PROICT: STRENGTHENING THE CORE CAPABILITIES OF THE LIBERIAN TELECOMMUNICATIONS AUTHORITY (LTA)

OPTICAL FIBER CABLE (OFC) REPORT AND RECOMMENDATIONS

May 2021

This publication is made possible by the support of the American People through the United States Agency for International Development (USAID) and was prepared by Integra Government Services International LLC in partnership with Atlantic TM for the Digital Frontiers Project.

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Optical Fiber Cable (OFC) Report and Recommendations

Contract No. (Prime):	AID-OAA-A-17-00033
Subcontract No.	1003249-C-20-022
Submitted:	May 28, 2021
Prime Contractor:	DAI Global, LLC
Subcontractor:	Integra Government Services International LLC 1156 15th Street NW, Suite 800 Washington, D.C. 20005
Author:	Henry Benson and H Sama Nwana

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ACRONYMS

ACE	Africa Coast to Europe (submarine cable)
ACT	Telecommunications Act 2007
BSC	Base Station Controller
G2P	Government to People
IPTV	Internet Protocol Television
ISP	Internet Service Provider
ITU	International Telecommunication Union
LDC	Least Developed Countries
LEC	Liberia Electricity Corporation
LibTelCo	Liberian Internet eXchange Point
LIXP	Liberia Telecommunication Corporation
LTA	Liberia Telecommunications Authority
LWSC	Liberia Water & Sewer Corporation
MNO	Mobile Network Operator
MOE	Ministry of Education
MOF	Ministry of Finance
MOPT	Ministry of Communications and Information Technology
MSME	Micro, Small, and Medium Enterprise
NOFBI	National Optic Fiber Backbone Initiative
NERN	National Education and Research Network
OFC	Optical Fiber Cable
OEM	Original Equipment Manufacturer
OPGW	Optical Power Ground Wire
PABX	Private Automatic Branch Exchange

PPP	Public Private Partnership
QoS	Quality of Service
RNC	Radio Network Controller
RoW	Right of Ways
SSA	Sub-Saharan Africa
TRANSCO	Transmission Company Côte d'Ivoire, Liberia, Sierra Leone and Guinea
TVWS	Television Whitespace
USF	Universal Service Fund
VSAT	Very Small Aperture Terminal
WARCIP	West African Regional Communications Infrastructure Program
2G	Second Generation.
3G	Third Generation
4G	Fourth Generation

EXECUTIVE SUMMARY

Since Liberia landed its first Optical Fiber Cable (OFC) off the shore of Monrovia in 2011, the country has experienced immense growth and expansion in the Information and Communication Technology (ICT) sector. The rollout of optical fiber in Monrovia (the nation's capital) has expanded internet usage. Sadly, the lack of rollout of fiber in the rest of the country, outside Monrovia, has seen much less broadband internet usage.

Much work has been done to enhance several legal and regulatory frameworks geared at liberalizing the ICT sector—to create open access and promote competition and growth. Major stakeholders, such as Internet Service Providers (ISPs) and Mobile Network Operators (MNOs) are providing optical fiber connectivity to their respective customers in Monrovia. Under the revised technology neutral license regime issued by the LTA in 2015, MNOs are authorized to build their own optical fiber infrastructures.

However, as part of this study, it became clear that the absence of a more specific OFC policy and regulatory framework in Liberia is hampering the expansion of OFC-inspired broadband growth in Liberia, particularly outside of Monrovia.

To this end, as a part of the Government of Liberia's (GoL) partnership with the United States Agency for International Development (USAID) Digital Frontiers Project, Promoting American Approaches to Information and Communications Technology (ICT) Policy and Regulation (ProICT) Activity, a more specific policy and regulatory framework has been developed that is tailored towards providing a holistic and coordinated approach to implementing OFC deployment in Liberia. The proposed OFC approach and recommendations are based on OFC open competition with minimal obligations on OFC licensees during the period of the current Liberia ICT Policy (2019–2024).

Also included in this report are three brief annexes:

- Annex 1. References and Bibliography;
- Annex 2. A Brief Draft OFC Policy and Regulatory Framework for Liberia;
- Annex 3. Draft Technical Guidelines for Trenched and Aerial Fiber in Liberia

It is recommended that the LTA quickly consult these two draft annexes and implement them via an official order. In the interim, both draft annexes may accompany any new OFC licenses issued by the LTA.

1. INTRODUCTION

Under the United States Agency for International Development (USAID) Digital Frontiers Project, DAI Global subcontracted Integra Government Services International LLC (Integra) in partnership with Atlantic-TM Cameroon to implement the Promoting American Approaches to Information and Communications Technology (ICT) Policy and Regulation (ProICT) Activity and provide consultancy services towards strengthening the core capabilities of the Liberian Telecommunications Authority (LTA). The primary purpose of the engagement is to strengthen the core capabilities of the LTA with regulatory and technical expertise in areas the LTA identified in consultation with USAID and subsequent conversations with the technical team.

ProICT Liberia consists of the following six workstreams:

1. Modernizing the regulations governing the deployment of fiber optic cables.

2. Developing regulatory standards for television whitespace (TVWS) and related rural access technologies.

3. Assisting the LTA's administration to develop, optimize, and implement strategies for the Liberian Universal Access Fund (UAF).

4. Providing advisory and technical assistance to the LTA to help strengthen its role in transitioning the Liberian Internet eXchange Point (LIXP) to an independent and sustainable management structure.

5. Strengthening the Network Type Approval regime at the LTA.

6. Assisting with the reorganization of Liberia's FM radio spectrum to allow for the highest and best use of these critical radio frequencies.

PURPOSE OF THIS LIBERIA OFC MODERNIZATION REGULATIONS REPORT

This report specifically concerns the first workstream highlighted above (i.e., modernizing regulations governing the deployment of fiber optic cables in Liberia). The purpose of this Liberia OFC Modernization Regulations Report is three-fold:

1. To review the current state of the rollout of Optical Fiber Cables (OFC) in Liberia, i.e. availability, as of May 2021, both dug in (*trenched*) OFCs by telecoms operators or overhead *aerial* OFCs by entities such as the Liberia Electricity Company (LEC);

2. To strengths, weaknesses, opportunities, and threats (SWOT) review OFC rollouts in Liberia to identify ways to improve its Governance, operations, and most importantly, new proposed OFC regulations in Liberia; and

3. To assist and strengthen the LTA on a new proposed draft OFC framework, recommendations, and regulations to assist in driving both competition and optimal widespread coverage of the

fiber backbone across Liberia, as well as maximizing the use of the Africa Coast to Europe (ACE) submarine cable.

This report also provides the basis for an advocacy effort of the relevant Liberian stakeholders including the LTA and several other Government stakeholders on OFC rollout in Liberia.

OFC MODERNIZATION REPORT STRUCTURE

The structure of this OFC Modernization Report (excluding the Executive Summary) is as follows:

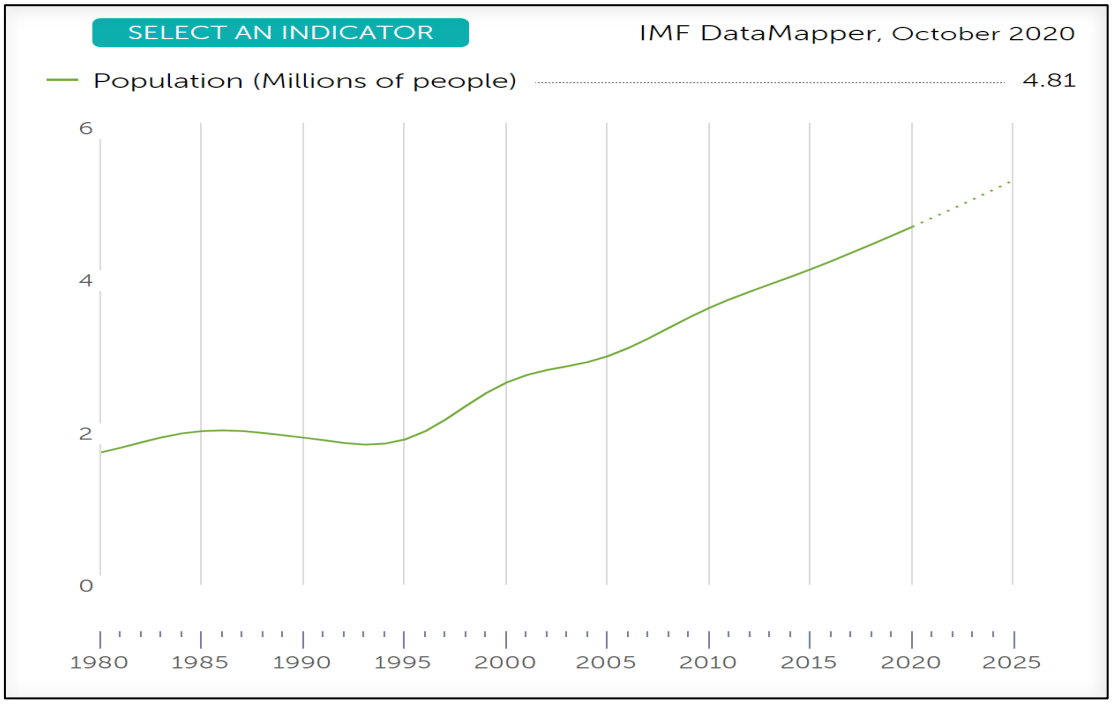
- Section 1: Introduction (this section) outlines the purpose and structure of this report;
- Section 2: Broadband Connectivity in Liberia briefly describes the current state of broadband connectivity in Liberia;
- Section 3: Current State of OFC Roll Out in Liberia maps both the OFC players as well as both dug in OFCs by telecoms operators and overhead OFCs by entities such as the Liberia Electricity Company (LEC);
- Section 4: OFC SWOT Analysis maps various aspects of the Liberian OFC scene using the strategic assessment tool "Strength, Weakness, Opportunities, and Threats Matrix" to identify ways to improve OFC governance, operations, and most importantly, new proposed OFC regulations in Liberia;
- Section 5: OFC Recommendations provides draft OFC recommendations based on the situational analysis, strategic assessment, and international best practices; and
- Key Annexes present: 1) References, 2) A brief draft OFC policy and regulatory framework for Liberia, and 3) Draft technical guidelines for trenched and aerial fiber in Liberia.

