%	100.00%
March	96.66%	99.91%	100.00%	100.00%	99.99%	100.00%
April	98.38%	89.25%	96.03%	100.00%	100.00%	100.00%
May	99.84%	100.00%	99.17%	100.00%	100.00%	100.00%
June	100.00%	94.35%	99.42%	99.98%	100.00%	100.00%

July	100.00%	96.44%	94.37%	99.97%	100.00%	99.99%
August	95.16%	94.97%	100%	100.00%	100.00%	100.00%
Sept	100.00%	100.00%	95.32%	100.00%	99.78%	100.00%
Oct	96.77%	98.56%	100.00%	99.98%	100.00%	100.00%
Nov	99.74%	99.99%	100.00%	100.00%	100.00%	100.00%
Dec	99.25%	100.00%	100.00%	99.99%	100.00%	100.00%
Mean	97.97%	97.46%	98.69%	99.99%	99.98%	98.69%

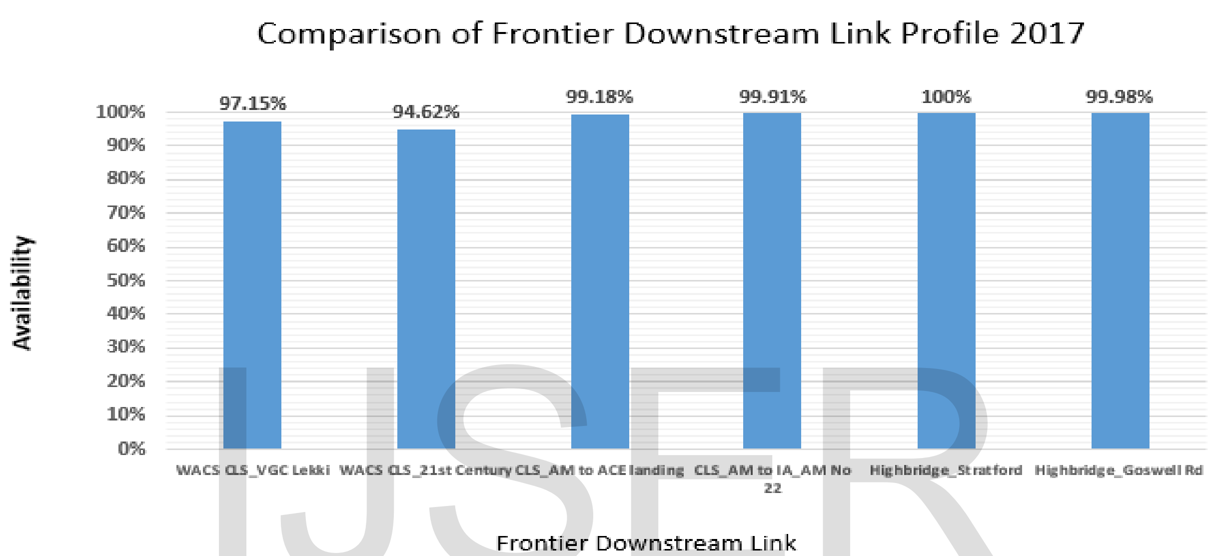

Figure 9: Frontier downstream link for 2017.

