Study period 2018-2021

Question 5/1
Telecommunications/ ICTs for rural and remote areas

Annual deliverable 2019-2020

Broadband development and connectivity solutions for rural and remote areas

Executive summary

This annual deliverable reviews major backbone telecommunication infrastructure installation efforts and approaches to last-mile connectivity, describes current trends in last-mile connectivity and policy interventions and recommended last-mile technologies for use in rural and remote areas, as well as in small island developing States (SIDS). Discussions and contributions made during a workshop on broadband development in rural areas, held in September 2019, have been included in this document, which concludes with two sets of high-level recommendations for regulators and policy-makers, and for operators to use as guidelines for connecting rural and remote communities.

More information on ITU-D study groups:
E-mail: devSG@itu.int Tel.: +41 22 730 5999 Web: www.itu.int/en/ITU-D/study-groups

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1. Introduction

The telecommunications/ICT sector and technologies have evolved over a long period of time, starting with ancient communication systems such as drum beating and smoke signals to the electric telegraph, the fixed telephone, radio and television, transistors, video telephony and satellite. Developments have moved faster with the introduction of the Internet, digital telephone technology, digital media and, the wireless revolution, which ushered in mobile services. These developments saw wireline technologies dominating the pre-mobile period in history. The challenge during the pre-mobile period was how to connect rural and remote areas using fixed wireline telecommunications for mainly voice and telegraphic communication and to some extent, radio communication, as the costs were high. Sector operators were mostly government-owned and mainly monopolies in their resident countries. In developing countries, such monopolies were not run efficiently, hence they did not generate sufficient income to invest in areas that were regarded as non-viable. This state of affairs resulted in long waiting periods for installation of fixed-telephone lines, particularly for persons living in rural areas. With the advent of fixed broadband, the problem of uneven distribution continued.

Great strides have been made across the world in the construction and installation of telecommunication/ICT backbone infrastructure to enable both basic connectivity and roll-out of broadband services to rural and remote areas. However, without effective and efficient last-mile connectivity solutions, rural and remote communities are likely to remain largely unconnected. This is even more so given the challenges of rugged terrain, lack of investment and high information and communication technology infrastructure installation costs.

This document looks briefly at major efforts that have been made in terms of installation of backbone telecommunication infrastructure and the historical and current approach to last-mile connectivity. It then covers current trends in last-mile connectivity, policy interventions and recommended last mile technologies for use in rural and remote areas, as well as in small island developing States (SIDS). All these issues are discussed on the basis of contributions to Question 5/1 and presentations made during the workshop on broadband development in rural areas which was hosted by the Question 5/1 Group in September 2019[1]. The discussion also takes into account the major challenges for rural and remote area connectivity, which include lack of, or inadequate supporting infrastructure, difficult terrain, illiteracy, high cost of installation of ICT infrastructure and policy issues.

Major challenges for rural and remote area connectivity include lack of, or inadequate supporting infrastructure, difficult terrain, illiteracy, high cost of installation of ICT infrastructure and policy issues.

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[1] Workshop on broadband development in rural areas which was hosted by the Question 5/1 Group in September 2019, https://www.itu.int/en/ITU-D/Study-Groups/2018-2021/Pages/meetings/session-Q5-1-sept19.aspx.

1.1. Existing and current trends in backbone infrastructure

The backbone infrastructure currently in place across the world includes the following:

- **Wireline communication infrastructure** involving use of copper wire or glass fibre that terminates in a fixed location.
- **Fibre-optic cables** which are part of wireline technology and transmit data from one place to another through pulses of light. Fibre-optic cables can be single mode or multimode. Fibre can be transparent glass, or plastic. They can also be soluble or insoluble. Fibre supports high-speed transmission as opposed to copper wires and allows longer transmission distances.
- **Wireless technology** which involves the use of telecommunication towers which support cellular communication antennas and can either be rooftop towers or stand alone.
- Continents are now linked together using **submarine cables,** with such cable networks linking different parts of the world. While most countries have good quality bandwidth on international and national long distance and urban infrastructure, in many countries, particularly in Africa, inland backbone networks still require a lot of improvement and do not cover all parts of the country. Given that different parts of the world are linked together by submarine fibre and the submarine cable network is extensive, a map of the network has been included in **Annex 1**. According to telegeography.com there are approximately between 378 and 420 submarine cables around the world. A comprehensive list of most of the submarine cables is shared in **Annex 2**.