2. BROADBAND CONNECTIVITY IN LIBERIA

LIBERIA BACKGROUND: GEOGRAPHY AND DEMOGRAPHICS

Located on the West Coast of Africa, Liberia spans approximately 45,000 square miles of land. The country has land boundaries with Guinea in the North, Sierra Leone in the West, on the East by the Ivory Coast, and South by the Atlantic Ocean. As of the last census commissioned in 2008, Liberia's population has increased dramatically. Based on a series of accounts from notable international organizations, Liberia's population is estimated to be 4.8 million as of 2020. (IMF, 2020)[1]

Figure 1. Liberia's Population Growth Over Time (1980 - 2020)



Source: https://www.imf.org/en/countries/LBR

POLITICAL, ECONOMIC LANDSCAPE

Liberia will need to improve its business environment to progress toward greater economic freedom. The country is gradually, but steadily, recovering from decades of civil conflict, which cyclically devastated its economy. Liberia has untapped natural resources but is still considered a poor nation. In fact, per the World Bank's World Development Indicators Database, Liberia ranks as the sixth poorest country in the world, with a gross national income per capita of $1,226 in 2020.[2] The impact of the

[1] There is conflicting information on Liberia's population because there is no official estimate from the Liberian government.

[2] "GNI per Capita, PPP (Constant 2017 International $)." 2019. World Bank. https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.KD?most_recent_value_desc=false.

COVID-19 pandemic is an added stress on the already afflicted Liberian economy, which was plagued by the Ebola Virus Disease (EVD) crisis between 2014 and 2016. The country has lost significant revenues as a result of private investment closures and the withdrawal of United Nations Peacekeeping.

Notwithstanding, the country's mining, agriculture, and ICT sectors have the potential to contribute to the revamping of the economy. With its focus on private sector-led growth, Liberia has a liberalized economy that is transitioning from a centrally planned and heavily regulated economy towards an open and free economy based on the market system.

DEFINING BROADBAND FOR LIBERIA

The traditional definition of broadband for the Least Developed Countries (LDCs) takes into consideration high-speed data transfer of approximately 256 Kbit/s (Nwana, 2014 pp. 306). In today's (2021) post-Covid-19 environment, this definition no longer holds. Rather, it is generally considered as a connection to the internet through a high-speed transmission link, which is determined by individual country specifications. There is no cohesive definition for broadband. Because it is fast, resilient, and considered a stimulant to economic growth, broadband has become one of the significant innovations in today's age, like the invention of electricity during the industrial age. It has a significant transformative effect on how people live and work and empowers an individual user with previously unimaginable capabilities and global reach. The internet, through high-speed broadband, accounts for the world's largest library and repository of information and knowledge.

Figure 2. ACE Cable Landing in Monrovia (2011)

Image Source: phy.org

The International Telecommunication Union (ITU) estimates that affordable and ubiquitous broadband will be critical to economic growth in the 21st century, as it will significantly impact all sectors including education, health, power, and agriculture. For Liberia, effectively deploying and disseminating optical fiber, and by extension, broadband is expected to be a catalyst for job creation and global competitiveness and has the potential to transform the lives of ordinary Liberians.

LIBERIA'S BROADBAND BENCHMARKING

There has been immense capital investment in broadband infrastructure in Liberia in the past decade, which has culminated in significantly more access compared to the civil war era. The infusion of capital investments on the part of the private sectors (mainly the mobile operators), along with the regulatory frameworks that are in place, has contributed to driving these impactful trends. According to the Global News Network[3], a pan-African news platform, Liberia is ranked seventh in Africa for the highest internet speeds.

While this information seems encouraging, Liberia unfortunately remains significantly low globally on broadband speed. This statistic further underscores the need to give strategic importance to developing broadband infrastructures if Liberia truly intends to use the ICT sector to grow its economy.

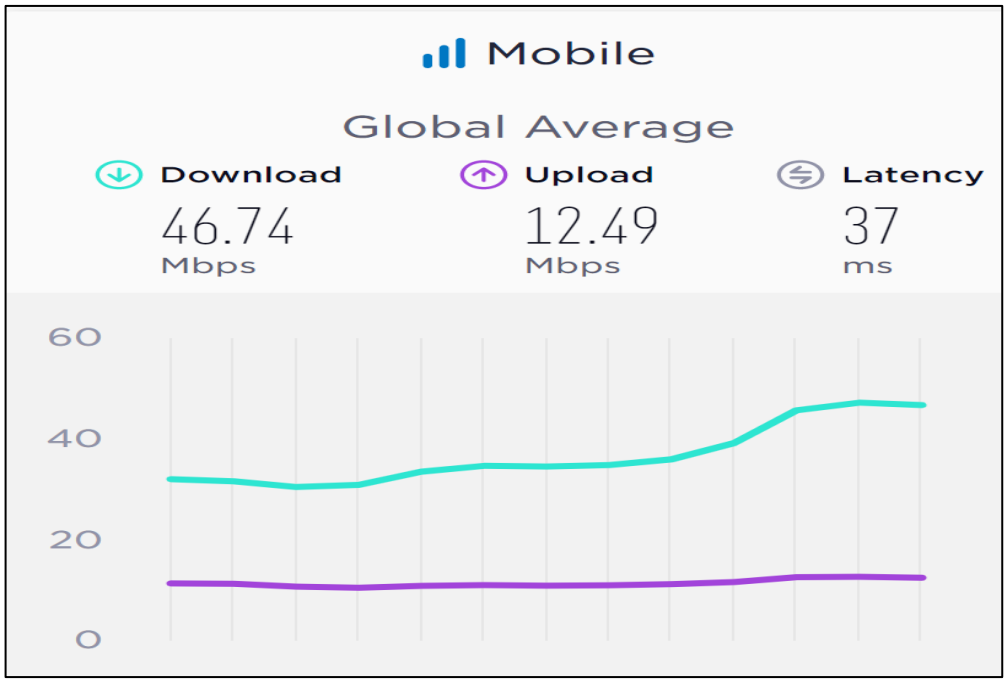
TABLE 1. GLOBAL RANKINGS OF MEDIAN DOWNLOAD SPEEDS 2020

RANK	COUNTRY	DOWNLOAD SPEED (MBPS)	UPLOAD SPEED (MBPS)	# DOWNLOAD TESTS	# UPLOAD TESTS	NO. IPS
1	Liechtenstein	199.28	39.78	96	98	10
2	Hong Kong	112.32	91.40	4,782	5589	933
3	Denmark	107.78	66.02	21,495	22217	912
95	Myanmar	4.40	5.22	1,196	1537	987
96	Belarus	4.37	2.70	1,340	1628	827
97	St. Kitts and Nevis	4.36	1.21	95	73	22
98	Liberia	4.23	2.70	18	30	10
99	India	4.09	2.69	41,4725	399945	227,100
100	Guatemala	3.78	1.76	8,885	9766	2,799
101	South Africa	3.70	2.27	40,879	39240	16,373

Source: Internet Speeds by Country - Fastest Internet In The World Map (fastmetrics.com)

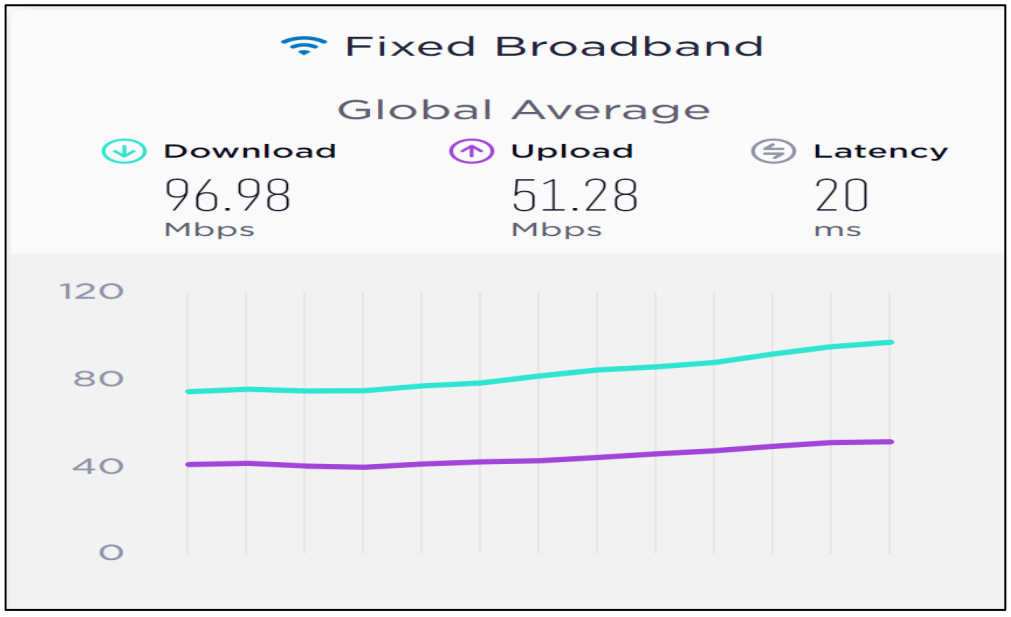
[3] Global News Network Liberia. https://www.gnnliberia.com.