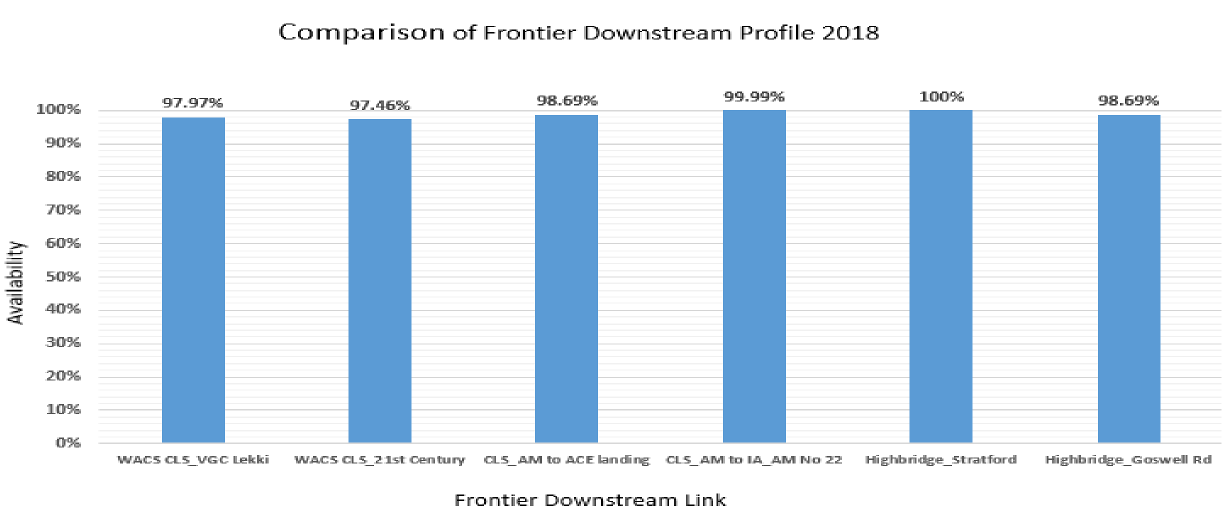

Figure 10: Frontier downstream link for 2018.

This observation prompted a drive further down the broadband supply chain to investigate what happens along the entire terrestrial backhaul in Nigeria relative to the network service provider under study, as it affects broadband QoE in the country. To this end, the downtime and rate of optic fibre link outages on metropolitan (metropolitan connection) and access network (local connection) for the network under research was investigated, quantified and analyzed for the same years as implemented for FDOL. The result so obtained is illustrated in Figures 11 and 12 respectively.