2. Trends in telecommunication/ICT backbone infrastructure

Of late, there has been an increase in the use of towers due to the growth of investment in Long Term Evolution Advanced (LTE-Advanced) solutions. LTE network connectivity has surged in demand due to the need for high-speed Internet connectivity coupled with the emergence of demand for Internet of Things (IoT) and increased affordability of smart phones. This scenario has seen the increased need for telecommunication towers to provide radio access network services to end users. The trend has also evolved to the use green towers which make use of renewable energy such as solar and wind. An estimated 4 million telecommunication towers have been installed across the world and this figure is expected to reach 5 million by 2020[2].The demand for towers is expected to continue growing, as 5G networks are expected to drive the fourth industrial revolution. Cell towers are an integral part of 5G networks.

Submarine cables appear to be the backbone of the global economy, while towers appear to take more prominence in land telecommunications. The over-the-top (OTT) services industry has some major OTT operators investing in submarine cables and driving growth. Hence major OTT players, such as Google and Facebook, individually and jointly with telecommunication carriers, are projected to own and co-own nearly 40 submarine cables by the end of 2021[3]. The following trends are prominent:

[2] The Global Market for Telecoms Towers 2014 – 2020, 2014, available at: https://www.reportbuyer.com/product/2372401/the-global-market-for-telecoms-towers-2014-2020.html.

[3] Web Insights by Suvesh Chattopadyaya, 9 April 2019, available at: https://www.submarinenetworks.com/en/insights/an-attempt-to-identify-emerging-trends-in-submarine-cable-systems.

- Increased demand for submarine connectivity.
- Close integration between submarine cable systems and terrestrial backhaul networks.

The following trends are prominent: Increased demand for submarine connectivity; and close integration between submarine cable systems and terrestrial backhaul networks.

Satellite telecommunications, being independent from ground-based infrastructure, are very handy in isolated regions, deserts, oceans and disaster-prone parts of the world. They are more reliable than terrestrial telecommunications for emergency purposes. The tendency is therefore to use satellite technology for areas and regions that are hard-to-reach through fibre and towers.

3. Last-mile connectivity

While satellites, submarine cables, backbone fibre and telecommunication towers provide the necessary backbone, an effective last mile or first mile network system is required to serve end users in rural and remote areas, from the point of presence of the backbone. A number of solutions exist and these include:

- **Wired systems** which include optical fibre. These require amplification over long distances to avoid failure. They, however, offer high information capacity.
- **Traditional wired local area networks** which involve the use of copper coaxial cables running through nodes in the network. These include asymmetrical subscriber lines (ADSL), data-over cable service and power line communications (PLC). These lines, which are predominately copper telephone lines, have been modified to support higher transmission bandwidth and improved modulation, compared to the old voice band systems. Some have also have been enhanced by new technologies such as G. Fast and VDSL2 and G.hn, to offer high-speed solutions and incorporate automatic switching to minimize physical maintenance visits by service providers, to business or homes of customers, within any particular telephone exchange area.
- **Community antenna television systems (cable television systems)** which are expanded to provide bi-directional communication. These, however, have limited user capacity.
- **Optical fibre.** Due to increased bandwidth requirements in the modern world, fibre has been deployed since the beginning of the 21st century, with the adoption of broadband applications for two-way user generated content. The traditional copper and coaxial networks could not meet all the demand, hence fibre-to-the-home (FTTH) became the preferred network to meet the demand effectively. Optical fibre as a last-mile solution has the advantage of offering high capacity, high performance and low-error rates in transmission. The high cost of installing fibre has seen fibre solutions become prevalent in urban areas in developing countries as these areas offer high returns on investment compared to the rural and remote areas. While copper wires are often prone to theft, fibre does not face this problem.

The traditional copper and coaxial networks could not meet all the demand, hence fibre-to-the-home (FTTH) became the preferred network to meet the demand effectively.