Figure 3. Average Mobile Broadband Speed Test for January 2021



Source of Data: www.speedtest.net/global[4]

Figure 4. Average Fixed Broadband Speed Test for January 2021

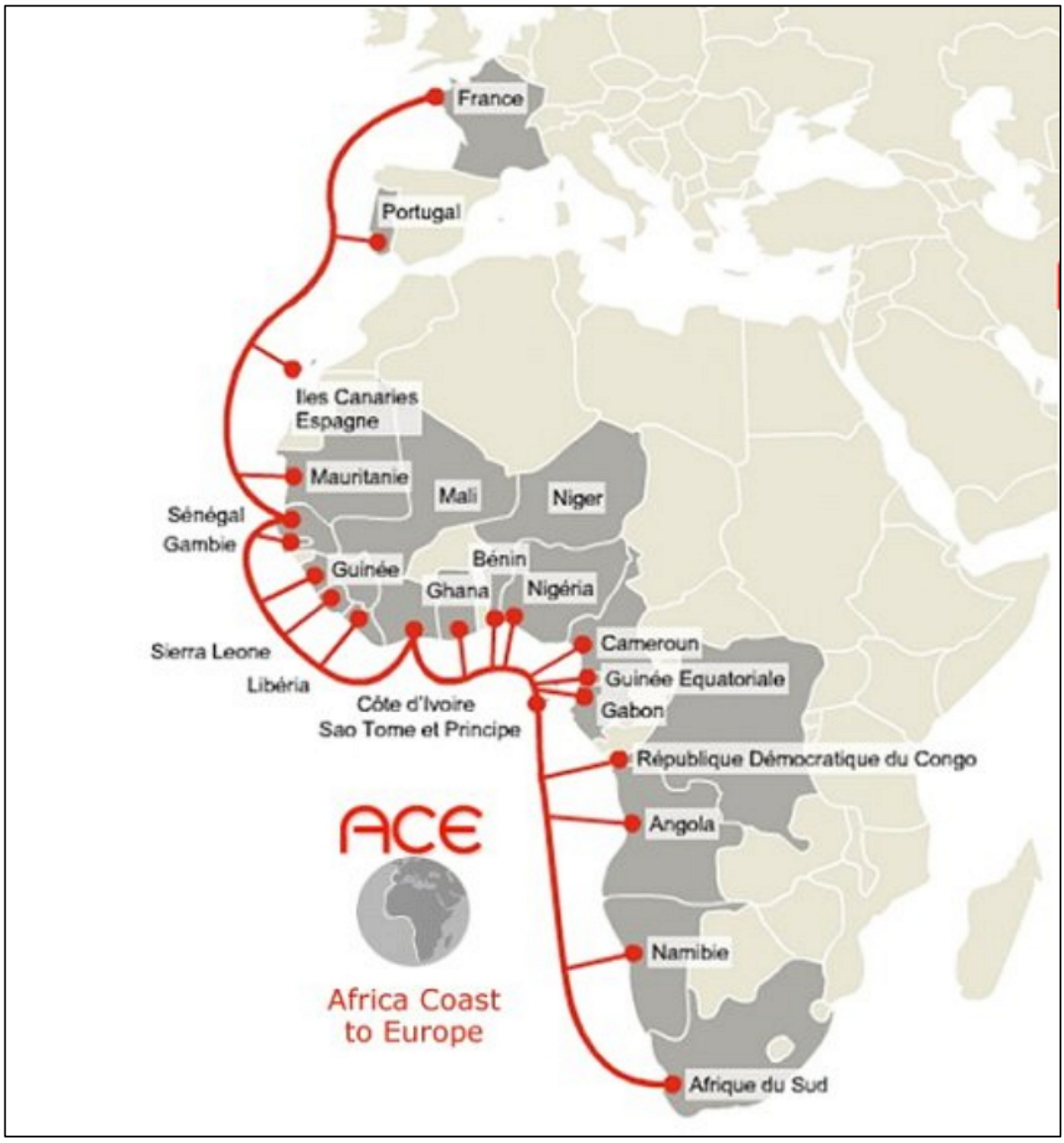


Source of Data: www.speedtest.net/global[5]

[4] Figures 1 was accessed on October 13, 2020 from speedtest.com, which is a reputable online speed measurement portal of all ISPs in Liberia. The data reflect mobile measurements for August 2020.

3. DEFINITIONS AND CURRENT STATE OF OFC ROLL OUT IN LIBERIA

Figure 5. ACE Cable Map



Source: Systems - Submarine Networks

[5] Figure 2 was accessed on October 13, 2020 from speedtest.com, which is a reputable online speed measurement portal of all ISPs in Liberia. The data reflect fixed Broadband measurements for August 2020.

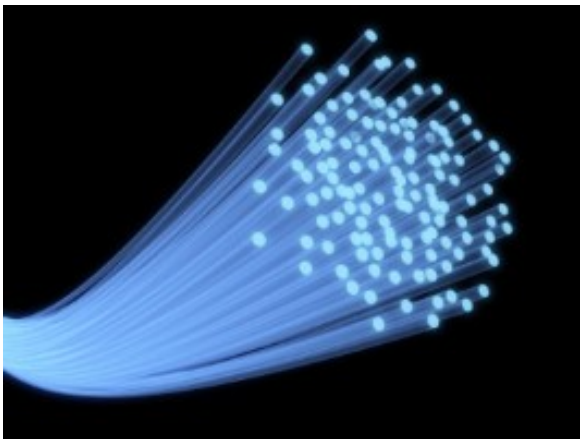
3.1 OFC DEFINITION AND TYPES OF OFC INSTALLATIONS

Optical fibers transmit data at very high speeds. Therefore, it is the *de facto* technology of choice used for internet cables in preference to traditional copper wires (which they are replacing) that are bulkier, heavier, less flexible, and carry less data.

FIBERS, CABLES, AND INDIVIDUAL FIBER

A cable that transmits data through transparent fibers (or threads) or plastic silica (glass) of a diameter just thicker than a human hair is called an OFC. Optical fibers transmit light between the two ends of the fiber over long distances. They are used to transmit digitally modulated messages over light waves along the fiber. OFCs are better than metal wires because they are immune to electromagnetic interference and so the light signals across the fibers suffer very little loss. The main disadvantages are OFC cables are that they are more delicate, expensive to install, and tricky to fix together (e.g., after cuts). Figure 6 shows a typical fiber with dozens of glass fibers.

Figure 6. Typical Fiber (with 144 or 228 individual fibers in tubes of 8 fibers per cable)



Optical fiber cable is typically installed into an underground duct network at lengths of around 2Km. The 2Km lengths of cable are joined together in joint enclosures housed in underground chambers. The joint enclosures provide a watertight environment for managing individual fibers within the cable. The individual fibers are fusion spliced to minimize loss.

The underground duct is typically 100mm in diameter and telecoms operators often install 4 *sub-ducts* into each main duct. Each sub-duct can contain one fiber optic cable.

Each fiber optic cable will contain many individual fibers, with typical fiber counts of 144 or 288 individual fibers. Fibers are color coded and typically housed in a tube of eight fibers within the cable. A cable with 144 individual fibers will contain 18 such tubes. The cable has a strong inner core, which is used for pulling the cable into the sub-duct.

TYPES OF OFC INSTALLATIONS

Fiber backbone OFCs are typically installed either by *Direct Burial or Trenching*. This involves digging a hole, placing the cable in it, and then refilling the hole. OFCs are also installed *Aerially*, above the ground and in the air. Although aerial OFC runs can be affected by wind, ice, and other environmental factors.

More backbone OFCs in countries like Liberia would be done through direct burial or trenching.

OFC INSTALLATION (FIBER OPTIC JOINTS, DUCTS, AND SUB-DUCTS)

Telecommunications operators will ideally install more than *one duct on a trunk route*, although they may install two, four, six, or eight at a time. A four-duct system, which has sub-ducts, will have the capacity for 16 cables and each cable may contain 288 fibers. This provides for additional capacity, maintenance, and a means of adding distribution cables if required.

The underground duct is laid in a trench at a depth that is dependent on the environment. When installed on a highway, the depth to the top of the uppermost duct is typically 1200mm for Liberia. This may be reduced to 600mm if installed in a footpath. The duct will be more secure at a deeper depth, but the cost will increase. When installed in a highway for example, the designers will consider the potential damage by heavy vehicles and often specify this minimum depth. A footpath will have lighter traffic and so the duct can be installed at a lower depth. There is a trade-off between depth and cost and this is considered in the design of the fiber route.

Figure 7. Mechanical Trenching Machine Laying Down Fiber

Source: www.foa.org

The fiber optic duct will have underground chambers installed at intervals of approximately 500m, or sometimes less if the route has bends or access is required. The chambers at 500m intervals are necessary to pull the cable into the sub-duct, chambers at 2Km will house the fiber optic cable joints. The chambers and lids need to be of a solid construction. Chambers in the highway may have metal lids, while chambers in a footway may have concrete lids. Secondary locking lids may be installed for security purposes.

All ducts and sub-ducts will be installed with pulling rope (to pull in the cables) and at each chamber, the ducts will be capped or finished with a gland to prevent rodent ingress, water ingress, or noxious fumes traveling through the plant. Attention to the construction of chambers will prevent damage to the cable.

The duct is laid in an excavated trench that may be dug by hand or by using a mechanical trenching machine or mechanized digger. This will depend on the environment and the other services that may be near the trench. Digging close to power cables or gas pipes must be done with particular care. When crossing bridges or culverts, a plastic duct may be substituted for a metal duct, which may, for example, be attached to the bridge structure.

The duct is not commonly laid directly into the trench, but rather the duct is laid on a filler such as sand or grit so that the ducts do not touch each other or the sides of the trench. The spoil, if suitable, may be used for reinstatement of the trench, and the road or footway surface reinstated to the appropriate specification.

When designing a fiber optic route, using a grass verge to the side of the road is often preferred due to the reduced costs of reinstatement.

Some operators also install plastic tape above the duct with details about the duct and the owner. Any future civil works above the duct should see the tape before accidentally cutting through the duct. In areas where this is deemed a high risk, the duct may be covered with fiberboard, or in extreme cases a metal board.

It may not always be possible to lay duct into a trench. The case of culverts or bridges has been mentioned, however other obstacles may exist such as railway lines or canals. In such cases, it is often better to use an existing crossing, such as a bridge, but this may not always be possible. Where this is not possible, other techniques may be employed such as the use of a robotic mole to drive a duct from one side of a railway line to another. These specialized installation methods are not considered in this document.

OFC INSTALLATION CONSIDERATIONS

The long-term performance of any fiber optic system can be attributed to four key aspects.

1. Specification and design of the system and installation.
2. Quality of the materials.
3. Quality of the installation.
4. Operation and maintenance of the system.

If not appropriately managed, the typical short- and long-term issues may include:

- Ducts or chambers collapsing;
- Road surface deterioration;
- Blockages in the duct or sub-duct;
- Poor access to joints (putting a splicing chamber in the middle of a busy road junction);

- Repeated breaks caused by other civil contractors;
- Water, chemicals, or rodent ingress causing damage to the plant;
- High optical attenuation of the fibers;
- Difficulty splicing due to physical parameters; and
- Poor chromatic dispersion or high polarization mode distortion.

The specification and design of the system and installation can greatly influence the cost and long-term performance. The specification should cover all aspects of the cable, duct, chambers, and reinstatement and the design will cover the physical route, chamber location, joint locations, and etc.

The quality of the materials needs to be checked both in advance of and post installation. This may typically include factory tests of the fiber optic cables, joint enclosures, ducts, and sub-ducts. These tests may include factory testing of the optical performance of the fiber, physical fiber dimensions, and load testing of ducts and sub-ducts.

During installation, the quality of reinstatement materials may be tested (i.e., size and water content of fill), use of break fuses when installing cable, quality of the concrete mix, and etc.

Most telecommunications operators will employ civil inspectors who ensure that the civil specifications are adhered to in the physical plant installation. They will also check that traffic management, health, and safety considerations are managed by the contractor.