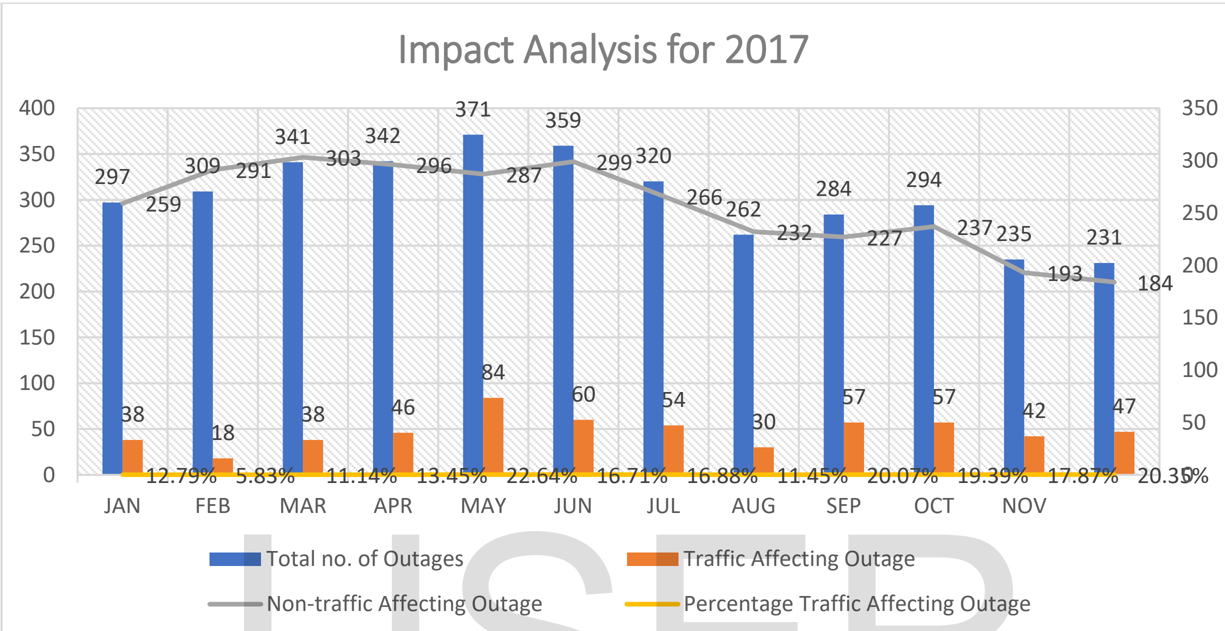

Figure 11: Rate of terrestrial fibre outage for 2017

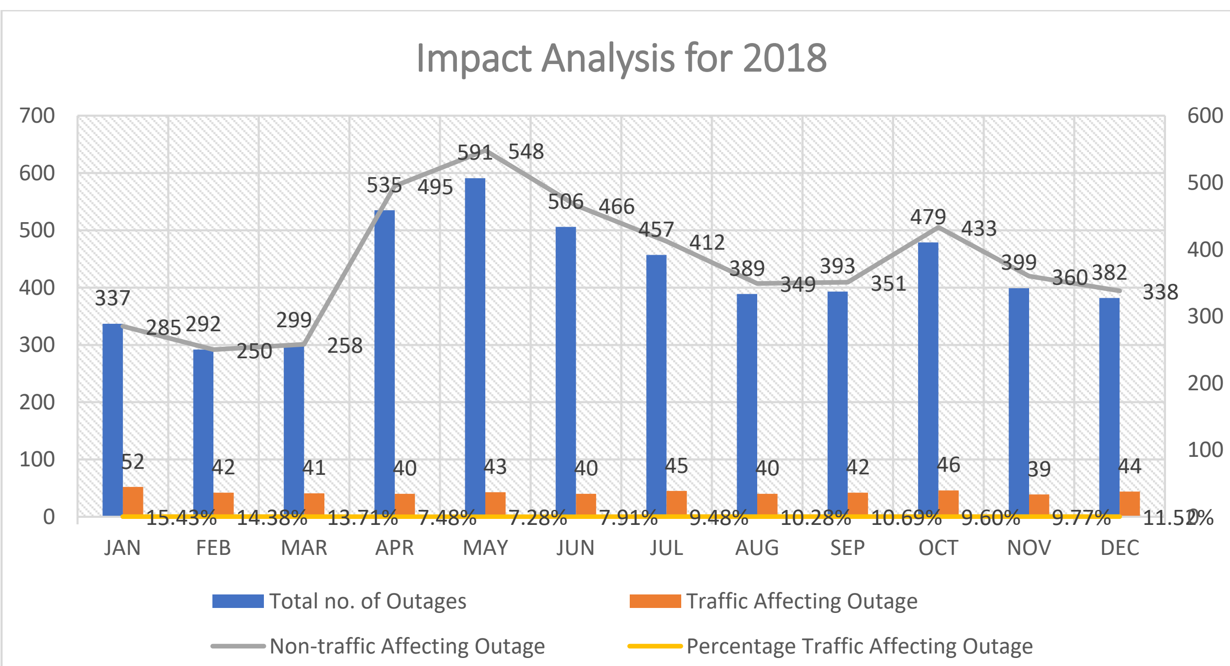

Figure 12: Rate of terrestrial fibre outage for 2018

We establish from the forgoing illustrations therefore, that percentage traffic affecting outages on the downstream segment and hence the entire terrestrial fibre backhaul is largely unstable in Nigeria.

5. Conclusion

The status of frontier downstream optic fibre link, FDOL, is a hint on the robustness or weakness of terrestrial optic fibre infrastructure in a country. The availability profile of frontier backhaul links from three countries and networks, with services from same submarine cable source was compared. Quantitative/statistical analysis show that the mean value of 96.80% is lowest within the Nigerian terrestrial links among the countries evaluated. The percentage traffic affecting outages on the terrestrial fibre backhaul in Nigeria is largely unstable and inconsistent. Therefore, frontier downstream optic fibre links between Submarine cable landing stations and Carrier's Point-of-Presence, PoP, need to be fortified for optimal availability as pointers to the stability of terrestrial optic fibre infrastructures in a country.

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