- **Wireless systems** which use unguided wires to transmit data, while being susceptible to unwanted signal interference and external noise, have a significant advantage over wired systems for last-mile connectivity, as they do not require wires to be installed. They can however be adversely affected by terrain, buildings, fog and rain and in some cases wind, particularly where data have to travel long paths. The effect of these elements is reflection, reaction and deflection of waste, thereby altering transmission characteristics. Expensive systems are then used to deal with the distortions. They are however more reliable in terms of reduced losses, in the free space environment compared to wired systems. These cellular technologies usually cover wide or metropolitan areas.
- **Light waves and free space** optics, which constitute visible and infrared light waves that are shorter than radio-frequency waves. Their use is however limited by obstructions in the environment, including weather elements. In such cases, the high frequency shorter waves, which allow high data transfer rates, may have to be substituted by longer (redder) waves, whose resistance to obstruction is lower, but may result in lower data transfer rates.
- **Radio frequency or wireless radio systems** limited to lower information capacity applications, for example, facsimile and radio teletype.
- **Satellite communications** through satellite systems which use long path length, irrespective of whether they are low earth-orbiting satellites or not. As a last-mile solution, satellite transmission should be spread over large geographical areas, as it is very expensive, even to install one satellite. The satellite systems should have a high or large information capacity to accommodate many sharing users with each user having an antenna, with directing and pointing requirements. This makes satellite communications as a last-mile connectivity, expensive. However, satellite technology offers an opportunity to connect hard-to-access places and there is need to find ways to reduce costs and make the technology affordable.
- **E-Line** is a transmission system whose characteristics fall between wired and wireless systems. It uses a single central conductor that transports energy in a plain wire. It can support high information capacity range frequencies.

4. Trends in last-mile connectivity

There are other technologies that are increasingly being utilized and can be very effective, given the wide range of smart applications that are now available even for rural and remote communities. These include the following:

4.1. Wi-Fi technology

Wi-Fi hot spots and local area networks, which can be installed at rural points of community activities, including shopping centres and university campuses, can serve a variety of users. These are also suitable for homes, where all family members can access Wi-Fi connectivity. Wi-Fi technologies are very effective if the backbone landing is not far from the locality and can be used to create a mesh network. In India[4], several rural areas have been connected using Wi-Fi, as a last-mile connectivity solution. In Zimbabwe[5] the community information centres constructed by the universal services fund of the country use Wi-Fi technology.

[4] Presentation by Mohit Bansal at the workshop on broadband development in rural areas hosted by the Question 5/1 Rapporteur Group,25 September 2019, available at: https://www.itu.int/oth/D0718000005.
[5] Presentation by Batsirayi Mukumba at the workshop on broadband development in rural areas hosted by the Question 5/1 Rapporteur Group, 25 September 2019, available at: https://www.itu.int/oth/D0718000003.

In India, several rural areas have been connected using Wi-Fi, as a last-mile connectivity solution. In Zimbabwe, the community information centres constructed by the universal services fund of the country use Wi-Fi technology.

4.2. High altitude platform systems (HAPS) and unmanned aerial vehicles (UAVs)

Unmanned aerial vehicles[6], such as drones, can serve as mobile base stations to provide connectivity. Airbus Zephyr, for example, uses a series of lightweight solar-powered UAVs. Another example is Google Loon that has been tried in different countries, such as New Zealand and Peru, which uses a network of balloons flying on the edge of space. KT's Skyship can be used to provide communications, surveillance and monitoring in case of disaster situations.

5. Business regulatory models and policies

The technologies and solutions discussed in this document are generally subject to regulation. It is therefore important to look at the regulatory models used and make recommendations for effective last-mile connectivity for rural and remote areas.

Regulators usually license large mobile service and satellite providers, who have a large coverage and some guaranteed quality of service (QoS). These large operators are commonly known to be reluctant to serve rural and remote areas which they consider to bring about a low return on investment. It is therefore important to look at licensing models that can be used for connecting rural and remote areas.

5.1. Mobile virtual network operator (MVNO) model

Under the mobile virtual network operator (MVNO) model, the operators do not own infrastructure but use the infrastructure and networks of larger operators. While these MVNOs can increase accessibility because they operate using the same existing infrastructure as large operators, they operate in the same coverage areas as the large operators and therefore do not provide a solution to further extension of telecommunications into rural and remote areas. These small operators function under authorizations which are less stringent than licences. In most cases, they are not licensed and operate under commercial agreements with large mobile network operators whereby they provide only data services and no voice over IP, in order to protect operators who pay licence fees. They increase competition, which lowers the costs of access by people in rural and remote areas, but their geographical coverage remains limited, as they do not extensively cover rural and remote areas. Many countries across the world have MVNOs.

[6] Presentation by Jaheung Koo at the workshop on broadband development in rural areas hosted by the Question 5/1 Rapporteur Group, 25 September 2019, available at: https://www.itu.int/oth/D0718000002 and https://news.itu.int/kt-skyship-search-rescue-platform/.