It is recommended to undertake independent testing of fiber optic attenuation, return loss across fiber splices, polarization mode distortion, and chromatic dispersion. During fiber cable splicing, the correct fiber management and use of glands, maintenance loops, and etc. in fiber enclosures are often checked.

Other aspects to consider are highway restrictions, all aspects of health and safety, environmental considerations, commissioning and handover, long-term maintenance, inspection, and security.

Documentation of the fiber route is typically provided electronically using detailed Geographical Information Systems (GIS). Accurate mapping of the underground plant is essential for future maintenance and may also be a legal requirement.

The client may provide the interface for gaining all necessary permits and permissions to build the infrastructure and liaise with other utilities to avoid damage to other plants.

The fiber optic cable will ultimately terminate in a building. Access to the building will often be through building access chambers and ducts into the lower floor or basement. The cable entry points must be adequately sealed, and it may be necessary to transition from exterior cable to internal cable (low smoke halogen free). The internal cable is then terminated on an optical distribution frame (which may or may not be supplied by the contractor). Construction of these chambers and any building access must be completed with attention to the building construction such that no damage or weakness is introduced.

3.2 CURRENT OFC PLAYERS AND OFC LANDSCAPE IN LIBERIA

There are several prominent key players in the Liberian OFC landscape, rolling out fiber in an arguably uncoordinated fashion. The recommendations provided could help coordinate the OFC sector in Liberia.

The broadband landscape in Liberia is being transformed by the deployment of wireless networks—predominantly 3G. The public and private sectors have infused significant funding in optical fiber deployment in the country. Government and private sector investments to land the ACE cable in Liberia is indicative of such funding.[6] With such enormous broadband infrastructure, OFC infrastructures such as last-mile and fiber to the home (FTTH) are now harnessing and improving the livelihoods of ordinary Liberian residents. There are currently two mobile networks in country (listed below) providing broadband service (including 3G, and 4G).

AFRICA COAST TO EUROPE (ACE) SUBMARINE CABLE

The ACE cable was launched in 2011 to provide the much-needed international connectivity to the telecom sector. The Sub Marine Cable Network, a fiber optic network report group asserts that:

> "The Africa Coast to Europe (ACE) submarine cable spans 12,000 km along the west coast of Africa, connecting 18 countries including France, Portugal, the Canary Islands (Spain), Mauritania, Senegal, Gambia, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Benin, Ghana, Nigeria, Equatorial Guinea, Gabon, São Tomé and Príncipe, Mali, and Niger (ACE Phase I). Seven of these African countries—The Gambia, Guinea, Equatorial Guinea, Liberia, Mauritania, Sao Tomé & Principe, and Sierra Leone—benefit for the first time from a direct connection to a submarine cable. Two landlocked countries, Mali and Niger, connect to the ACE cable system through terrestrial network extensions. The ACE Phase II will add 5000 km cable connecting Cameroon, Namibia, Angola, the Democratic Republic of Congo, Congo-Brazzaville, and South Africa. The ACE consortium comprises France Telecom/Orange, together with its subsidiaries Côte d'Ivoire Telecom, Orange Cameroon, Orange Mali, Orange Niger, and Sonatel, have combined forces with other major partners to form an international consortium" (Sub Marine Cable Network, 2020).

Currently, ACE is the only optical fiber cable with a presence in Liberia. With a 25 million dollar loan from the World Bank, the GoL formally commissioned the ACE fiber optic cable in 2011. The exploitation of ACE is largely concentrated in the capital city of Monrovia and underutilized[7] at approximately 20-25 percent capacity usage.

LIBERIAN OFC NATIONAL BACKBONE

The ACE cable was launched in 2011 to provide the much-needed international connectivity to the rest of the globe. However, it needs a fully developed Liberian OFC backbone to maximize the exploitation

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[6] Approximately 25 million USD was borrowed from the World Bank by the Liberian Government to land the ACE Cable in Liberia.

[7] Information gathered from Mr. Daniel Brewer, Former CCL Station Manager.

of the ACE International submarine cable. Today (as of May 2021), there is no wide scale national backbone to further deploy the fiber in rural parts of the country. Notwithstanding, the Government is holding separate talks with Huawei, the Chinese telecom giant, and CSquared, a fiber wholesale provider in Liberia to build the backbone network. The GoL has also recently designated LibTelCo as the "national telecom operator" and given overall responsibility for building the OFC backbone in Liberia.

Liberia does not have a national fiber backbone network. Vast segments of the country are still underserved—depending only on 2G Edge and general packet radio service (GPRS) as the primary sources for data connectivity. In places with relatively low optical fiber presence, bandwidth capacities are usually backhauled via microwave, very small aperture terminal (VSAT), or some other wireless means.

CABLE CONSORTIUM OF LIBERIA (CCL)

The CCL, as the administrator of the ACE cable, has a 100 percent control of Liberia's international bandwidth traffic with its members, MTN, Orange, and LibTelCo each holding 15, 10, and 20 percent respectively, and the Government of Liberia has a 35 percent holding of shares. The CCL manages the operations of the ACE cable.

CSQUARED

CSquared has been a telecommunications (optical fiber) wholesale provider in Liberia since 2017. In partnership with the Government of Liberia and USAID, CSquared owns a metro fiber link in Monrovia and provides services to the Government of Liberia, mobile network operators, and other private businesses.

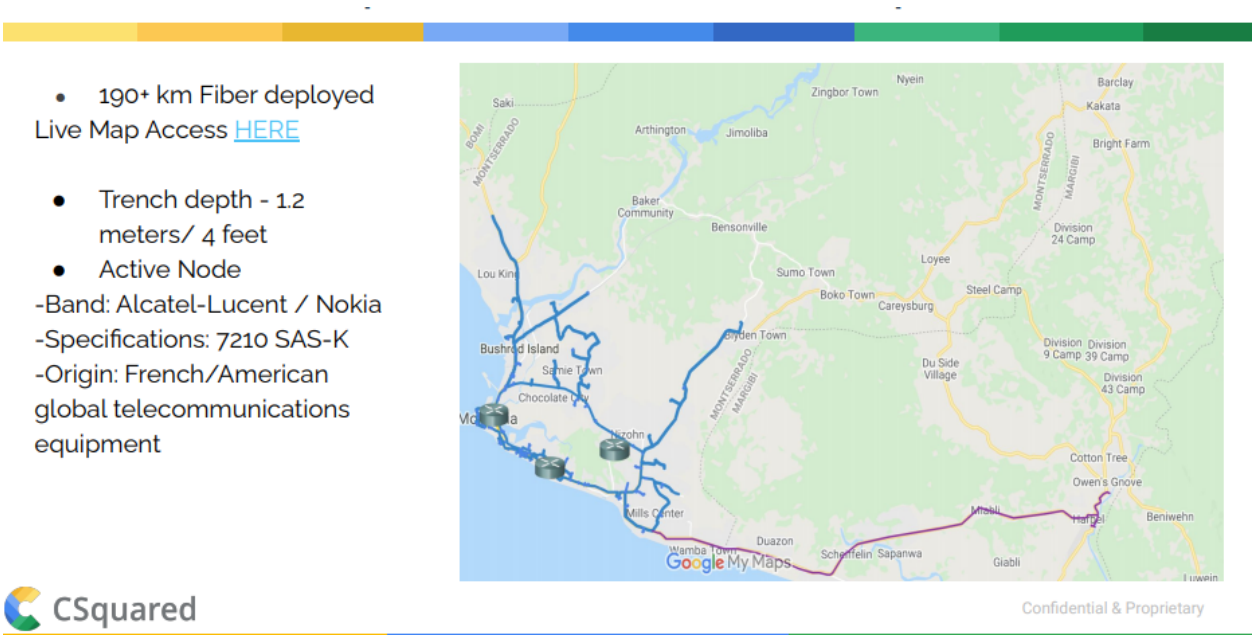
Notably, the CSquared metro fiber link provides connectivity to the University of Liberia campus in Fendell, Montserrado County—approximately 20 miles from Monrovia, the capital of Liberia.

Figure 8. Fiber Rollout in Liberia

Source of Image: Csquared.com

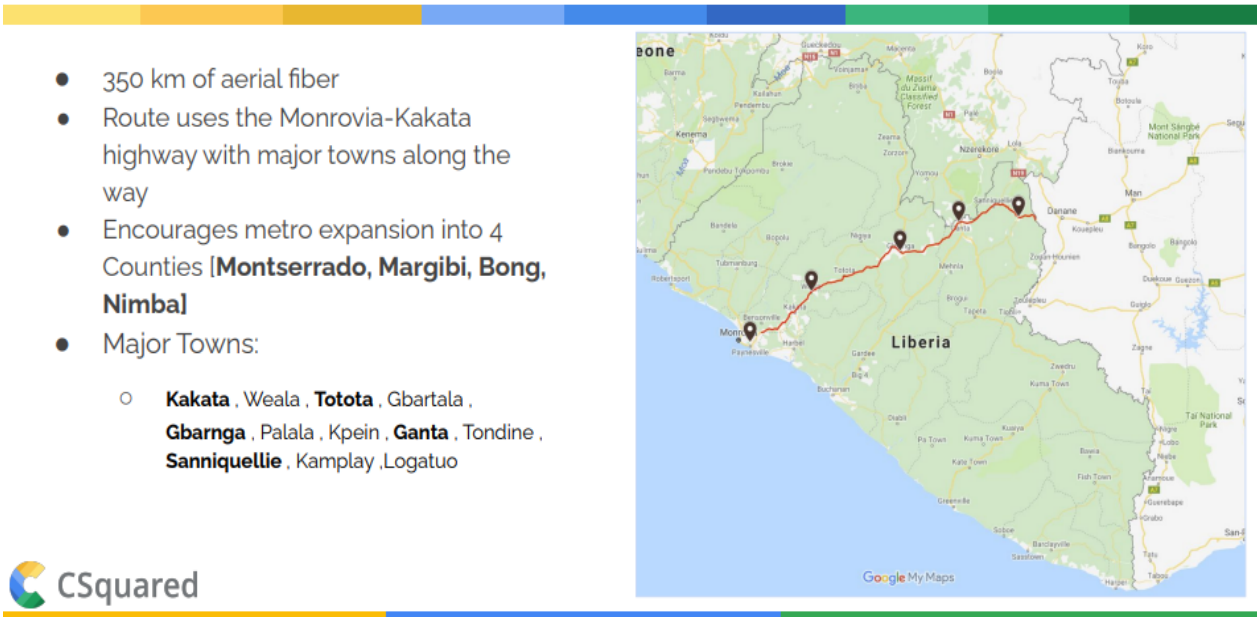
Figure 9 shows CSquared's current footprint in Liberia, mostly in Montserrado County, while Figure 10 depicts the CSquared Phase 1 national expansion from Monrovia all the way to Guinea and to the Cote d'Ivoire border.