5.2. Community network model

Community networks[7] are very small or medium scale network operations usually managed by members of the community in which the network is located. These operators can work under agreements with large operators, or limited licences. Countries in Central and Latin America have tried these community networks, which are also being introduced in countries in Africa under the assistance of the Internet Society.

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5.3. Hybrid model

The hybrid model is a combination of large operators and small operators. The big operator provides capacity to connect to the Internet and the small community network operators provide last-mile connectivity. A classic example[8] was the partnership between the Internet Society, the Georgian Government and the local community in Tusheti, a small historic geographic region in Eastern Georgia, located on the northern slopes of the Greater Caucasus Mountains. The network has helped support the economic sustainability of the remote region.

6. Recommendations and guidelines for regulators and policy makers

Based on contributions made to Question 5/1 and the outcomes of the Question 5/1 workshop on broadband development in rural areas, held in Geneva in September 2019, the following recommendations can be made for now:

- Ease regulatory requirements for community network operators.
- Promote tax and customs duty breaks to enable more investment in infrastructure.
- Enhance transparency and ease of doing business to encourage investment in infrastructure.
- Focus on complementary access networks that service underserved markets.

With regard to policies, from the contributions submitted to Question 5/1 and the workshop discussion, the following observations can be made:

- Governments should recognize that market forces do not always address connectivity for rural and remote areas. Therefore, governments should promote investment of all kinds that is, public, private, partnership models (PPPs), in relation to both supply and demand creation for broadband network infrastructure deployment for rural and remote areas.
- Governments should also create an enabling environment that includes the elaboration and deployment of incentives for investment in broadband infrastructure in unserved and underserved areas.

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[7] Neither the WTDC nor the Plenipotentiary Conference have agreed on a definition of community networks and therefore ITU has no current agreed definition. The term has been used to denote communications infrastructure deployed and operated by citizens to meet their own communication needs, as highlighted in the workshop presentation by the Internet Societies. The concept has been used in Georgia, Brazil and Zimbabwe, and a number of countries in South America. Depending on the policy and legislation of the country concerned, the term can also refer to small operator businesses originating from the locality.

[8] Presentation by Aminata Garba at the workshop on broadband development in rural areas hosted by the Question 5/1 Rapporteur Group, 25 September 2019, available at: https://www.itu.int/oth/D0718000008 and https://www.internetsociety.org/resources/doc/2017/tusheti-case-study/.

- Governments which have not created universal service funds may need to strongly consider doing so and further ensure that licensing includes universal service obligations for Internet.
- Governments should make land available for installation of mobile towers and have clear policies and precision in the role of each government department in the document approval chain for facilitating installations.
- "Dig once" policies should be implemented in relation to the laying of fibre, in order to make the cost of installation affordable, while at the same time keeping service fees low.
- Given that low demand is one of the reasons why operators shun infrastructure investment in rural and remote areas, creation of local content is critical in stimulating demand. Production of content services and application is therefore key for policy-makers.
- Policy-makers are encouraged to ensure that ICT training is incorporated into school curriculum as literacy also stimulates demand.
- Regulators and policy-makers may need to support rural coverage in unserved and underserved areas by attaching conditions to spectrum licensing.
- Policy-makers may also re-write the mandate for universal service to go beyond voice services to include mobile broadband.
- Governments should consider welcoming a wider range of technological solutions, including emerging technologies when licensing, to encourage broadband deployment in rural and remote areas.

7. Recommendations and guidelines for operators

- Upgrade 2G network sites to 3G or 4G.
- Extend or densify networks through low-cost solutions.
- Use alternative energy to power tower sites.
- Make use of Wi-Fi hotspots for public areas.
- Embrace smaller operators, virtual network operators and community networks run by local community businesses, as complementary rather than view them as competition.
- Invest in research and development to find cost effective last-mile connectivity solutions for rural and remote areas.
- Make use of partnerships with governments and universal service funds, when deploying networks to rural and remote areas.
- Encourage and implement infrastructure sharing.

References

1) Various ITU-D Study Group 1 Question 5/1 contributions and case studies: https://www.itu.int/net4/ITU-D/CDS/sg/rgqlist.asp?lg=1&sp=2018&rgq=D18-SG01-RGQ05.1&stg=1
2) Presentations and discussions during the ITU-D Study Group 1 Question 5/1 workshop on broadband development for rural areas, held on 25 September 2019 : https://www.itu.int/en/ITU-D/Study-Groups/2018-2021/Pages/meetings/session-Q5-1-sept19.aspx

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E-mail: devSG@itu.int Tel.: +41 22 730 5999
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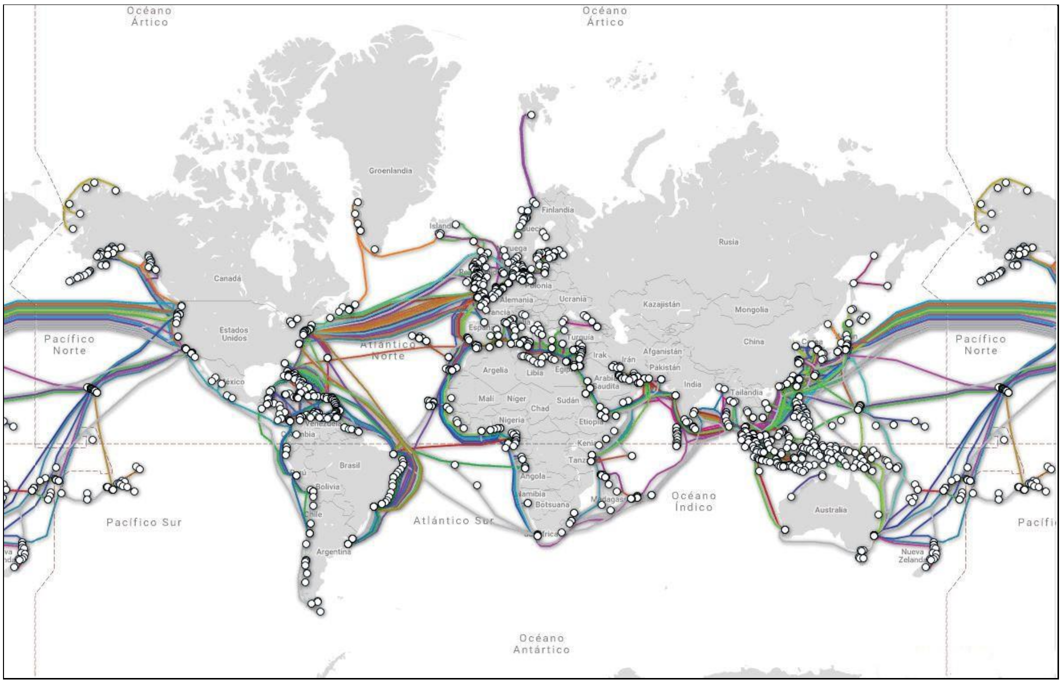
Annex 1: Map of the global submarine cable network



Source: Submarine Cable Map by TeleGeography (Accessed 12/12/2019)

Annex 2: Listing of submarine cables (A-Y)

ACS Alaska-Oregon Network (AKORN)	Aden-Djibouti	Adria-1	AEConnect-1
Africa Coast to Europe (ACE)	Alaska United East	Alaska United Southeast	Alaska United Turnagain Arm (AUTA)
Alaska United West	ALBA-1	Aletar	Alonso de Ojeda
ALPAL-2	America Movil Submarine Cable System-1 (AMX-1)	America Movil-Telxius West Coast Cable	American Samoa-Hawaii (ASH)
Americas-I North	Americas-II	Amerigo Vespucci	Antillas 1
APCN-2	Aphrodite 2	Apollo	Aqualink
ARBR	ARCOS	ARSAT Submarine Fiber Optic Cable	Asia Africa Europe-1 (AAE-1)
Asia Pacific Gateway (APG)	Asia Submarine-cable Express (ASE)/Cahaya Malaysia	Asia-America Gateway (AAG) Cable System	Atisa
Atlantic Crossing-1 (AC-1)	Atlantis-2	Atlas Offshore	AU-Aleutian
AURORA Cable System	Australia-Japan Cable (AJC)	Australia-Papua New Guinea-2 (APNG-2)	Australia-Singapore Cable (ASC)
Avassa	Azores Fiber Optic System (AFOS)	Bahamas 2	Bahamas Domestic Submarine Network (BDSNi)
Bahamas Internet Cable System (BICS)	Balalink	BALOK	Baltic Sea Submarine Cable
Baltica	Bass Strait-1	Bass Strait-2	Basslink
Batam Dumai Melaka (BDM) Cable System	Batam Sarawak Internet Cable System (BaSICS)	Batam Singapore Cable System (BSCS)	Batam-Rengit Cable System (BRCS)
Bay of Bengal Gateway (BBG)	Bay to Bay Express (BtoBE) Cable System	BCS East	BCS East-West Interlink
BCS North - Phase 1	BCS North - Phase 2	BERYTAR	Bharat Lanka Cable System
Bicentenario	BlueMed	Bodo-Rost Cable	Boracay-Palawan Submarine Cable System
Boriken Submarine Cable System (BSCS)	Botnia	Brazilian Festoon	BRUSA
BT Highlands and Islands Submarine Cable System	BT-MT-1	BUGIO	C-Lion1
Cabo Verde Telecom Domestic Submarine Cable Phase 1	Cabo Verde Telecom Domestic Submarine Cable Phase 2	Cabo Verde Telecom Domestic Submarine Cable Phase 3	CADMOS
CAM Ring	Canalink	CANDALTA	CANTAT-3
Caribbean Regional Communications Infrastructure Program (CARCIP)	Caribbean-Bermuda U.S. (CBUS)	Caucasus Cable System	Cayman-Jamaica Fiber System
Ceiba-1	Ceiba-2	Celtic	Celtic Norse
CeltixConnect-1 (CC-1)	CeltixConnect-2 (CC-2)	Challenger Bermuda-1 (CB-1)	Channel Islands-9 Liberty Submarine Cable