Figure 9. CSquared's Current Liberia Footprint (as of May 2021)



Source: CSquared

Figure 10. CSquared's Proposed Expansion Footprint



Source: CSquared

LIBTELCO

LibTelCo was set up in 1973 by the first Liberia Telecommunications Corporation Act, initially both as an operator and regulator. The GoL went on to introduce competition in the mobile market in 2001. The company rolled out and launched voice and data services over a CDMA 2000 wireless network, but decommissioned it in 2014, focusing afterward on a fiber-based ISP role, predominantly in Monrovia. As a result of the GoL's decision to support creating CSquared, a Google majority-owned company tasked with creating a state-of-the-art fiber optic network around Monrovia, LibTelCo also lost the primacy in fiber connectivity.

LibTelCo operates mostly in Monrovia, a 25Km fiber optic network. LibTelco also appears to be cooperating with CSquared and leveraging its new fiber optic rings around Monrovia, especially to provide redundancy to its customers.

The LibTelCo 2019 Annual Report[8] suggests the overall company priority continues to be providing fiber-based internet access services to the Government and other large institutions and private clients. LibTelCo also claims to be preparing to launch new services, including internet protocol television (IPTV), Data Center, Private Automatic Branch Exchange (PABX), LTE-based wireless internet access, and other services. LibTelCo has already initiated cooperation with the LEC to utilize its fiber infrastructure. Indeed, LibTelCo has already started to cooperate with LEC to use its Optical Power Ground Wire (OPGW) fiber.

ORANGE

Formerly Cellcom Liberia, Orange Liberia (Orange) continues to capture a significant portion of the data market in Liberia since its inception into market in 2017. As of 2019, Orange Liberia had approximately 58.09 percent of the data market in Liberia.

Orange is a member of the CCL with ten percent of shareholding and a strong fiber optic presence in Monrovia. Other than leasing the capacity of the CSquared fiber infrastructure, Orange is deploying fiber into rural parts of Liberia. The company embarked on deploying fiber to Grand Bassa (a major seaport city) and has since deployed approximately 200km of *aerial fiber* on the route from Monrovia to Grand Bassa County.

MTN/LONESTAR

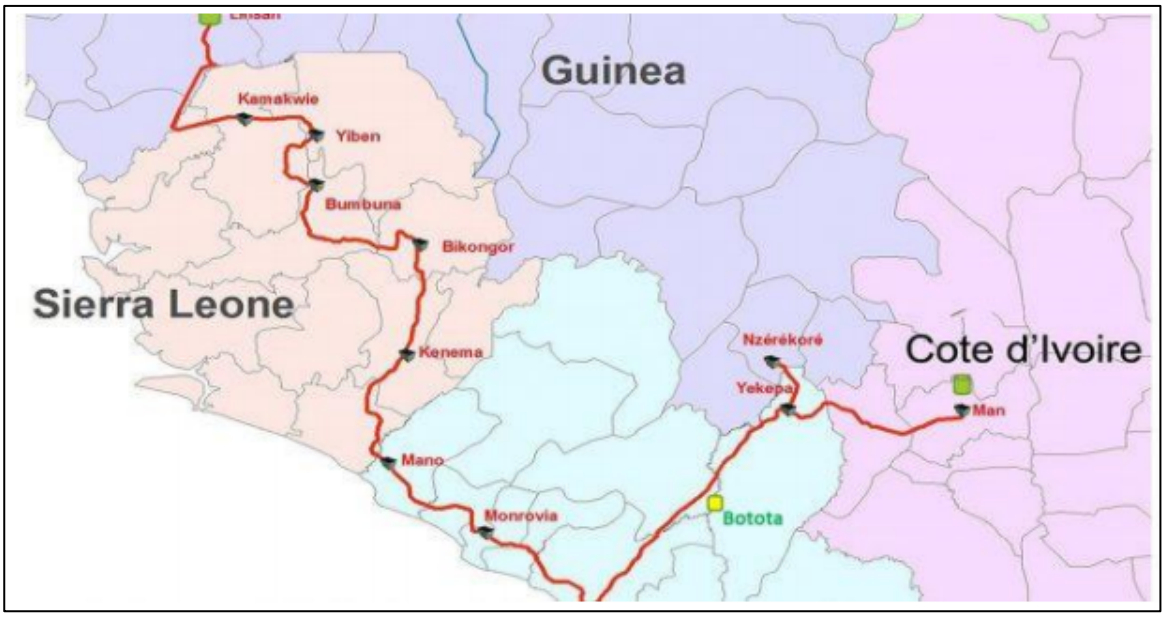
MTN Liberia is a member of the CCL with ten percent shareholding. MTN acquired Novafone—one of three GSM operators in Liberia and a five percent shareholder in the CCL. Information to date suggests that the company has limited fiber rollout, mainly in Monrovia between the CCL's downtown Monrovia headquarters and the Conga Town district.

TRANSCO

[88] LibTelCo. 2019. "2018–2019 Annual Report." Annual Report. Monrovia, Liberia.

TRANSCO (TRANSmission Company Côte d'Ivoire, Liberia, Sierra Leone, and Guinea) was set up by an international treaty between these respective governments in 2012, the LEC (Liberian Electricity Corporation) and LibTelCo.

Figure 11. TRANSCO Planned Route as Envisioned in 2012



Source of Image[9]: Loda & Cameron (2019)

The agreement entered as far back as 2012, proposed that TRANSCO and LEC would complete the rolling out over 700km of OPGW infrastructure in Liberia by mid-2020. Both companies at the time agreed to allow up to 75 percent use of the fibers for telecommunications purposes. The GoL is a shareholder in both companies and can transfer some of such rights to other GoL State companies, like LibTelCo.

This study concluded that TRANSCO—although not overwhelming per its 2012 projection of 700km of OPGW of fiber to be conclude by mid 2020, TRANSCO has made some strides in that direction. A briefing[10] by TRANSCO in 2019 laments the following: "TRANSCO CLSG is a Special Purpose Company established through an international Treaty between the four countries to finance, construct, operate, maintain, own and develop the said power transmission line network. TRANSCO CLSG is owned by the four founding countries. The CLSG network stretches 530Km in Liberia, including 48 OPGW (Optical Power Ground Wire) fiber cores. The project is about 60 percent complete and will be finished by March 2020.

[9] Global Infrastructure Hub. 2019. "Côte d'Ivoire Côte d'Ivoire-Liberia-Sierra Leone-Guinea (CLSG) Interconnector Project Overview." Sydney, Australia: Global Infrastructure Hub. https://cdn.gihub.org/umbraco/media/2519/gih-showcase-projects-2019-cslg-interconnector-project-art-web.pdf.

[10] The following quote was gathered from USAID feedback on the draft version of this report.

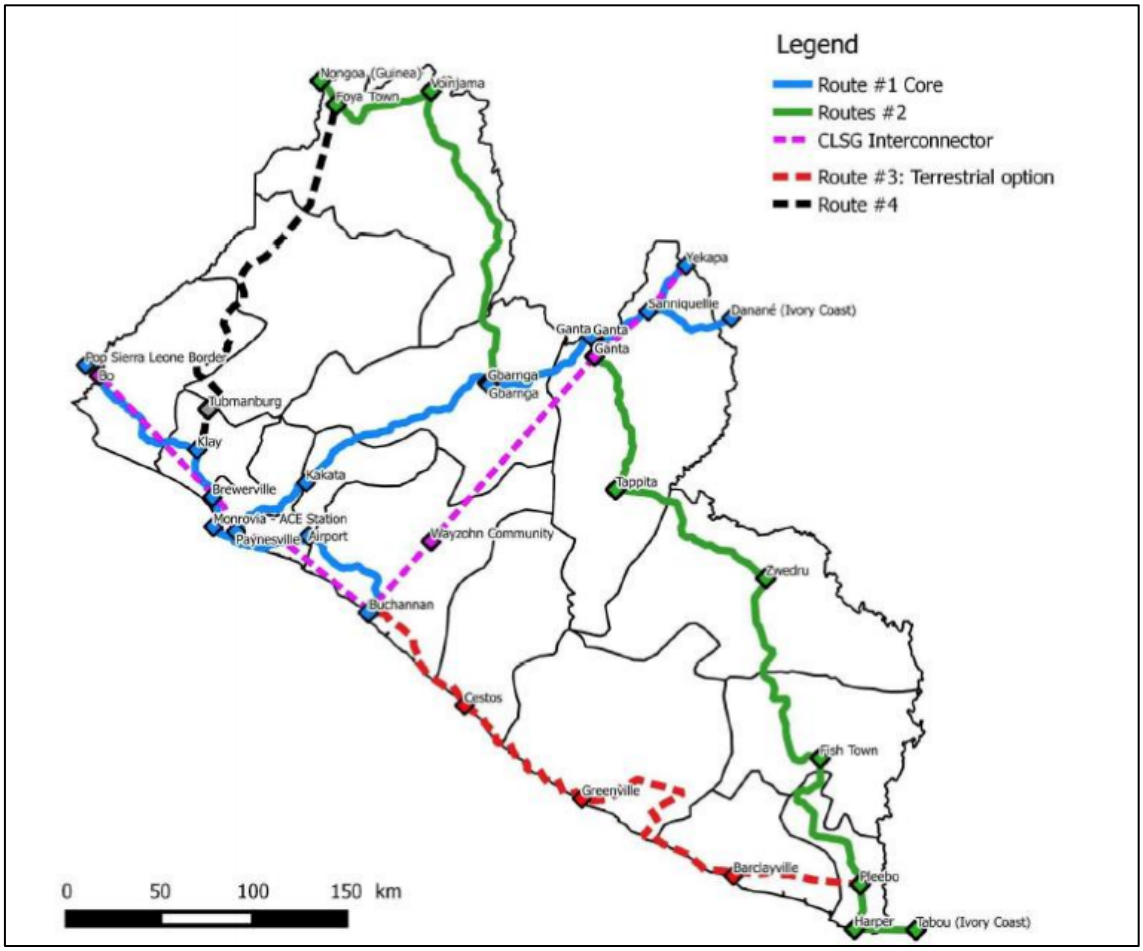
LIBERIA ELECTRICITY CORPORATION (LEC)

The LEC has some OPGW fiber in Liberia, but this project could not ascertain clearly how many kilometers of fiber LEC possesses. However, LibTelCo has started to cooperate with the LEC to use its OPGW fiber.