Chennai-Andaman & Nicobar Islands Cable	Chuuk-Pohnpei Cable	Circe North	Circe South
COBRAcable	Colombia-Florida Subsea Fiber (CFX-1)	Columbus-II b	Columbus-III
Comoros Domestic Cable System	Concerto	Converge ICT Domestic Submarine Cable	Coral Sea Cable System (CSCS)
Corse-Continent 4 (CC4)	Corse-Continent 5 (CC5)	Cross Straits Cable Network	Crosslake Fibre
Curie	DAMAI Cable System	Danica North	DANICE
Denmark-Norway 5	Denmark-Norway 6	Denmark-Poland 2	Denmark-Sweden 15
Denmark-Sweden 16	Denmark-Sweden 17	Denmark-Sweden 18	Dhiraagu Cable Network
Dhiraagu-SLT Submarine Cable Network	Diamond Link Global	Didon	Djibouti Africa Regional Express 1 (DARE1)
Dumai-Melaka Cable System	Dunant	E-LLAN	EAC-C2C
East-West	East-West Submarine Cable System	Eastern Africa Submarine System (EASSy)	Eastern Caribbean Fiber System (ECFS)
Eastern Light	ECLink	Elektra-GlobalConnect 1 (GC1)	EllaLink
Emerald Bridge Fibres	Energinet Laeso-Varberg	Energinet Lyngsa-Laeso	England Cable
Equiano	ESAT-1	ESAT-2	Estepona-Tetouan
Europe India Gateway (EIG)	FALCON	Far East Submarine Cable System	FARICE-1
Farland North	FASTER	Fehmarn Bält	Fiber Optic Gulf (FOG)
Fibra Optica Austral	Fibralink	Finland Estonia Connection (FEC)	Finland-Estonia 2 (EESF-2)
Finland-Estonia 3 (EESF-3)	FLAG Atlantic-1 (FA-1)	FLAG Europe-Asia (FEA)	FLAG North Asia Loop/REACH North Asia Loop
Flores-Corvo Cable System	FLY-LION3	FOS Quellon-Chacabuco	Gemini Bermuda
Geo-Eirgrid	Georgia-Russia	Germany-Denmark 2	Germany-Denmark 3
Glo-1	Glo-2	Global Caribbean Network (GCN)	GlobalConnect 2 (GC2)
GlobalConnect 3 (GC3)	GlobalConnect-KPN	GlobeNet	GO-1 Mediterranean Cable System
Gondwana-1	Greenland Connect	Greenland Connect North	GTMO-1
GTMO-PR	GTT Atlantic	GTT Express	Guadeloupe Cable des Iles du Sud (GCIS)
Guam Okinawa Kyushu Incheon (GOKI)	Guernsey-Jersey-4	Gulf Bridge International Cable System (GBICS)/Middle East North Africa (MENA) Cable System	Gulf of California Cable
Gulf2Africa (G2A)	H2 Cable	Hainan-Hong Kong Submarine Cable System	HANNIBAL System