3.3 CURRENT OFC EMERGING BACKBONE MAP FOR LIBERIA (BOTH TRENCHED AND OVERHEAD)

It is important that the LTA and the GoL start coordinating all the fiber efforts to realize the emergence of the fiber backbone in Liberia as soon as possible. However, the best pictorial view of the proposed national fiber backbone for Liberia comes from the 2015 West African Regional Communications Infrastructure Program (WARCIP), as shown in Figure 12.

Figure 12. West African Regional Communications Infrastructure Program (WARCIP) Proposed National Backbone for Liberia (from the Liberia Project 2015)



Source of Image[11]: Loda & Cameron (2019)

[11] Ibid.

Some interesting observations:

1. The Monrovia (Montserrado County) to Buchanan (Grand Bassa County) route has been completed via aerial fiber, largely by Mobile Operator Orange, achieving a Route 1 # Core between Monrovia and Buchanan. It may be part of the future Route Cote D'Ivoire, Liberia, Sierra Leone to Guinea (CLSG) Interconnector.

2. CSquared proposed expansion footprint as shown in Figure 10 would realize Route No. 1 Core between Monrovia and Kakata, Gbarnga to Ganta, Sanniquellie to Yekapa, and to the Ivory Coast.

3. Therefore, it appears Market OFC players are prepared to finance and operate Route #1 Core spine backbone links.

4. Routes 2, 3, and 4 may require GoL subsidies in different proportions.

5. The WARCIP OLC backbone vision is clearly a very good one, which needs coordinating with TRANSCO and other national OFC efforts within Liberia to realize the backbone as soon as possible.

4. SWOT ANALYSIS OF LIBERIA OFC BACKBONE EFFORTS

An analysis of the strengths, weaknesses, opportunities, and threats (SWOTs) of the Liberian OFC backbone efforts to date will help to identify key strengths and weaknesses, and thus help in exploiting opportunities and mitigating risks arising out of the threats.

Figure 13. SWOT Analysis

Strengths	Weaknesses
• Potential to promote e-government initiatives • Promote digital literacy and awareness driving demand for more fiber • Supportive Broadband Policy 2019–24 requiring Fiber by Government • CSquared & Orange making some good progress	• Lack of OFC Regulatory Framework and Regulations (this study addresses this) • Lack of coherent national fiber backbone • LibTelCo "designated national operator" is financially weak • Lack of Financial Resources • Lack of capacity in both GoL and LTA
Opportunities	**Threats**
• Huge demand for broadband and optic fiber in unserved/under-served areas. • Proliferation of broadband in the country gives boost to nation's economy. • TRANSCO & LEC efforts; WARCIP • CSquared, MTN, Orange, LibeTelCo filling out the Liberian backbone in an a more "coordinated fashion", with a central OFC agency such as LibTelCo. • New OFC Framework & Regulations driving further fiber competition and investment	• Lack of Implementation behind Political will – e.g. TRANCO's failed promises • Country Economic Investment Unattractiveness • LibTelCo lack of recent financial Audits • Lack of Policy and Regulatory framework

Below is further elaboration of the areas identified in the above illustration.

STRENGTHS

1. **Supportive Broadband Policy 2019–24 requiring fiber by Government.** Pursuant to Chapter 1, sub section 1 of the ICT Policy of 2019–2024, the Government of Liberia supports

the expansion of a fiber optic backbone to cover all 15 counties of Liberia.

2. **Potential to promote e-government initiatives driving more demand for broadband and OFC fiber. It is also the GoL policy to promote digital literacy and awareness.** According to Section 5.11 of the Policy ICT of 2019–2024, "The overall goal of e-Government is to make the Government more result-oriented, efficient and citizen-centered. The e-Government strategy will focus on redefining the relationship between the government and citizens with the objective of empowering the citizens through increased and better access to government services. The e-Government initiative should be a shared vision between the national and county governments and the private sector, and the implementation process will involve all stakeholders."

3. **Promote digital literacy and awareness.** In accordance with 5.11.2 of the ICT Policy, "The government will ensure that all of its ICT infrastructure and services (including e-government services, public access facilities, documentation, records, universal access initiatives, etc.) are accessible to all, including the disabled."

4. **CSquared and Orange are making good progress.** CSquared currently runs a fiber metro link in Liberia. It has applied for a license from the LTA to extend its operations in other counties outside of Montserrado County where its operation is restricted all the way to Nimba County in the West, close to the Cote d'Ivoire border. Orange has covered about 200km of fiber deployment on the route to Buchanan from Monrovia.

WEAKNESSES

1. **Lack of OFC regulatory framework and regulations.** There is no coherent regulatory framework to guide the deployment of optical fiber. A draft policy and regulatory framework are provided in Annex 1.

2. **Lack of a coherent national fiber backbone.** There is no coherent effort to realize the Liberian OFC national backbone through: 1) Market OFC operators, 2) LEC efforts, 3) TRANSCO efforts, and 4) WARCIP efforts or LibTelCo as the "designated national operator."

3. **LibTelCo, the "designated national operator" is financially weak.** Though designated as the "national operator," and given specific responsibilities under such designation, LibTelCo does not have the financial and technical means to compete in the market.

4. **Lack of financial resources.** With competing priorities from across sectors, the Government of Liberia lacks the financial resources to commit to expanding optical fiber in Liberia.

5. **Lack of capacity in both GoL and the LTA.** Both MoPT and the LTA lack the technical capacity to manage complex fiber deployment projects.

OPPORTUNITIES

1. **Huge demand for broadband and optic fiber in unserved and under-served areas.** The accessibility of OFC in under-served and unserved areas has the potential to drive demand.

2. **Proliferation of broadband in the country gives a boost to the national economy.** E-government initiatives are classic examples.

3. **TRANSCO and LEC efforts; WARCIP.** TRANSCO and LEC are promising additional OFC transmission capabilities. These promises must be realized. The WARCIP vision remains the most cogent backbone OFC vision that was found.

4. **CSquared, Orange, MTN, and LibTelCo filling out the Liberian backbone in a more coordinated fashion.** A more central OFC agency, in this instance – Litelco, for example, would be required to realize the "filling out" of the routes in Figure 12. These major players—with shareholdings in the CCL—are deploying OFC in and around Montserrado County. Some have begun extending their deployments beyond Montserrado into Grand Bassa County. Grand Bassa is a lucrative route because it harbors the second largest seaport in Liberia, as well as some major concessionaries.

5. **The new OFC Framework and regulations are driving further fiber competition and investment.** The new OFC framework would create the regulatory enabling environment to promote open access, a liberalized market, and enhance competition.

THREATS

1. **Lack of implementation behind political will.** The TRANSCO project demonstrates this cogently, as does the Liberian lack of follow-through on the WARCIP project.

2. **Liberia's unattractive investment environment.** Liberia is suffering key macro-economic challenges post the Ebola crisis, and now the Covid-19 pandemic. It is also a small economy and needs to make itself more attractive to gain international investments.

3. **LibTelCo and LEC's financial weakness.** LibTelCo as the "designated national operator" is clearly financially weak. Its lack of international-class recent financial audits also contributes. The same applies to the LEC.

4. **Lack of a coherent policy and regulatory framework for OFC.** This is usually a major threat to OFC rollout. For example, without one, the GoL has been requesting ownership positions in new licensees like CSquared, trying to implement a regulated monopoly approach via LibTelCo (with no funds), etc. There is also no central agency to drive this top ICT policy for Liberia. These all lead to a very slow rollout of OFC in Liberia. The hope is that this study helps address this threat.

5. RECOMMENDATIONS

The following delineates four recommendations that should be adopted by the LTA and GoL to strengthen its OFC activities in Liberia.

RECOMMENDATION 1: DEFINE AND ADOPT AN OFC POLICY AND REGULATORY FRAMEWORK FOR LIBERIA

A regulatory framework (draft provided in Annex 1) is critical to the realization of the OFC fiber backbone in Liberia. It should clearly spell out the approach that the GoL and the LTA are taking to hasten the rollout of fiber in Liberia and any obligations it may place on OFC licensees. The MOPT should be responsible to develop policy around optical fiber deployment as it is clearly spelt out in the ICT Policy of 2019. On the other hand, the LTA should develop regulations to actualize the policy.

RECOMMENDATION 2: GOL TO ESTABLISH A NATIONAL FIBER BACKBONE INITIATIVE

The GoL and the LTA should establish—like in Kenya[12]—a National Optic Fiber Backbone Initiative (NOFBI) to extend the planned spine backbone beyond where the market players currently go. The NOFBI would be owned by the GoL but may be managed by well-funded LibTelCo, CCL, or another OFC licensee, who would coordinate other OFC telecommunications operators on an open access basis, in return for a management fee. The NOFBI would also define and update the spine backbone fiber network to cover all fifteen counties (Figure 12) and seek ways to implement its emergence as soon as possible. Because rolling out the spine backbone is the top priority in the ICT Policy (2019–2024), this study strongly recommends setting up a NOFBI like Kenya.

As described by Kenya's ICT Authority, NOFBI "is a project aimed at ensuring connectivity in all the 47 counties of Kenya. The implementation of this project aims to ease communication across counties as well as improve government service delivery to the citizens such as application of national identity cards, passports and registration of birth and death certificates. The project is being implemented in 2 phases: NOFBI Phase 1 and NOFBI Phase 2". Phase 1 commenced in 2007 and Phase 2 started in 2014. The majority consensus is that NOFBI has truly focused and succeeded in ensuring the fiber backbone passes through as many counties as possible in Kenya, including 58 towns in 35 countries covering 4300km of OFC during Phase 1. Further, at least 3000 km of this fiber is already being used by the Government of Kenya and commercial players such as Safaricom and Telkom. Phase 2 is to build1600km fiber, principally to link all 47 county headquarters, of which 1200km has been built to date.

There are some key lessons for Liberia to draw from Kenya's NOFBI. The key advantage of the NOFBI has been the unequivocal universal access OFC driver to all 47 counties, also linking all 47 headquarters. This would certainly benefit the citizens and offices of Liberia's 15 counties as well. Nevertheless, there are some key differences between the Kenyan NOFBI and the Liberian OFC context today. For example, the private equity-funded Telkom Kenya (the Kenyan equivalent of

[12] "National Optic Fibre Backbone (NOFBI) – ICT Authority." n.d. Icta.go.ke. ICT Authority of Kenya. http://icta.go.ke/national-optic-fibre-backbone-nofbi/.

LibTelco) operates and maintains the fiber backbone. LibTelco hardly has the financing required to do this in Liberia. Furthermore, the Governments of Kenya and China both funded the NOFBI backbone, built by Chinese tech giant, Huawei. As this level of funding has yet to be secured or committed to date in Liberia, the level of Kenya's NOFBI success would not be guaranteed.

Despite the above challenges, given that the fiber backbone is Liberia's number one ICT objective, it is appropriate that the GoL establish a similar NOFBI and urgently seek the finances to fund it. In doing so, perhaps the GoL will ALSO address the LibTelCo challenge by privatizing it, as this has been a long-held ambition of the Government.

RECOMMENDATION 3: GOL TO ESTABLISH AN INVESTMENT STRATEGY FOR ECONOMICALLY DEPRIVED ROUTES

The government through the MOPT and the LTA should devise a mechanism to attract investment to deploy on alternative routes other than those considered economically lucrative (Routes No. 2, 3, and 4 on Figure 12).

It is obvious that Operators will tend to invest only on those routes that they find viable and able to generate appreciable returns of investment, as is already happening with Routes #1. For example, routes connecting and serving the port city of Buchanan and the concession city of Yekepa will most like generate more interest that routes connecting and serving cities like Cesto and Zwedru. On those economically deprived routes, the government should:

- Fully or partially fund the fiber deployment on those routes;
- Provide incentives in the form of tax breaks for operators to entice their investment decisions;
- Give preferential provision for the use of ideal radio frequencies and spectrum to entice investment decisions; and
- Commission the use of the USF to fund such routes.

RECOMMENDATION 4: GOL AND LTA TO ENCOURAGE AND DELIVER ON SEAMLESS RIGHT OF WAY PROCESS

The LTA should help licensees negotiate reduced right of way fees for fiber buildouts or securing the right of way waiver agreements, and simplifying the application process. While RoW may be less of an issue in Liberia than in other SSA countries, it remains an issue with regards to ensuring consistency and timeliness in gaining these rights across different counties in an efficient manner. Furthermore, RoWs are easily obtained across routes where there are already clearly built roads by the GoL, such as with the CSquared fiber from Monrovia to Kakata, or the Orange fiber from Monrovia to Buchanan. However, where there are no GoL-built roads, the OFC players would need to map out the optimal RoW routes, without the support of a clear NOFBI at this time.

ANNEX I. REFERENCES AND SOURCES

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World Bank Document and Reports Portal: http://documents1.worldbank.org

U.S. International Trade Administration: https://www.trade.gov

ANNEX 2. BRIEF DRAFT OFC POLICY AND REGULATORY FRAMEWORK

This annex briefly summarizes a proposed Draft OFC Policy and Framework and Guidelines for Liberia.

RELEVANT OFC OBJECTIVES IN THE LIBERIA ICT POLICY (2019–2024)

The Liberia ICT Policy (2019–2024) has some clear objectives relevant to the emergence of OFC in Liberia. The primary objective (Objective one) concerns OFC, however objectives four and seven are also relevant.

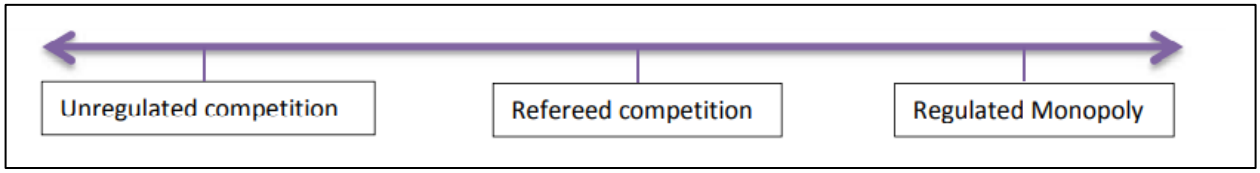
- Objective 1: Expand ICT infrastructure and establish a national fiber optic backbone to connect all 15 county capitals and cross-border connectivity with reliable links;
- Objective 4: Ensure critical ICT infrastructure is well protected and effective response mechanisms are in place to deal with cybersecurity issues and other physical disasters (e.g., epidemics); and
- Objective 7: Establish a National Education and Research Network (NREN) for all tertiary and secondary education institutions to provide access to high-speed internet and digital educational.

Below are the proposed brief framework and guidelines.

ALLOW FOR OPEN COMPETITION FOR OFC IN LIBERIA IN FROM 2024–2025

There are typically three policy and regulatory options to choose from to incentivize construction and operations of terrestrial fiber networks, as is summarized in the 2015 USAID Report (Wright et al., 2015[13]): Regulated Monopoly, Refereed Competition and Open Competition.

Figure 14. Common Policy and Regulatory Options to for Terrestrial Fiber Networks



Source: USAID Report by Wright *et al.* (2015)

One or a hybrid of these three policy and regulatory framework approaches has been used to promote fiber diffusion across Sub-Saharan Africa. The question, however, is which approach is most optimal for Liberia at this moment in 2021?

- Regulated Monopoly: This approach gives a single firm absolute control over the national fiber network in Liberia. It is the case that the GoL has recently designated LibTelCo as the "national telecom operator" and given overall responsibility for building the OFC backbone in Liberia. It is also

[13] PA00TCT5.pdf (usaid.gov) - https://pdf.usaid.gov/pdf_docs/PA00TCT5.pdf

the case that LibTelCo neither has the financial strength nor the cash flow—as per Objective 1 of the Liberia ICT Policy (2019–2024) —"To build and establish a national fiber optic backbone to connect all 15 county capitals and cross-border connectivity with reliable links." Therefore, this option is not recommended for Liberia.

- Regulated Open Access (refereed competition): This approach has private OFC companies compete to provide capacity to retail operators, and all market participants enjoy FRND-ly[14] open access to bottleneck infrastructure, irrespective of ownership and operation of the OFC infrastructure. It is overseen by a robust regulator, who monitors and enforces voluntary and mandated access terms, LRIC[15] prices, dispute resolution, and agreed industry rate of return—where all transactions are subject to private contracts. This approach assumes a critical number of OFC providers are likely to build across most of the fifteen counties of Liberia. This regulated open access approach is also not realistic or recommended in Liberia.

- Open Competition ("unregulated" competition): This approach has open OFC competition amongst all market OFC players with a minimal role for the regulator (LTA) and the GoL. The regulator licenses the OFC players, but does little else. They do not enforce interconnection prices; there is no intervention to resolve access to bottlenecks; minimal dispute resolution over OFC matters, etc. Private OFC players bear the risks of network deployment and operation and are free to exclude competitors. They determine the extent of OFC coverage, and they innovate as they see fit to reach remote areas (e.g., by deploying aerial fiber rather than trenching). Although it is possible that this approach would achieve the lowest OFC coverage of the three approaches, it is recommended that open competition (almost "Wild West" with minimal controls) is the most optimal option for Liberia at this time. Notably, this approach has been adopted in Nigeria.

Based on this study, the recommendation is that there be open OFC competition for Liberia for the remainder of the period of the published Liberian ICT Policy (2019–2024). There are minimal regulatory needs from the LTA beyond monitoring licenses and issuing them to "fit and proper" OFC applicants on a first-come-first-serve basis.

RISKS WITH OPEN COMPETITION FOR OFC IN LIBERIA

There are two important risks to this approach.

1. *No Universal OFC Backbone by 2024–2025:* The first risk is that no fifteen-county national network would be constructed, and therefore there would be no universal access of fiber possible in the period up to 2024–2025.

2. *Duplication of Fiber and Infrastructure Sharing Risks and Mitigation:* Another risk observed in other countries like Nigeria is that there may be a duplication of OFC fiber roll out on urban and profitable routes like Monrovia to Buchanan, and insufficient fiber in rural areas. There is also the risk of little infrastructure sharing of the OFC fiber happening, for example, Orange building

[14] Fair, Reasonable and Non-Discriminatory.

[15] Long Run Incremental Costs.

Monrovia to Buchanan and not providing ducts to allow its competitors like CSquared or MTN to thread their own fiber on the same route. The only viable mitigation to such risks under the Open Competition framework is for the GoL and the LTA to use their soft power over the OFC players to address such key concerns that come with open competition.

OPEN COMPETITION DOES NOT MEAN NO REGULATION

Operators who are licensed by the LTA must understand that open competition does not mean there is no regulatory oversight of the OFC activities.

- OFC players in Liberia must be licensed by the LTA to roll out any fiber in Liberia.
- By definition, a license confers *rights*, but also *obligations* on the licensee. For example, rights to enter a market as an OFC player, rights to roll out the fiber, or rights to "Rights of Ways" (RoWs); but also, some obligations like reporting obligations to the LTA, the requirement that licensees must be "fit and proper" license holders, prescriptions on the quality of fiber that can be rolled out, and guidelines on both trenched and overhead fiber, etc.
- The open competition approach minimizes the obligations but does not eliminate all obligations.

OPEN COMPETITION OFC APPROACH NEXT REVIEW

It is recommended that the Open Competition approach to OFC in Liberia be reviewed again in 2025, providing sufficient certainty to OFC licensees to roll out their fiber with minimal regulation over the next four years.

DRAFT LIBERIA OPEN MARKET OFC POLICY AND REGULATORY FRAMEWORK RECOMMENDATIONS

The recommendations can be summarized as follows (drawing from Wright *et al*, 2015 and Nwana, 2014):

1. *Open Market OFC Approach*: The GoL and the LTA would allow for open market minimally regulated OFC competition in Liberia in the period of 2024–2025, matching the period of the current Liberia ICT Policy from MoPT. This means the LTA licenses the prospective fit and proper OFC players on a first-come-first-serve basis and enforces no interconnection prices, no formal dispute resolution over OFC matters (except over publicly funded fiber), no stipulation of routes to roll out fiber, etc. Private OFC players would bear the risks of network deployment and operation and are free to exclude competitors. They would determine the extent of OFC coverage, and they can innovate as they see fit to reach remote areas (e.g., by deploying aerial fiber rather than trenching).

2. *OFC Liberalization and Minimalistic Obligations on Licensees Including No Liberian Ownership Obligations*: The GoL and the LTA would impose minimal restrictions on the OFC licensees and eliminate restrictions on the number of licenses. A liberalized fiber backbone policy in Liberia would have a better chance of attracting substantial investment in OFC backbone networks. The GoL and the LTA would also not oblige any Liberian ownership of OFC licensees.