HANTRU1 Cable System	Havfrue/AEC-2	Hawaiki	Hawk
HICS (Hawaii Inter-Island Cable System)	HIFN (Hawaii Island Fibre Network)	High-capacity Undersea Guernsey Optical-fibre (HUGO)	Hokkaido-Sakhalin Cable System (HSCS)
Hong Kong-Americas (HKA)	Hong Kong-Guam (HK-G)	Honotua	i2i Cable Network (i2icn)
IMEWE	INDIGO-Central	INDIGO-West	Indonesia Global Gateway (IGG) System
INGRID	Interchange Cable Network 1 (ICN1)	Interchange Cable Network 2 (ICN2)	International Gateway (IGW)
IOX Cable System	IP-Only Denmark-Sweden	Ireland-France Cable-1 (IFC-1)	Isles of Scilly Cable
Italy-Albania	Italy-Croatia	Italy-Greece 1	Italy-Libya
Italy-Malta	Italy-Monaco	JaKa2LaDeMa	JAKABARE
Jakarta Surabaya Cable System (JAYABAYA)	Jakarta-Bangka-Bintan-Batam-Singapore (B3JS)	Jambi-Batam Cable System (JIBA)	Janna
Japan Information Highway (JIH)	Japan-Guam-Australia North (JGA-N)	Japan-Guam-Australia South (JGA-S)	Japan-U.S. Cable Network (JUS)
JASUKA	Java Bali Cable System (JBCS)	Jerry Newton	Jonah
Junior	JUPITER	Kanawa	Kattegat 1
Kattegat 2	Kerch Strait Cable	KetchCan1 Submarine Fiber Cable System	Kodiak Kenai Fiber Link (KKFL)
Korea-Japan Cable Network (KJCN)	Kumul Domestic Submarine Cable System	Kuwait-Iran	La Gomera-El Hierro
Labuan-Brunei Submarine Cable	Lanis-1	Lanis-2	Lanis-3
Latvia-Sweden 1 (LV-SE 1)	Lazaro Cardenas-Manzanillo Santiago Submarine Cable System (LCMSSCS)	Lev Submarine System	LFON (Libyan Fiber Optic Network)
Libreville-Port Gentil Cable	Link 1 Phase-1	Link 1 Phase-2	Link 2 Phase-1
Link 2 Phase-2	Link 3 Phase-1	Link 3 Phase-2	Link 4 Phase-2
Link 5 Phase-2	Lower Indian Ocean Network (LION)	Lower Indian Ocean Network 2 (LION2)	Luwuk Tutuyan Cable System (LTCS)
Lynn Canal Fiber	MainOne	Malaysia-Cambodia-Thailand (MCT) Cable	Malbec
Malta-Gozo Cable	Malta-Italy Interconnector	Manatua	Mandji Fiber Optic Cable
Maple Leaf Fibre	MAREA	Mariana-Guam Cable	Mataram Kupang Cable System (MKCS)
Matrix Cable System	Mauritius and Rodrigues Submarine Cable System (MARS)	Maya-1	Med Cable Network

MedNautilus Submarine System	Melita 1	Meltingpot Indianoceanic Submarine System (METISS)	Mid-Atlantic Crossing (MAC)
Middle East North Africa (MENA) Cable System/Gulf Bridge International	Miyazaki-Okinawa Cable (MOC)	Monet	Moratelindo International Cable System-1 (MIC-1)
N0R5KE Viking	National Digital Transmission Network (NDTN)	Nationwide Submarine Cable Ooredoo Maldives (NaSCOM)	NATITUA
Nelson-Levin	New Cross Pacific (NCP) Cable System	Nigeria Cameroon Submarine Cable System (NCSCS)	NordBalt
North Sea Connect (NSC)	North West Cable System	Northern Lights	NorthStar
Nunavut Undersea Fibre Optic Network System	NYNJ-1	Okinawa Cellular Cable	Oman Australia Cable (OAC)
OMRAN/EPEG Cable System	Oran-Valencia (ORVAL)	Orient Express	OTEGLOBE Kokkini-Bari
Pacific Caribbean Cable System (PCCS)	Pacific Crossing-1 (PC-1)	Pacific Light Cable Network (PLCN)	Palapa Ring East
Palapa Ring Middle	Palapa Ring West	Palawa-Iloilo Cable System	Pan American (PAN-AM)
Pan European Crossing (UK-Belgium)	Pan European Crossing (UK-Ireland)	Pan-American Crossing (PAC)	Paniolo Cable Network
PASULI	PEACE Cable	PENBAL-5	Pencan-8
Pencan-9	Persona	PGASCOM	Picot-1
PIPE Pacific Cable-1 (PPC-1)	Pishgaman Oman Iran (POI) Network	PLDT Domestic Fiber Optic Network (DFON)	PNG LNG
Polar Circle Cable	POSEIDON	Prat	Qatar-U.A.E. Submarine Cable System
Quintillion Subsea Cable Network	Redellhabela-1	Rockabill	Russia-Japan Cable Network (RJCN)
Rønne-Rødvig	S-U-B Cable System	Saba, Statia Cable System (SSCS)	SABR
SAFE	Saint Maarten Puerto Rico Network One (SMPR-1)	Sakhalin-Kuril Islands Cable	Samoa-American Samoa (SAS)
San Andres Isla Tolu Submarine Cable (SAIT)	SAT-3/WASC	Saudi Arabia-Sudan-1 (SAS-1)	Saudi Arabia-Sudan-2 (SAS-2)
Scandinavian Ring North	Scandinavian Ring South	Scotland-Northern Ireland 1	Scotland-Northern Ireland 2
SEA-US	sea2shore	Seabras-1	SEACOM/Tata TGN-Eurasia
SeaMeWe-3	SeaMeWe-4	SeaMeWe-5	SEAX-1
Segunda FOS Canal de Chacao	Seychelles to East Africa System (SEAS)	SHEFA-2	Silphium
Singapore-Myanmar (SIGMAR)	Sirius North	Sirius South	Sistem Kabel Rakyat 1Malaysia (SKR1M)
SJJK	Skagenfiber East	Skagenfiber West	Skagerrak 4