3. *Encourage Entry of Alternative OFC Infrastructure Providers*: Other utilities, like the Liberian Electricity Corporation (LEC), have existing fiber optic networks for self-use. Road building companies building any new roads in Liberia would be encouraged to partner with other alternative infrastructure players to roll out (and fill out) the OFC backbone in Liberia. The LTA would permit, and encourage, the emergence of different owners of alternative fiber networks in Liberia—and such alternative infrastructure providers would make capacity available to telecom operators. Such alternative infrastructure providers like LEC or road network operators typically control significant RoW to build essential infrastructure and are encouraged to seek opportunities to combine their efforts with alternative infrastructure providers. The LTA would license and authorize alternative infrastructure providers such as the LEC to lease dark fiber on its network to telecom operators.

4. *Mandating Fiber Rollout for All New Road Construction (implementing a "pay once" and "dig once" policy)*: Following on from the latter, promoting fiber deployment requires that the GoL mandate all new roads projects must include ducting and other facilities that are necessary to roll out OFC. It is a minimal incremental cost to road construction companies and the GoL would negotiate and finance the incremental costs to also duct fiber during road builds. This passive layer is typically 70–80 percent of the OFC costs. Such mandating is the ultimate way of implementing an OFC "pay-once-dig-once" policy. The GoL would be the ultimate financer for the OFC rollout along new roads being constructed if there are no commercial takers, because the GoL fully realizes that it makes little sense for the Government not to add the minimal fiber ducting costs to major spine road projects in Liberia. The GoL may choose to work through LibTelCo (as the designated "national telecom operator") to implement a pay-once-dig-once policy.

5. *Access to Rights of Ways (RoW) at Minimal Cost*: The GoL should work with its relevant Ministries and the LTA to guarantee RoW at minimal costs to OFC licensees. This would reduce costs, time, and risks to operators of their OFC roll out. RoW is usually a significant impediment in Sub-Saharan Africa (SSA). Rolling out fiber has been identified as the number one priority in the Liberian ICT Policy (2019–2024).

6. *GoL to Establish a National Optic Fiber Spine Backbone Initiative (NOFBI)*: The GoL would establish—like in Kenya—a National Optic Fiber Backbone Initiative (NOFBI) to extend the planned spine backbone beyond where the market players currently go. The NOFBI would be owned by the GoL but may be managed by LibTelCo, CCL, or another OFC licensee, who would provide access to other Telco communications operators on an open access basis, in return for a management fee. NOFBI would also define and update the spine backbone fiber network to cover all fifteen counties, and seek ways to implement its emergence as soon as possible. Since rolling out the spine backbone is the top priority in the ICT Policy (2019–2024), it is strongly recommended that a NOFBI similar to Kenya's be set up in Liberia.

7. *The LTA to Promote Competition in Downstream OFC Markets*: If there is more competition in downstream retail telecommunications markets by operators and ISPs for fiber capacity, this would drive more demand for the spine OFC backbone capacity. More demand for the spine backbone would enable faster realization.

8. *Encourage Operators to Jointly Construct and Operate OFC Backbone Networks*: The open competition OFC approach being adopted by the LTA and the GoL would allow for *competition* (i.e. competition and cooperation) of usually competing OFC operators. Therefore, the LTA should encourage operators like MTN and LibTelCo, or CSquared and Orange, to jointly construct a fiber optic route in Liberia. Such arrangements have happened in both Rwanda and Uganda. The LTA reserves the right post 2024–2025 to examine the market power of such arrangements but would only do so in 2025 at the earliest.

9. *Minimum Standards for Trenched and Overhead Fiber Rollouts*: Despite the Open Competition approach, the LTA reserves the right and would specify minimum terms and conditions (T&Cs) for which trenched fiber, overhead fiber, and even GoL rolled out fiber must abide.

10. *Open Access for All Fiber with any Public Funding*: If public funds contribute to the funding of any backbone spine (e.g., to induce or to subsidize private sector OFC roll out to otherwise commercially unprofitable routes), then the government should insist on open access to that route. This is a core recommendation from the European Union Commission in its guidelines on public financing of broadband networks. Therefore, if because of some of the prior recommendations LibTelCo, CCL, or the LEC rollout spine backbone fiber using public funds, they would be subject (via the LTA) to the following open access obligations:

    a. Wholesale access: "Open access" typically in the telecoms sector is shorthand for "wholesale access" of OFC routes to their competitors.

    b. Transparency: The T&Cs for open access arrangements must be transparent and published (preferably on the LTA website) to all interested third parties like smaller ISPs who may want to provide retail services on such publicly funded OFC spine routes.

    c. Non-discrimination: Open access arrangements would not discriminate between retail providers, big or small (e.g., between MTN Liberia verse small Liberian ISPs like K3 Telecom, Electro Shack, PowerNet, and NAS Global.

    d. Fairness and Reasonableness: Open access requests by retailers to the wholesale provider must be fair and reasonable. Fairness in pricing irrespective of the size of the operator; fairness in reasonable timescales to be provided access irrespective of the size of the operator, etc.

    e. Timely Enforcement: Open access obligations would be effectively enforced so that incumbents do not delay access, degrade service, or discriminate against retailers.

    This would mean the CSquared metro link from downtown Monrovia to Fendel's University of Liberia campus (which obtained USAID funding intended for the Government of Liberia) would be subject to open access obligations.

ANNEX 3. DRAFT TECHNICAL GUIDELINES FOR TRENCHED AND AERIAL FIBER IN LIBERIA

This annex briefly summarizes a proposed Draft OFC Technical Guidelines for trenched and aerial fiber in Liberia.

MINIMUM COVER FOR BURIED FIBER OPTIC CABLE (UNDERGROUND TRENCHING)

TABLE 2. MINIMUM COVER FOR BURIED FIBER OPTIC CABLE (UNDERGROUND TRENCHING)		
LOCATION	DEPTH (ACCEPTABLE)	DEPTH (IDEAL)
Minimum Cover in Soil	1.2 meters	> 1.2 meters
Minimum Cover Under Drainage Ditches	1.2 meters	> 1.2 meters
Minimum Cover In Rock (Any Location)	1.2 meters	> 1.2 meters
Minimum Cover At Roadway Crossing	1.2 meters	> 1.2 meters

MINIMUM HEIGHT OF AERIAL FIBER OPTIC CABLING (OVERHEAD/OPGW)

TABLE 3. MINIMUM HEIGHT OF AERIAL FIBER OPTIC CABLING (OVERHEAD/OPGW)		
LOCATION	HEIGHT (ACCEPTABLE)	HEIGHT (IDEAL)
Optical Fiber Ground Wire (OPGW) Above Ground	14 feet Above Ground (4.26 meters)	> 6 meters Above ground

OPTICAL GROUND WIRE SPECIFICATIONS/RECOMMENDED GUIDE

CABLE DESCRIPTION

Cable, which has the dual performance functions of a conventional ground wire with telecommunication capabilities.

QUALITY

To ensure a continuing level of quality in cable products through several quality control programs including ISO 9001.

RELIABILITY

To ensure product reliability through rigorous qualification testing of each product family. Both initial and periodic qualification testing are performed to assure the cable's performance and durability in the field environments.

REFERENCES

The referenced specifications in this document are tested according to international standards as follows:

TABLE 4. OPTICAL FIBER COMPLIANCE RECOMMENDATIONS

SPECIFICATIONS	DETAILS
IEC 60793-1	Optical fiber Part 1: Generic specifications
IEC 60793-2	Optical fiber Part 2: Product specifications
ITU-T G.652	Characteristics of a single-mode optical fiber cable
ITU-T G.655	Characteristics of a non-zero dispersion-shifted single-mode optical fiber and cable
EIA/TIA 598 B	Color code of fiber optic cables
IEC 60794-4-10	Aerial optical cables along electrical power lines - family specification for OPGW
IEC 60794-1-2	Optical fiber cables-Part 1-2: Generic specification - Basic optical cable test procedures
IEEE1138-2009	IEEE Standard for testing and performance for optical ground wire (OPGW) for use on electric utility power lines
IEC 61232	Aluminum-clad steel wire for electrical purposes
IEC 60104	Aluminum magnesium-silicon alloy wire for overhead line conductors
IEC 61089	Round wire concentric lay overhead electrical stranded conductors

TABLE 5. OPTICAL FIBER SPECIFICATIONS RECOMMENDATIONS

CATEGORY	DESCRIPTION	SPECIFICATIONS/AFTER CABLING
Optical Specifications	Attenuation @1310 nm	≤0.36 dB/km

	Attenuation @1550 nm	≤0.22 dB/km
	Zero Dispersion Wavelength	1300~1324 nm
	Zero Dispersion Slope	≤ 0.092 ps/nm^2·km
	PMD Link value	≤0.2 ps/√km
	Cable Cutoff Wavelength (λ_{cc})	≤1260 nm
	Macro bending Loss 1. (100 turns; Φ50 mm) @1550 nm 2. (100 turns; Φ50 mm) @1625 nm	11. 1. ≤ 0.05 dB 2. ≤ 0.10 dB
	Mode Field Diameter @1310 nm	9.2±0.4μm
Dimensional Specifications	Cladding Diameter	125 ±1.0μm
	Core/clad concentricity error	≤0.6μm
	Cladding Non-Circularity	≤1.0 percent
Mechanical Specifications	Proof stress	≥0.69Gpa

OFC INSTALLATION GUIDELINES – AERIAL FIBER

Telecommunications operators can also install aerial fiber. Compared with trenched fiber, aerial fiber is typically much cheaper and faster to deploy, particularly for spine backbone fiber.

Telecommunications operators should ideally install more than one aerial duct on a trunk route. They may install two, four, six or eight at a time. A two-duct system, which has sub-ducts, will have capacity for eight cables, and each cable may contain 144 fibers. This provides for additional capacity, maintenance, and a means of adding distribution cables if required.

Aerial fiber too may allow installers to reuse existing pole infrastructure used for electricity.

The aerial cables that are most commonly used OFC can be divided into three main types: GYTC8S, GYXTC8Y and GYXTC8S. Any of these would be acceptable.

Aerial fiber should be at a minimum height of 14 feet or 4.26 meters above the ground. Ideally, it should be above six meters.

DOCUMENTATION OF OFC INSTALLATION IS KEY

Documentation of the fiber route should typically be done electronically using detailed Geographical Information Systems. Accurate mapping of underground plant is essential for future maintenance and may also be a legal requirement.