SMPCS Packet-1	SMPCS Packet-2	Solas	Sorsogon-Samar Submarine Fiber Optical Interconnection Project (SSSFOIP)
South America-1 (SAm-1)	South American Crossing (SAC)	South Asia Express (SAEx2)	South Atlantic Cable System (SACS)
South Atlantic Express (SAEx1)	South Atlantic Inter Link (SAIL)	Southeast Asia Japan Cable (SJC)	Southeast Asia-Japan Cable 2 (SJC2)
Southern Caribbean Fiber	Southern Cross Cable Network (SCCN)	Southern Cross NEXT	St. Pierre and Miquelon Cable
St. Thomas-St. Croix System	Strategic Evolution Underwater Link (SEUL)	Subcan Link 1	Subcan Link 2
Sumatera Bangka Cable System (SBCS)	Suriname-Guyana Submarine Cable System (SG-SCS)	Svalbard Undersea Cable System	Swansea-Brean
Sweden-Estonia (EE-S 1)	Sweden-Finland 4 (SFS-4)	Sweden-Finland Link (SFL)	Sweden-Latvia
SxS	Taba-Aqaba	Taino-Carib	Taiwan Strait Express-1 (TSE-1)
Tamares North	Tampnet Offshore FOC Network	Tangerine	Tanjun Pandan-Sungai Kakap Cable System
Tannat	Tarakan Selor Cable System (TSCS)	Tasman Global Access (TGA) Cable	TAT-14
Tata TGN-Atlantic	Tata TGN-Gulf	Tata TGN-Intra Asia (TGN-IA)	Tata TGN-Pacific
Tata TGN-Tata Indicom	Tata TGN-Western Europe	TE North/TGN-Eurasia/SEACOM/Alexandros/Medex	Telstra Endeavour
Tenerife-Gran Canaria	Tenerife-La Gomera-La Palma	Tenerife-La Palma	TERRA SW
Thailand-Indonesia-Singapore (TIS)	The East African Marine System (TEAMS)	Tobrok-Emasaed Cable System	Tonga Cable
Tonga Domestic Cable Extension (TDCE)	Trans-Pacific Express (TPE) Cable System	TRANSCAN-2	TRANSCAN-3
Transworld (TW1)	Trapani-Kelibia	TT-1	Tui-Samoa
Turcyos-1	Turcyos-2	Tverrlinken	UAE-Iran
UGARIT	UK-Channel Islands-7	UK-Channel Islands-8	UK-Netherlands 14
Ultramar GE	Ulysses 2	Unisur	Unity/EAC-Pacific
Venezuela Festoon	Vodafone Malta-Sicily Cable System (VMSCS)	WALL-LI	WARF Submarine Cable
West African Cable System (WACS)	Yellow		

Source: PriMetrica, Inc. (Last updated on 5 December 2019)

More information on ITU-D study groups:
E-mail: devSG@itu.int Tel.: +41 22 730 5999 Web: www.itu.int/en/ITU-D/study-groups